Caroline
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School
Ambition Confidence Success
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AQA

GCSE

COMBINED

PHYSICS

PAPER 1

REVISION BOOKLET

Name:................... Class: ....

AQA Combined Physics Paper 1 content

For your End of Year exam, you will be sitting a full AQA GCSE Chemistry Paper 1. You will be examined on the following topics.

What's assessed	Time	Marks available
• Energy • Electricity • Particle model of matter • Atomic structure	1 hr 15 mins	70

Energy and Energy Resources	
1. Conservation and dissipation of energy - Changes in energy stores - Conservation of energy - Energy and work - Gravitational potential energy stores - Kinetic energy and elastic potential energy stores - Energy dissipation - Energy and efficiency - Electrical appliances - Energy and power	**2. Energy transfer by heating** - Energy transfer by conduction - Specific heat capacity - Heating and insulating buildings **Required Practical: Specific Heat Capacity** – Determine the SHC of a metal block of known mass by measuring the energy transferred to the block and its temperature rise, and the use of the equation for SHC
3. Energy resources - Energy demands - Energy from wind and water - Power from the Sun and Earth - Energy and the environment - Big energy issues	

Electricity	
4. Electrical Circuits - Electrical chares and fields (Physics only) - Current and charge - Potential difference and resistance - Component characteristics - Series circuits - Parallel circuits **Required Practical: Resistance** – Set up circuits and investigate the resistance of a wire, and resistors in series and parallel **Required Practical: I-V Characteristics** – Correctly assemble a circuit and investigate the current-potential difference characteristics of circuit components	**5. Electricity in the home** - Alternating current - Cables and plugs - Electrical power and potential difference - Electrical current and energy transfer - Appliances and efficiency

Particle Model of Matter	
6. Molecules and matter - Density - States of matter - Changes of state - Internal energy - Specific latent heat - Gas pressure and temperature **Required Practical: Density** – Measure the mass and volume of objects and liquids and calculate their densities using the density equation	

Atomic Structure	
7. Radioactivity - Atoms and radiation - The discovery of the nucleus - Changes in the nucleus - More about alpha, beta and gamma radiation - Activity and half life	

P1 Conservation and dissipation of energy – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Changes in energy stores	I can state some examples of energy stores.		I can describe a wide range of energy stores in different contexts.		I can describe the nature of energy stores in detail including the relationship between objects.	
	I can state the processes that can transfer energy from one store to another.		I can describe changes in energy stores in terms of the process that causes the change.		I can explain factors that affect the size of changes in energy stores.	
	I can identify changes in some energy stores using simple systems.		I can use quantitative descriptions of changes in energy stores.		I can represent energy changes graphically, accounting for changes in all stores.	
Conservation of energy	I can state that energy is conserved in any transfer.		I can apply the law of conservation of energy in straightforward situations.		I can apply the law of conservation of energy to explain why forces cause heating effects.	
	I can state that energy is dissipated (is no longer useful) when it heats the environment.		I can describe changes in energy stores explaining why energy ceases to be useful.		I can describe closed systems and the changes to energy stores within them using the principle of conservation of energy.	
	I can investigate the energy transfers in a pendulum and bungee.		I can describe the energy changes in a range of experiments and account for energy dissipation to the surroundings.		I can evaluate in detail experiments to investigate energy changes.	
Energy and work	I can state that energy is measured in joules (J).		I can describe the action of frictional forces on objects and the associated heating effect.		I can use the principle of conservation of energy and forces to explain why objects become heated by frictional forces.	
	I can calculate the work done by a force.		I can use the equation for work done to calculate distances or size of forces.		I can apply the equation for work done in a wide range of contexts.	
	I can measure the work done by a force experimentally.		I can use repeat values to measure the work done by a force experimentally.		I can evaluate in detail an experiment to measure work done, explaining why there is variation in the measurements.	
Gravitational potential stores	I can state the factors that affect the change in the gravitational potential energy store of a system.		I can describe the effect of different gravitational field strength on the gravitational potential energy store changes of a system.		I can perform calculations using rearrangements of the gravitational potential energy store equations.	
	I can calculate the gravitational potential energy store of a system using the weight of an object and its height.		I can calculate the gravitational potential energy store of a system using the mass gravitational field strength, and height.		I can apply gravitational potential energy store equations in a wide range of contexts.	
	I can measure the gravitational potential energy store changes in a system with a simple practical activity.		I can describe energy changes that involve a heating effect as opposed to movement of an object.		I can account for all changes of energy during falls or increases in height, including health effects.	

P1 Conservation and dissipation of energy – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Kinetic and elastic stores	I can state the factors that affect the size of a kinetic energy store of an object.		I can calculate the kinetic energy store of an object.		I can perform calculations involving the rearrangement of the kinetic energy equation.	
	I can state the factors that affect the elastic potential energy store of a spring.		I can calculate the elastic potential energy store of a stretched spring.		I can perform calculations involving the rearrangement of the elastic potential energy equation.	
	I can describe energy transfers involving elastic potential energy and kinetic energy stores.		I can investigate the relationship between the energy stored in a spring and the kinetic energy store of an object launched from it.		I can perform a wide range of calculations involving transfer of energy.	
Energy dissipation	I can identify useful and wasted energy in simple scenarios.		I can analyse energy transfers to identify useful and less useful energy transfers.		I can use a wide range of energy stores and physical processes to decide on wasted and useful energy transfers.	
	I can describe energy dissipation in terms of heating the surroundings.		I can describe energy dissipation and how this reduces the capacity of a system.		I can apply the concept of energy dissipation in a wide range of scenarios.	
	I can measure the frictional force acting on an object.		I can investigate the factors that affect frictional forces.		I can evaluate in detail an experiment to measure the frictional forces acting on an abject.	
Energy and efficiency	I can describe an efficient transfer as one that transfers more energy by a useful process.		I can calculate the efficiency of a range of energy transfers.		I can describe design features that can be used to improve the efficiency of an energy transfer.	
	I can state that the efficiency of a simple energy transfer is always less that 100%.		I can use the law of conservation of energy to explain why efficiency can never be greater than 100%.		I can rearrange the efficiency equation to find input or total output energy.	
	I can describe the energy transfers carries out by electrical devices.		I can describe the processes that waste energy in electrical devices.		I can explain the operation of electrical devices in terms of forces and electric current.	
Electrical appliances	I can list some electrical appliances.		I can rank electrical devices in terms of their power.		I can compare electrical devices in terms of efficiency.	
	I can survey a range of electrical devices and their operation.		I can compare mains-powered and battery-powered devices.		I can calculate the efficiency of an electrical device.	
	I can calculate the efficiency of a simple energy transfer.		I can investigate the efficiency of a motor.		I can evaluate in detail an efficiency investigation to justify conclusions.	
Energy and power	I can state the unit of power as the watt and kilowatt.		I can calculate the energy transferred by an electrical device.		I can compare the power ratings of devices using standard form.	
	I can, with support, rank electrical appliances in order of power.		I can calculate the efficiency of a device from power ratings.		I can apply the efficiency equation in a range of situations, including rearrangement of the equation.	
	I can identify 'wasted' and 'useful' energy transfers in electrical devices.		I can find the wasted power of a device.		I can combine the electrical power equation with other equations to solve complex problems.	

P2 Energy transfer by heating – Paper 1

Lesson	Aiming for 4	Aiming for 6	Aiming for 8
Energy transfer by conduction	I can describe materials as good or poor thermal conductors.	I can analyse temperature change data to compare the thermal conductivity of materials.	I can explain the different thermal conductivities of materials using the free electron and lattice vibration explanations of conduction.
	I can compare the thermal conductivities of materials in simple terms.	I can describe the changes in the behaviour of the particles in a material as the temperature of the material increases.	I can evaluate the results of an experiment into thermal conductivity in terms of repeatability and reproducibility of data, and the validity of conclusions drawn from the data.
	I can relate the thermal conductivities of a material to the uses of that material in familiar contexts.	I can apply understanding of thermal conductivity in reducing energy dissipation through the choice of appropriate insulating materials.	I can justify the choices of material involved in insulation or conduction using the concept of thermal conductivity and other data.
Specific heat capacity	I can describe materials in terms of being difficult or easy to heat up (increase the temperature of).	I can describe the effects of changing the factors involved in the equation.	I can evaluate materials used for transferring energy in terms of their specific heat capacity.
	I can state the factors that affect the amount of energy required to increase the temperature of an object.	I can calculate the energy required to change the temperature of an object.	I can use the specific heat capacity equation to perform a wide range of calculations in unfamiliar contexts.
	I can, with some support, measure the specific heat capacity of a material.	I can measure the specific heat capacity of a material and find a mean value.	I can evaluate in detail the results of an experiment to measure specific heat capacity.
Heating and insulating buildings	I can state some design features used to prevent energy transfer to the surroundings in the home.	I can describe how some design features used to reduce energy dissipation from a home work.	I can evaluate in detail design features used to reduce the rate of energy loss from the home.
	I can calculate the payback time of a simple home improvement feature.	I can compare home improvement features in terms of payback time.	I can decide on home improvement features using payback time and savings beyond the payback time.

P3 Energy resources – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Energy demands	I can identify which fuels are renewable and which are non-renewable.		I can outline the operation of a fossil fuel burning power station.		I can compare energy use from different sources and different societies from available data.	
	I can identify activities that require large energy transfers.		I can outline the operation of a nuclear power station.		I can compare fossil fuels and nuclear fuels in terms of energy provided, waste, and pollution.	
	I can state that biofuels are carbon neutral whereas fossil fuels are not.		I can explain why biofuels are considered carbon neutral.		I can discuss some of the problems associated with biofuel use and production.	
Energy from wind and water	I can state that wind turbines, wave generators, hydroelectric systems, and tidal systems are renewable energy resources.		I can describe the operation of a wind farm.		I can compare the operation of hydroelectric, wave, and tidal systems in terms of reliability, potential power output, and costs.	
	I can state some simple advantages or disadvantages of renewable energy systems.		I can describe the operation of a hydroelectric system.		I can explain in detail the purpose, operation, and advantages of a pumped storage system.	
	I can outline the operation of a renewable energy source.		I can suggest the most appropriate energy resource to use in a range of scenarios.		I can justify the choice of an energy resource by using numerical and other appropriate data.	
Power from the Sun and the Earth	I can explore the operation of a solar cell.		I can compare and contrast the operation of solar cells (photovoltaic cells) with solar heating panels.		I can analyse the power output of a variety of energy resources.	
	I can state one difference between solar cells and solar heating systems.		I can describe the operation of a solar power tower.		I can calculate the energy provided by a solar heating system by using the increase in water temperature.	
	I can state that radioactive decay is source of heating in geothermal systems.		I can describe the operation of a geothermal power plant.		I can plan in detail an investigation into the factors that affect the power output of a solar cell.	
Energy and the environment	I can list some environmental problems associated with burning fossil fuels.		I can describe the effects of acid rain and climate change.		I can evaluate methods of reducing damage caused by waste products of fossil fuels and nuclear fuels.	
	I can identify the waste products of fossil fuels and nuclear fuel.		I can describe techniques to reduce the harmful products of burning fossil fuels.		I can discuss in detail the problems associated with nuclear accidents and the public perception of nuclear safety.	
	I can state simple advantages and disadvantages of a variety of renewable energy resources.		I can compare a wide range of energy resources in terms of advantages and disadvantages.		I can evaluate the suitability of an energy resource for a range of scenarios, taking into account a wide range of factors.	

P3 Energy resources – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Big energy issues	I can rank the start-up times of various power stations.		I can use base load and start-up time data to explain why some power stations are in constant operation whereas others may be switched on and off.		I can use capital and operational costs of energy resources to evaluate their usefulness.	
	I can compare some of the advantages and disadvantages of various energy resources.		I can compare energy resources in terms of capital and operational costs.		I can form persuasive arguments for or against a variety of energy resources.	
	I can discuss the construction of a power plant in the local area in simple terms by using information provided.		I can debate the construction of a power plant in the local area by using a wide range of information, much of which is provided.		I can debate the construction of a power plant in local area by using a wide range of information, much of which is independently researched.	

Chapter 1: Conservation and dissipation of energy

Knowledge organiser

Systems

A **system** is an object or group of objects.

Whenever anything changes in a system, energy is transferred between its stores or to the surroundings.

A **closed system** is one where no energy can escape to or enter from the surroundings. The total energy in a closed system never changes.

Energy stores

kinetic	energy an object has because it is moving
gravitational potential	energy an object has because of its height above the ground
elastic potential	energy an elastic object has when it is stretched or compressed
thermal (or internal)	energy an object has because of its temperature (the total kinetic and potential energy of the particles in the object)
chemical	energy that can be transferred by chemical reactions involving foods, fuels, and the chemicals in batteries
nuclear	energy stored in the nucleus of an atom
magnetic	energy a magnetic object has when it is near a magnet or in a magnetic field
electrostatic	energy a charged object has when near another charged object

Energy transfers

Energy can be transferred to and from different stores by:

Heating
Energy is transferred from one object to another object with a lower temperature.

Waves
Waves (e.g., light and sound) can transfer energy.

Electricity
An electric current transfers energy.

Forces (mechanical work)
Energy is transferred when a force moves or changes the shape of an object.

Examples of energy transfers

When you stretch a rubber band, energy from your chemical store is mechanically transferred to the rubber band's elastic potential store.

When a block is dropped from a height, energy is mechanically transferred (by the force of gravity) from the block's gravitational potential store to its kinetic store.

When this block hits the ground, energy from its kinetic energy store is transferred mechanically and by sound waves to the thermal energy store of the surroundings.

The electric current in a kettle transfers energy to the heating element's thermal energy store. Energy is then transferred by heating from the heating element's thermal energy store to the thermal energy store of the water.

When an object slows down due to friction, energy is mechanically transferred from the object's kinetic store to its thermal store, the thermal store of the object it is rubbing against, and to the surroundings.

Work done

When an object is moved by a force **work** is done on the object. The force transfers energy to the object. The amount of energy transferred is equal to the work done. You can calculate the work done (and the energy transferred) using the equation:

(L) work done (J) = force (N) × distance moved along the line of action of the force (m)

Calculating the energy in an energy store

An object's gravitational potential energy store depends on its height above the ground, the gravitational field strength, and its mass.

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

(L) $E_p = m\,g\,h$

An object's kinetic energy store depends only on its mass and speed.

kinetic energy (J) = 0.5 × mass (kg) × (speed)^2 (m/s)

(L) $E_k = \frac{1}{2} m\,v^2$

The elastic potential energy store of a stretched spring can be calculated using:

elastic potential energy (J) = 0.5 × spring constant (N/m) × (extension)^2 (m)

$E_e = \frac{1}{2} k\,e^2$ (assuming the limit of proportionality has not been exceeded)

Power is how much work is done (or how much energy is transferred) per second. The unit of power is the watt (W).

1 watt = 1 joule of energy transferred per second

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

(L) $P = \frac{E}{t}$

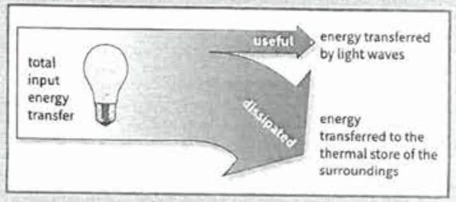
or

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

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

Useful and dissipated energy

Energy cannot be created or destroyed – it can only be transferred usefully, stored, or dissipated (wasted).



Energy is never entirely transferred usefully – some energy is always dissipated, meaning it is transferred to less useful stores.

All energy eventually ends up transferred to the thermal energy store of the surroundings.

In machines, work done against the force of friction usually causes energy to be wasted because energy is transferred to the thermal store of the machine and its surroundings.

Lubrication is a way of reducing unwanted energy transfer due to friction.

Streamlining is a way of reducing energy wasted due to air resistance or drag in water.

Use of thermal insulation is a way of reducing energy wasted due to heat dissipated to the surroundings.

Efficiency is a measure of how much energy is transferred usefully. You must know the equation to calculate efficiency as a *decimal*:

efficiency = $\frac{\text{useful output energy transfer (J)}}{\text{total input energy transfer (J)}}$

(L) or

efficiency = $\frac{\text{useful power output (W)}}{\text{total power input (W)}}$

To give efficiency as a *percentage*, just multiply the result from the above calculation by 100 and add the % sign to the answer.

Key terms

Make sure you can write a **definition** for these key terms.

chemical, closed system, dissipated, efficiency, elastic potential, electrostatic, gravitational potential, kinetic, lubrication, magnetic, nuclear, power, streamlining, system, thermal, work done

Chapter 1: Conservation and dissipation of energy

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P1 questions		Answers
1	Name the five energy stores	Put paper here	kinetic, gravitational potential, elastic potential, thermal, chemical
2	Name the four ways in which energy can be transferred.		heating, waves, electric current, mechanically (by forces)
3	What is a system?	Put paper here	an object or group of objects
4	What is a closed system?		a system where no energy can be transferred to or from the surroundings – the total energy in the system stays the same
5	What is work done?	Put paper here	energy transferred when a force moves an object
6	What is the unit for energy?		joules (J)
7	What is one joule of work?		the work done when a force of 1 N causes an object to move 1 m in the direction of the force
8	Describe the energy transfer when a moving car slows down.	Put paper here	energy is transferred mechanically from the kinetic store of the car to the thermal store of its brakes. Some energy is dissipated to the thermal store of the surroundings
9	Describe the energy transfer when an electric kettle is used to heat water.	Put paper here	the electric current in a kettle transfers energy to the heating element's thermal store – energy is then transferred by heating from the heating element's thermal store to the thermal store of the water
10	Describe the energy transfer when a ball is fired using an elastic band.	Put paper here	energy is transferred mechanically from the elastic store of the elastic band to the kinetic store of the band – some energy is dissipated to the thermal store of the surroundings
11	Describe the energy transfer when a battery powered toy car is used.	Put paper here	energy is transferred electrically from the chemical store of the battery to the kinetic store of the toy car – some energy is dissipated to the thermal store of the surroundings
12	Describe the energy transfer when a falling apple hits the ground.	Put paper here	energy is transferred from the kinetic store of the apple and dissipated to the thermal store of the surroundings by sound waves
13	Name the unit that represents one joule transferred per second.	Put paper here	watt (W)
14	A motor is 30% efficient. What does that mean?		30% of the energy is usefully transferred and 70% is dissipated

Chapter 2: Energy transfer by heating

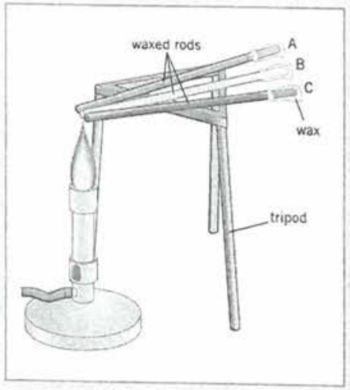
Knowledge organiser

Thermal conductivity

The **thermal conductivity** of a material tells you how quickly energy is transmitted through it by thermal conduction.

You can test the thermal conductivity of rods made of different metals using this experimental set-up. Each rod must have the same diameter and length, and the same temperature difference between its ends.

One end of each rod is covered in wax and the other ends are heated equally. The faster the wax melts, the higher the thermal conductivity of the metal.



Insulating buildings

Heating bills can be expensive so it is important to reduce the rate of heat loss from buildings.

Some factors that affect the rate of heat loss from a building include:

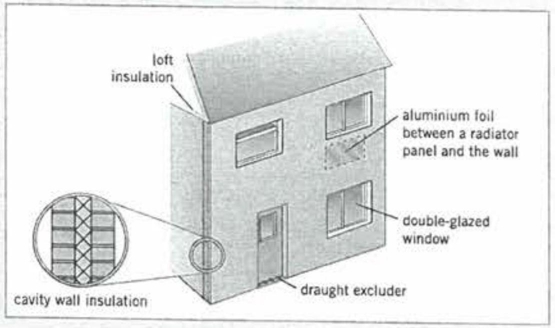
1 the thickness of its walls and roof
2 the thermal conductivity of its walls and roof.
lower thermal conductivity = lower rate of heat loss

The thermal conductivity of the walls and roof can be reduced by using **thermal insulators**.

A thermal insulator is a material which has a low thermal conductivity. The rate of energy transfer through an insulator is low.

The energy transfer per second through a material depends on:

1 the material's thermal conductivity
2 the temperature difference between the two sides of the material
3 the thickness of the material.



Specific heat capacity

When a substance is heated or cooled the temperature change depends on:

- the substance's mass
- the type of material
- how much energy is transferred to it.

Every type of material has a **specific heat capacity** – the amount of energy needed to raise the temperature of 1 kg of the substance by 1 °C.

The energy transferred to the thermal store of a substance can be calculated from the substance's mass, specific heat capacity, and temperature change:

change in thermal energy (J) = mass (kg) × specific heat capacity (J/kg°C) × temperature change (°C)

$$\Delta E = m\ c\ \Delta\theta$$

This equation will be given to you on the equation sheet, but you need to be able to select and apply it to the correct questions.

Key terms

Make sure you can write a definition for these key terms.

absorb | specific heat capacity | thermal conductivity | thermal insulator

Chapter 2: Energy transfer by heating

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P2 questions	Answers
1	What does a material's thermal conductivity tell you?	how well it conducts heat
2	Which materials have low thermal conductivity?	thermal insulators
3	Give three factors that determine the rate of thermal energy transfer through a material.	thermal conductivity of material, temperature difference, thickness of material
4	What factors affect the rate of heat loss from a building?	thickness of walls and roof, thermal conductivity of walls and roof, the temperature difference between the two sides of the wall/roof
5	Define specific heat capacity.	amount of energy needed to raise the temperature of 1 kg of a material by 1 °C

Put paper here

Put paper here

Chapter 3: Energy resources

Knowledge organiser

Energy resources

The main ways in which we use the Earth's energy resources are:

- generating electricity
- heating
- transport.

Most of our energy currently comes from **fossil fuels** – coal, oil, and natural gas.

Reliability and environmental impact

Some energy resources are more reliable than others. **Reliable** energy resources are ones that are available all the time (or at predictable times) and in sufficient quantities.

Both **renewable** and **non-renewable** energy resources have some kind of **environmental impact** when we use them.

Non-renewable energy resources

- not replaced as quickly as they are used
- will eventually run out

For example, fossil fuels and nuclear fission.

Renewable energy resources

- can be replaced at the same rate as they are used
- will not run out

For example, solar, tidal, wave, wind, geothermal, biofuel, and hydroelectric energies.

Non-renewable energy resources

Resource	Main uses	Source	Advantages	Disadvantages
coal	generating electricity	extracted from underground	• enough available to meet current energy demands • reliable – supply can be controlled to meet demand • relatively cheap to extract and use	• will eventually run out • release carbon dioxide when burned – one of the main causes of climate change • release other polluting gases, such as sulfur dioxide (from coal and oil) which causes acid rain • oil spills in the oceans kill marine life
oil	generating electricity transport heating			
natural gas	generating electricity heating			
nuclear fission	generating electricity	mining naturally occurring elements, such as uranium and plutonium	• no polluting gases or greenhouse gases produced • enough available to meet current energy demands • large amount of energy transferred from a very small mass of fuel • reliable – supply can be controlled to meet demand	produces nuclear waste, which is: • dangerous • difficult and expensive to dispose of • stored for centuries before it is safe to dispose of. nuclear power plants are expensive to: • build and run • decommission (shut down).

Renewable energy resources

Resource	Main uses	Source	Advantages	Disadvantages
solar energy	generating electricity heating	sunlight transfers energy to solar cells sunlight transfers energy to solar heating panels	can be used in remote places very cheap to run once installed no pollution/greenhouse gases produced	supply depends on weather expensive to buy and install cannot supply large scale demand
hydroelectric energy	generating electricity	water flowing downhill turns generators	low running cost no fuel costs reliable and supply can be controlled to meet demand	expensive to build hydroelectric dams flood a large area behind the dam, destroying habitats and resulting in greenhouse gas production from rotting vegetation
tidal energy	generating electricity	turbines on tidal barrages turned by water as the tide comes in and out	predictable supply as there are always tides can produce large amounts of electricity no fuel costs no pollution/greenhouse gases produced	tidal barrages: – change marine habitats and can harm animals – restrict access and can be dangerous for boats – are expensive to build and maintain cannot control supply supply varies depending on time of month
wave energy	generating electricity	floating generators powered by waves moving up and down	low running cost no fuel costs no pollution/greenhouse gases produced	floating generators: – change marine habitats and can harm animals – restrict access and can be dangerous for boats – are expensive to build, install, and maintain dependent on weather cannot supply large scale demand
wind energy	generating electricity	turbines turned by the wind	low running cost no fuel costs no pollution/greenhouse gases produced	supply depends on weather large amounts of land needed to generate enough electricity for large scale demand can produce noise pollution for nearby residents
geothermal energy	generating electricity heating	radioactive substances deep within the Earth transfer heat energy to the surface	low running cost no fuel costs no pollution/greenhouse gases produced	expensive to set up only possible in a few suitable locations around the world
biofuels	generating electricity transport	fuel produced from living or recently living organisms, for example, plants and animal waste	can be **carbon neutral** – the amount of carbon dioxide released when the fuel is burnt is equal to the amount of carbon dioxide absorbed when the fuel is grown reliable and supply can be controlled to meet demand	expensive to produce biofuels growing biofuels requires a lot of land and water that could be used for food production can lead to deforestation – forests are cleared for growing biofuel crops

Key terms

Make sure you can write a definition for these key terms.

biofuel · carbon neutral · environmental impact · fossil fuel · geothermal · hydroelectric · non-renewable · reliability · renewable

Chapter 3: Energy resources

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P3 questions	Answers
1	What is a non-renewable energy resource?	will eventually run out, is not replaced at the same rate it is being used
2	What is a renewable energy resource?	will not run out, it is being (or can be) replaced at the same rate as which it is used
3	What are the main renewable and non-renewable resources available on Earth?	renewable: solar, tidal, wave, wind, geothermal, biofuel, hydroelectric non-renewable: coal, oil, gas, nuclear
4	What are the main advantages of using coal as an energy resource?	enough available to meet current demand, reliable, can control supply to match demand, cheap to extract and use
5	What are the main disadvantages of using coal as an energy resource?	will eventually run out, releases CO_2 which contributes to climate change, releases sulfur dioxide which causes acid rain
6	What are the main advantages of using nuclear fuel as an energy resource?	lot of energy released from a small mass, reliable, can control supply to match demand, enough fuel available to meet current demand, no polluting gases
7	What are the main disadvantages of using nuclear fuel as an energy resource?	waste is dangerous and difficult and expensive to deal with, expensive initial set up, expensive to shut down and to run
8	What are the main advantages of using solar energy?	can be used in remote places, no polluting gases, no waste products, very low running cost
9	What are the main disadvantages of using solar energy?	unreliable, cannot control supply, initial set up expensive, cannot be used on a large scale
10	What are the main advantages of using tidal power?	no polluting gases, no waste products, reliable, can produce large amounts of electricity, low running cost, no fuel costs
11	What are the main disadvantages of using tidal power?	can harm marine habitats, initial set up expensive, cannot increase supply when needed, amount of energy varies on time of month, hazard for boats
12	What are the main advantages of using wave turbines?	no polluting gases produced, no waste products, low running cost, no fuel costs
13	What are the main disadvantages of using wave turbines?	unreliable, dependent on weather, cannot control supply, initial set up expensive, can harm marine habitats, hazard for boats, cannot be used on a large scale
14	What are the main disadvantages of using wind turbines?	unreliable, dependent on weather, cannot control supply, take up lot of space, can produce noise pollution
15	What are the advantages and the disadvantages of using geothermal energy?	advantages: no polluting gases, low running cost disadvantages: initial set up expensive, available in few locations
16	What are the main advantages and disadvantages of using biofuels?	advantages: can be 'carbon neutral', reliable disadvantages: expensive to produce, use land/water that might be needed to grow food
17	What are the main advantages and disadvantages of using hydroelectric power?	advantages: no polluting gases, no waste products, low running cost, no fuel cost, reliable, can be controlled to meet demand disadvantages: initial set up expensive, dams can harm/destroy marine habitats

Put paper here

P4 Electric circuits – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Current and charge	I can identify circuit components from their symbols.		I can describe the operation of a variable resistor and a diode and their effects on current.		I can explain the nature of an electric current in wires in terms of electron behaviour.	
	I can draw and interpret simple circuit diagrams.		I can calculate the charge transferred by a steady current in a given time.		I can perform a range of calculations, including rearrangement of the equation $Q=It$.	
	I can construct a simple electrical circuit.		I can construct an electrical circuit and accurately measure the current.		I can measure the current in a circuit accurately and use it to calculate the rate of flow of electrons.	
Potential difference and resistance	I can state that resistance restricts the size of a current in a circuit.		I can calculate the potential difference.		I can describe potential difference in terms of work done per unit charge.	
	I can state Ohm's law and describe its conditions.		I can calculate the resistance of a component.		I can rearrange equations for resistance and potential difference.	
	I can measure the current and potential difference in a circuit to determined the resistance.		I can measure the effect of changing the length of a wire on its resistance in a controlled experiment.		I can investigate a variety of factors that may affect the resistance of a metal wire, such as the current through it, length, cross-sectional area, and metal used.	
Component characteristics	I can identify the key characteristics of electrical devices.		I can describe the resistance characteristics of a filament lamp.		I can explain the resistance characteristics of a filament lamp in terms of electrons and ion collisions.	
	I can identify components from simple I–V graphs.		I can describe the characteristics of diode and light-emitting diode.		I can determine the resistance of a component based on information extracted from an I–V graph.	
	I can state the operation of a diode in simple terms.		I can investigate the resistance characteristics of a thermistor and a LDR.		I can compare the characteristics of a variety of electrical components, describing how the components can be used.	
Series circuits	I can state that the current in any part of a series circuit is the same.		I can find the potential difference across a component in a circuit by using the p.d. rule.		I can explain, in detail, why the current in a series circuit is the same at all points by using the concept of conservation of charge (electrons).	
	I can calculate the potential difference provided by cell combinations.		I can calculate the current in a series circuit containing more than one resistor.		I can analyse a variety of series circuit to determine the current through, p.d. across, and resistance of combinations of components.	
	I can calculate the total resistance of two resistors placed in series.		I can investigate the resistance of series circuits with several components.		I can evaluate in detail the investigation of series circuits and explain discrepancies.	

P4 Electric circuits – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Parallel circuits	I can identify parallel sections in circuit diagrams.		I can measure the p.d. across parallel circuits and explain any discrepancies.		I can analyse parallel circuits in terms of current loops.	
	I can state the effect of adding resistors in parallel on the size of the current in a circuit.		I can describe the effect on the resistance in a circuit of adding a resistor in parallel.		I can calculate the current at any point in a circuit.	
	I can state that the p.d. across parallel sections of a circuit is the same.		I can investigate the effect of adding resistors in parallel on the size of the current in a circuit.		I can evaluate in detail an investigation into the effect of adding resistors in parallel on a circuit.	

P5 Electricity in the home – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Alternating current	I can state that the UK mains supply is a high-voltage alternating current supply.		I can describe the characteristics of the UK mains supply.		I can explain the process of half-wave rectification of an a.c. source.	
	I can state simple differences between a.c. and d.c. sources.		I can compare a.c. traces in terms of period and amplitude (voltage).		I can analyse a.c. traces with an oscilloscope to determine the voltage and frequency.	
	I can describe how the trace on an oscilloscope changes when the frequency or amplitude of the signal is changed.		I can operate a cathode ray oscilloscope to display an a.c. trace.		I can compare and contrast the behaviour of electrons in a wire connected to d.c. and a.c. supplies.	
Cables and plugs	I can identify the live, neutral, and earth wires in a three-pin plug.		I can discuss the choices of materials used in cables and plugs in terms of their physical and electrical properties.		I can explain why it is not necessary for some appliances to be earthed.	
	I can identify the key components of a typical three-pin plug and socket.		I can describe why a short circuit inside a device presents a hazard.		I can explain when there will be a current in the live, neutral, and earth wires of an appliance.	
	I can identify simple and obvious hazards in electrical wiring.		I can identify a variety of electrical hazards associated with plugs and sockets.		I can discuss in detail the hazards associated with poor electrical wiring.	
Electrical power and potential difference	I can state that the power of a device is the amount of energy transferred by it each second.		I can calculate the power of systems.		I can measure and compare the power of electrical devices and explain variations in readings.	
	I can describe the factors that affect the rate of energy transfer by a current in a circuit.		I can calculate the power of electrical devices.		I can calculate the electrical heating caused by resistance.	
	I can explain why different fuses are required electrical devices in simple terms.		I can select an appropriate fuse for a device.		I can combine a variety of calculations to analyse electrical systems.	
Electrical currents and energy transfer	I can state that an electric current consists of a flow of charge (electrons in a wire).		I can calculate the charge transferred by a current in a given time.		I can perform calculations involving rearrangement of the equations $Q = It$ and $E = VQ$.	
	I can identify the factors that affect the energy transfers in a circuit.		I can calculate the energy transferred by a charge passing through a potential difference.		I can explain how energy is conserved in terms of current and p.d. during energy transfers by an electric current.	
	I can state that a battery or power supply provides energy to a current whereas a resistor causes a transfer of energy to the surroundings.		I can apply the law of conservation of energy in a circuit.		I can use algebra to combine the equations $Q = It$ and $E = VQ$ to form the relationships $E = VIt$ and $P = IV$.	

P5 Electricity in the home – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Appliances and efficiency	I can describe the factors that affect the cost of using various electrical devices.		I can calculate energy transfer in kilowatt-hours.		I can convert between relevant units during calculations of energy transfer.	
	I can calculate energy transfer in joule.		I can convert between efficiencies stated in percentages and those stated in decimal forms.		I can analyse the use of a variety of electrical devices to determine their costs of operation.	
	I can state that energy transfer can be measured in kilowatt-hours.		I can calculate the power rating of a device from the energy transferred and the time of operation.		I can compare a range of electrical devices in terms of efficiency using calculations to support any conclusions.	

P6 Molecules and matter – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Density	I can describe density as a property of a material and not a particular object.		I can explain why some materials will float on water.		I can use the density equation in a wide variety of calculations.	
	I can state that the density of a material is the mass per unit volume.		I can calculate the density of materials.		I can use appropriate significant figures in final answers when measuring density.	
	I can calculate the volume of some regular shapes and the density of materials, with support.		I can measure the density of a solid and a liquid.		I can evaluate in detail the experimental measurement of density, accounting for errors in measurements.	
States of matter	I can describe the simple properties of solids, liquids and gases.		I can describe the arrangement of the particles in a solid, liquid, and gas.		I can describe the forces acting between particles in a solid, liquid, and gas.	
	I can name the changes of state.		I can explain the behaviour of a material in terms of the arrangement of particles within it.		I can describe the changes in the energy of individual particles during changes of state.	
	I can state that there are changes in stores of energy associated with a material when its temperature is increased.		I can describe the changes in behaviour of the particles in a material during changes of state.		I can explain in detail why the density of a material changes during a change of state, using a particle model.	
Changes of state	I can state that the melting point of a substance is a temperature at which it changes from a solid to a liquid and vice versa.		I can state that the melting and boiling points of a pure substance are fixed.		I can describe how the melting and boiling points of a substance can be changed.	
	I can state that the boiling point of a substance is the temperature at which it changes from a liquid to a gas and vice versa.		I can use the term 'latent heat' to describe the energy gained by a substance during heating for which there is no change in temperature.		I can describe in detail the behaviour of the particles during changes of state.	
	I can describe the process of melting and boiling.		I can find the melting or boiling point of a substance by using a graphical technique.		I can evaluate data produced by a heating experiment to discuss the reproducibility of the measurement of a melting point.	
Internal energy	I can state that the internal energy of a system increases as it is heated.		I can describe how the internal energy of an object can be increased by heating.		I can use the concepts of kinetic and potential energy to explain changes in internal energy.	
	I can identify which changes of state are related to increases in internal energy and which are related to decreases.		I can describe how the behaviour of particles changes as the energy of a system increases.		I can describe the changes in the size of intermolecular forces during changes of state.	
	I can outline the behaviour of particles in solids, liquids, and gases.		I can describe the energy changes by heating between objects within the same system.		I can explain in detail why the pressure of a gas increases as it is heated.	

P6 Molecules and matter – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Specific latent heat	I can state that heating a material will increase its internal energy.		I can describe the changes in particle bonding during changes of state.		I can perform a variety of calculations based on the latent heat equation.	
	I can describe energy changes during melting and vaporisation.		I can calculate the latent heat of fusion and latent heat of vaporisation for a substance.		I can combine variety of equations to solve problems involving heating.	
	I can measure the latent heat of vaporisation for water.		I can measure the latent heat of fusion for water.		I can evaluate the reproducibility of a measurement of latent heat based on collated data.	
Gas pressure and temperature	I can state that as the temperature of a gas in a sealed container increases, the pressure of the gas increases.		I can describe the behaviour of particles in a gas as the gas is heated.		I can describe the linear relationship between changes in temperatures and pressure for a gas.	
	I can describe a gas as consisting of a large number of rapidly moving particles.		I can outline Brownian motion and how this provides evidence for the particle nature of matter.		I can explain Brownian motion in terms of particle behaviour and collisions, relating the speeds of smoke particles and air molecules.	
	I can describe pressure as being caused by collisions of gas particles with the walls of its container.		I can describe the relationship between an increase in the temperature of a fixed volume of a gas and the increase in pressure of the gas.		I can describe in detail how the relationship between the pressure of a gas and its temperature can be investigated.	

P7 Radioactivity – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Atoms and radiation	I can name the three types of nuclear radiation.		I can describe some safety precautions used when dealing with radioactive materials.		I can describe in detail the decay of an unstable nucleus.	
	I can name the three sub-atomic particles found in an atom (proton, neutron, and electron).		I can describe how a Geiger counter can be used to detect radiation.		I can explain the similarities and differences between nuclear radiation and visible light.	
	I can identify some sources of background radiation.		I can identify natural and man-made sources of background radiation.		I can describe the relative penetrating powers of the three types of nuclear radiation.	
The discovery of the nucleus	I can identify the Rutherford (nuclear) model of an atom.		I can describe he plum pudding model of the atom.		I can compare the plum pudding model, Rutherford model, and Bohr model of the atom in terms of the evidence for each model.	
	I can identify the locations of protons, neutrons, and electrons in the nuclear model.		I can describe the evidence provided by the Rutherford scattering experiment.		I can explain how Rutherford and Marsden's experiment caused a rejection of the plum pudding model.	
	I can state that electrons can move between fixed energy levels within an atom.		I can describe the properties of protons, neutrons, and electrons.		I can describe how the initial evidence for the nuclear model was processed and how the model came to be accepted.	
Changes in the nucleus	I can identify the mass and atomic number by using nuclear notation.		I can calculate the number of neutrons in an isotope by using nuclear notation.		I can explain why particles are ejected from the nucleus during nuclear decay.	
	I can identify the type of decay taking place from a nuclear equation.		I can describe the differences between isotopes.		I can describe the changes in the nucleus that occur during nuclear decay.	
	I can describe how isotopes are atoms of the same element with different mass numbers.		I can complete decay equations for alpha and beta decay.		I can write full decay equations for example nuclear decays.	
More about alpha, beta, and gamma radiation	I can rank the three types of nuclear radiation in order of their penetrating power.		I can describe how the penetrating powers of radiation can be measured.		I can describe in detail how the thickness of a material being manufactured can be monitored by using a beta source.	
	I can rank the three types of nuclear radiation in order of their range through air.		I can describe the path of radiation types through a magnetic field.		I can compare the ionisation caused by different types of nuclear radiation.	
	I can state that all three types of nuclear radiation are ionising.		I can describe the process of ionisation.		I can evaluate in some detail the risks caused by alpha radiation inside and outside the human body.	

P7 Radioactivity – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Activity and half-life	I can state that the activity of a radioactive sample will fall over time.		I can find the ratio of a sample remaining after a given number of half-lives.		I can compare a physical model of decay with the decay of nuclei, noting the limitations of the model.	
	I can define half-life in simple terms such as 'the time it takes for half of the material to decay'.		I can state that all atoms of a particular isotope have an identical chance to decay in a fixed time.		I can outline how the age of organic material can be determined by using radioactive dating.	
	I can find the half-life of a substance from a graph of count rate (or nuclei remaining) against time with support.		I can plot a graph showing the decay of a sample and use it to determine half-life.		I can calculate the changes in count rate or nuclei remaining by using an exponential decay function.	

Chapter 4: Electric circuits

Knowledge organiser

Electric current

Electric current is when **charge** flows. The charge in an electric circuit is carried by electrons.

The unit of current is the ampere (amp, A).

1 ampere = 1 coulomb of charge flow per second

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

In circuit diagrams, current flows from the positive terminal of a cell or battery to the negative terminal. This is known as conventional current.

In a single closed loop, the current has the same value at any point in the circuit.

Metals are good conductors of electricity because they contain delocalised electrons, which are free to flow through the structure.

Potential difference

Potential difference (p.d.) is a measure of how much energy is transferred between two points in a circuit. The unit of potential difference is the volt (V).

- The p.d. across a component is the work done on it by each coulomb of charge that passes through it.
- The p.d. across a power supply or battery is the energy transferred to each coulomb of charge that passes through it.

For electrical charge to flow through a circuit there must be a source of potential difference.

Potential difference (V) = energy transferred (J)/ charge (C)

Charge

An atom has no charge because it has equal numbers of positive protons and negative electrons.

When electrons are removed from an atom it becomes *positively* charged. When electrons are added to an atom it becomes *negatively* charged.

Key terms

Make sure you can write a definition for these key terms.

ampere charge coulomb current electrostatic force LDR parallel potential difference resistance series thermistor

Resistance

When electrons move through a circuit, they collide with the ions and atoms of the wires and components in the circuit. This causes **resistance** to the flow of charge.

The unit of resistance is the ohm (Ω).

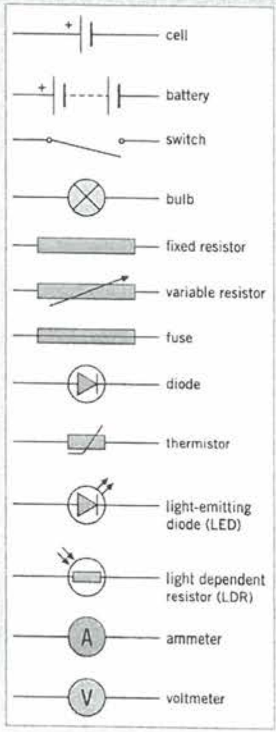
A long wire has more resistance than a short wire because electrons collide with more ions as they pass through a longer wire.

The resistance of an electrical component can be found by measuring the current and potential difference:

potential difference (V) = current (A) × resistance (Ω)

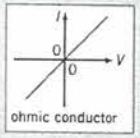
$V = IR$

Circuit components

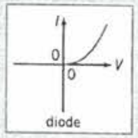


Current-potential difference graphs

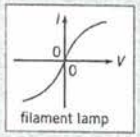
A graph of current through a component against the p.d. across it (I–V graph), is known as the component characteristic.



Current is directly proportional to the p.d. in an ohmic conductor at a constant temperature. The resistance is constant.



The current through a diode only flows in one direction – called the forward direction. There needs to be a minimum voltage before any current will flow.



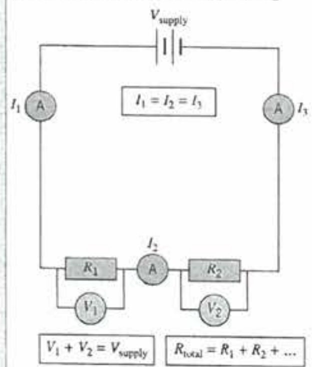
As more current flows through the filament, its temperature increases. The atoms in the wire vibrate more, and collide more often with electrons flowing through it, so resistance increases as temperature increases. The resistance of a thermistor decreases and temperature increases. The resistance of a light dependent resistor (LDR) decreases as light intensity increases.

The resistance of an ohmic conductor can be found by calculating the gradient at that point and taking the inverse:

$$\text{resistance} = \frac{1}{\text{gradient}}$$

Series circuits

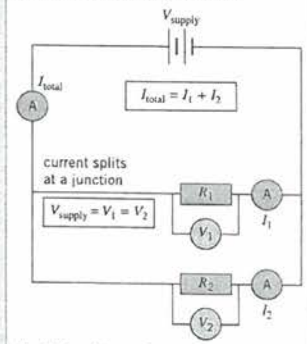
In a series circuit, the components are connected one after the other in a single loop. If one component in a series circuit stops working the whole circuit will stop working.



Components with a higher resistance will transfer a larger share of the total p.d. because $V = IR$ (and current is the same through all components).

Parallel circuits

A parallel circuit is made up of two or more loops through which current can flow. If one branch of a parallel circuit stops working, the other branches will not be affected.



The total resistance of two or more components in parallel is always less than the smallest resistance of any branch. This is because adding a loop to the circuit provides another route for the current to flow, so more current can flow in total even though the p.d. has not changed. Adding more resistors in parallel decreases the total resistance of a circuit.

Chapter 4: Electric circuits

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P4 questions	Answers
1	What is electric current?	rate of flow of charge
2	What units are charge, current, and time measured in?	coulombs (C), amperes (A), seconds (s) respectively
3	What is the same at all points when charge flows in a closed loop?	current
4	What must there be in a closed circuit so that electrical charge can flow?	source of potential difference (p.d.)
5	Which two factors does current depend on and what are their units?	resistance in ohms (Ω), p.d. in volts (V)
6	What happens to the current if the resistance is increased but the p.d. stays the same?	current decreases
7	What is an ohmic conductor?	conductor where current is directly proportional to the voltage so resistance is constant (at constant temperature)
8	What happens to the resistance of a filament lamp as its temperature increases?	resistance increases
9	What happens to the resistance of a thermistor as its temperature increases?	resistance decreases
10	What happens to the resistance of a light-dependent resistor when light intensity increases?	resistance decreases
11	What are the main features of a series circuit?	same current through each component, total p.d. of power supply is shared between components, total resistance of all components is the sum of the resistance of each component
12	What are the main features of a parallel circuit?	p.d. across each branch is the same, total current through circuit is the sum of the currents in each branch – total resistance of all resistors is less than the resistance of the smallest individual resistor

Chapter 5: Electricity in the home

Knowledge organiser

Mains electricity

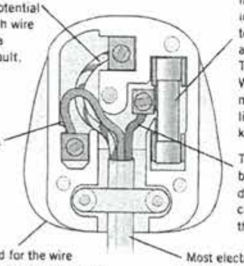
A cell or a battery provides a **direct current (dc)**. The current only flows in one direction and is produced by a **direct potential difference**.

Mains electricity provides an **alternating current (ac)**. The current repeatedly reverses direction and is produced by an **alternating potential difference**.

The positive and negative terminals of an alternating power supply swap over with a regular frequency.

The frequency of the mains electricity supply in the UK is 50 Hz and its voltage is 230 V.

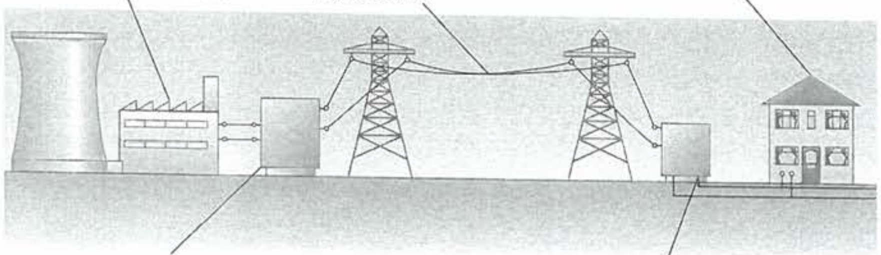
Plugs



The National Grid

The **National Grid** is a nationwide network of cables and transformers that link power stations to homes, offices, and other consumers of mains electricity.

Transformers are devices that can change the potential difference of an alternating current.



By making the grid potential difference much higher, a smaller current is needed to transfer the same power. Therefore, the National Grid is an efficient way to transfer power due to less heating loss in the wire.

Why do transformers improve efficiency?

A high potential difference across the transmission cables means that a lower current is needed to transfer the same amount of power, since:

power (W) = current (A) × potential difference (V)

$$P = IV$$ (L)

A lower current in the cables means less electrical power is wasted due to heating of the cables, since the power lost in heating a cable is:

power (W) = current² (A) × resistance (Ω)

$$P = I^2R$$ (L)

This makes the National Grid an efficient way to transfer energy.

If 100% efficiency is assumed:

primary potential difference × primary current = secondary potential difference × secondary current

$$V_pI_p = V_sI_s$$

Energy transfer in electrical appliances

Electrical appliances transfer energy.

For example, an hairdryer transfers energy electrically from a chemical store (e.g., the fuel in a power station) to the kinetic energy store of the fan inside the hairdryer and to the thermal energy store of the heating filaments inside the hairdryer.

When you turn an electrical appliance on, the potential difference of the mains supply causes charge (carried by electrons) to flow through it.

You can calculate the **charge flow** using the equation:

(L) charge flow (C) = current (A) × time (s)

$$Q = It$$

You can find the energy transferred to an electrical appliance when charge flows through it using:

(L) energy transferred (J) = charge flow (C) × potential difference (V)

$$E = QV$$

You can find the energy transferred by an electrical appliance using the equation:

(L) energy transferred (J) = power (W) × time (s)

Key terms

Make sure you can write a definition for these key terms.

alternating current, fuse, alternating potential difference, National Grid, charge flow, short circuit, coulombs, step-down transformer, direct current, step-up transformer, direct potential difference

Chapter 5: Electricity in the home

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P5 questions		Answers
1	Why is the current provided by a cell called a direct current (d.c.)?	Put paper here	only flows in one direction
2	What is an alternating current (a.c.)?		current that repeatedly reverses direction
3	What kind of current is supplied by mains electricity?	Put paper here	alternating current
4	What is the frequency and voltage of mains electricity?		50 Hz, 230 V
5	What colours are the live, neutral, and earth wires in a three-core cable?	Put paper here	live = brown, neutral = blue, earth = green and yellow stripes
6	What is the function of the live wire in a three-core cable?		carries the alternating potential difference from the supply
7	What is the function of the neutral wire in a three-core cable?	Put paper here	completes the circuit
8	What is the function of the earth wire in a three-core cable?		safety wire to stop the appliance becoming live
9	When is there a current in the earth wire?	Put paper here	when there is a fault
10	Why is the live wire dangerous?		provides a large p.d. that would cause a large current to flow through a person if they touched it
11	What is the National Grid?	Put paper here	nationwide network of cables and transformers that link power stations to customers
12	What are step-up transformers used for in the National Grid?		increase the p.d. from the power station to the transmission cables
13	What are step-down transformers used for in the National Grid?	Put paper here	decrease the p.d. from the transmission cables to the mains supply in buildings so that it is safe to use
14	How does having a large potential difference in the transmission cables help to make the National Grid an efficient way to transfer energy?		large p.d. means a small current is needed to transfer the same amount of power, small current in the transmission cables means less electrical power is wasted due to heating
15	What two things does energy transfer to an appliance depend on?	Put paper here	power of appliance, time it is switched on for
16	What are the units for power, current, potential difference, and resistance?		watts (W), amps (A), volts (V), ohms (Ω)

Chapter 6: Molecules and matter

Knowledge organiser

Changes of state

Changes of state and conservation of mass

Changes of state are physical changes because no new substances are produced. The mass always stays the same because the number of particles does not change.

Particles and kinetic energy

When the temperature of a substance is increased, the kinetic energy store of its particles increases and the particles vibrate or move faster.

If the kinetic store of a substance's particles increases or decreases enough, the substance may change state.

Density

You can calculate the density of an object if you know its mass and volume:

$$\text{density (kg/m}^3) = \frac{\text{mass (kg)}}{\text{volume (m}^3)}$$

$$\rho = \frac{m}{V}$$ (L)

Internal energy

Heating a substance increases its **internal energy**.

Internal energy is the sum of the total kinetic energy the particles have due to their motion and the total potential energy the particles have due to their positions relative to each other.

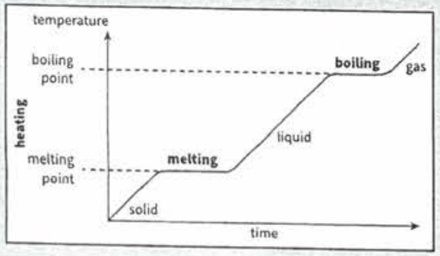
States of matter

Gas	**Arrangement**	• particles are spread out • almost no forces of attraction between particles • large distance between particles on average
	Movement	• particles move randomly at high speed
	Properties	• low density • no fixed volume or shape • can be compressed and can flow • spread out to fill all available space
Liquid	**Arrangement**	• particles are in contact with each other • forces of attraction between particles are weaker than in solids
	Movement	• particles are free to move randomly around each other
	Properties	• usually lower density than solids • fixed volume • shape is not fixed so they can flow
Solid	**Arrangement**	• particles held next to each other in fixed positions by strong forces of attraction
	Movement	• particles vibrate about fixed positions
	Properties	• high density • fixed volume • fixed shape (unless deformed by an external force)

Latent heat

In a graph showing the change in temperature of a substance being heated or cooled, the flat horizontal sections show when the substance is changing state.

The energy transfers taking place during a change in state do not cause a change in temperature, but do change the internal energy of the substance.



The energy transferred when a substance changes state is called the **latent heat**.

Specific latent heat – the energy required to change 1 kg of a substance with no change in temperature.

Specific latent heat of fusion – the energy required to melt 1 kg of a substance with no change in temperature.

Specific latent heat of vaporisation – the energy required to evaporate 1 kg of a substance with no change in temperature.

The energy needed to change the state of a substance can be calculated using the equation:

$$\text{thermal energy for a change in state (J)} = \text{mass (kg)} \times \text{specific latent heat (J/kg)}$$

$$E = m \times l$$

The relationship between temperature and pressure in gases

Gas temperature

The particles in a gas are constantly moving in random directions and with random speeds.

The temperature of a gas is related to the average kinetic energy of its particles.

When a gas is heated, the particles gain kinetic energy and move faster, so the temperature of the gas increases.

Gas pressure

The pressure a gas exerts on a surface, such as the walls of a container, is caused by the force of the gas particles hitting the surface.

The pressure of a gas produces a net force at right angles to the walls of a container or any surface.

If the temperature of a gas in a sealed container is increased, the pressure increases because

- the particles move faster so they hit the surfaces with more force
- the number of these impacts per second increases, exerting more force overall.

If a gas is compressed quickly, for example, in a bicycle pump, its temperature can rise. This is because

- compressing the gas requires a force to be applied to the gas – this results in work being done to the gas, since work done = force × distance
- the energy gained by the gas is not transferred quickly enough to its surroundings.

Key terms

Write a definition for these key terms.

boiling   condensation   conservation of mass   density   evaporation   freezing   fusion   internal energy   latent heat   melting   specific latent heat   sublimation   vaporisation

Chapter 6: Molecules and matter
Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P6 questions		Answers
1	Which two quantities do you need to measure to find the density of a solid or liquid?	Put paper here	mass and volume
2	What happens to the particles in a substance if its temperature is increased?		they move faster and the energy in their kinetic energy store increases
3	Why are changes of state physical changes?	Put paper here	no new substances are produced and the substance will have the same properties as before if the change is reversed
4	Why is the mass of a substance conserved when it changes state?		the number of particles does not change
5	What is the internal energy of a substance?	Put paper here	the total kinetic energy and potential energy of all the particles in the substance
6	Why does a graph showing the change in temperature as a substance cools have a flat section when the substance is changing state?		the energy transferred during a change in state causes a change in the internal energy of the substance
7	What is the name given to the energy transferred when a substance changes state?	Put paper here	latent heat
8	What is the specific latent heat of a substance?		the energy required to change the state of one kilogram of that substance with no change in temperature
9	What is the specific latent heat of fusion a substance?	Put paper here	the energy required to change one kilogram of the substance from solid to liquid at its melting point, without changing its temperature
10	What is the specific latent heat of vaporisation of a substance?		the energy required to change one kilogram of the substance from liquid to vapour at its boiling point, without changing its temperature
11	On a graph of temperature against time for a substance being heated up or cooled down, what do the flat (horizontal) sections show?	Put paper here	the time when the substance is changing state and the temperature is not changing
12	What property of a gas is related to the average kinetic energy of its particles?		temperature

Chapter 7: Radioactivity

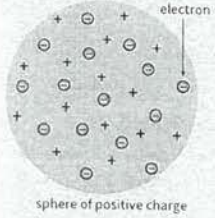
Knowledge organiser

Dalton's model

John Dalton thought the atom was a neutral solid sphere you cannot divide into smaller parts.

Plum pudding model

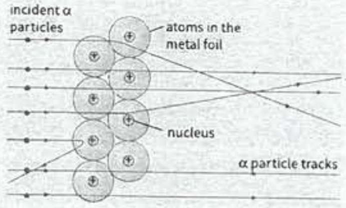
The discovery of negatively charged electrons led to the plum pudding model – a cloud of positive charge with electrons embedded in it.



Alpha scattering experiment

Positively charged alpha particles were fired at a thin sheet of gold foil.

- Most went straight through
- Some were deflected by small amounts
- 1 in 10 0000 deflected through large angles



Nuclear model

To explain the results, scientists deduced that there is a small positively charged nucleus at the centre of the atom where most of the mass is concentrated. The negative electrons orbit the nucleus.

Bohr's model

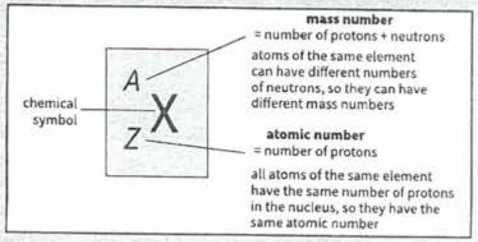
Bohr suggested the electrons orbit at specific distances called energy levels.

Basic structure of an atom

The nucleus, which is 10 000 times smaller than the radius of the atom, consists of two particles:

- positively charged protons
- neutrons which are neutral

An atom is uncharged overall and has equal numbers of protons and electrons.



Isotopes are atoms of the same element, with the same number of protons but a different numbers of neutrons.

Radioactive decay

Radioactive decay is when nuclear radiation is emitted by unstable atomic nuclei so that they become more stable. It is a *random* process. This radiation can knock electrons out of atoms in a process called **ionisation**.

Type of radiation	Change in the nucleus	Ionising power	Range in air	Stopped by	Decay equation
α alpha particle (two protons and two neutrons)	nucleus loses two protons and two neutrons	highest ionising power	travels a few centimetres in air	stopped by a sheet of paper	${}^{A}_{Z}X \rightarrow {}^{(A-4)}_{(Z-2)}Y + {}^{4}_{2}\alpha$
β beta particle (fast-moving electron)	a neutron changes into a proton and an electron	high ionising power	travels ≈ 1 m in air	stopped by a few millimeters of aluminium	${}^{A}_{Z}X \rightarrow {}^{A}_{(Z+1)}Y + {}^{0}_{-1}\beta$
γ gamma radiation (short-wavelength, high-frequency EM radiation)	some energy is transferred away from the nucleus	low ionising power	virtually unlimited range in air	stopped by several centimetres of thick lead or metres of concrete	${}^{A}_{Z}X \rightarrow {}^{A}_{Z}X + {}^{0}_{0}\gamma$

Half-life

The **half-life** of a radioactive source is the time

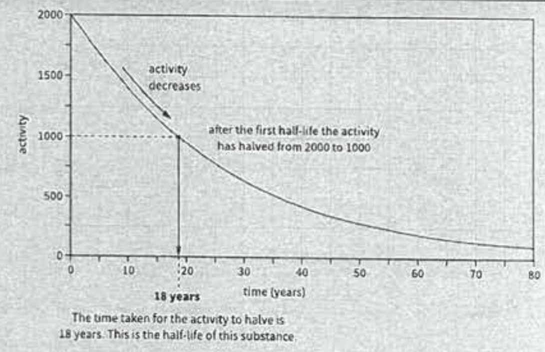
- for half the number of unstable nuclei in a sample to decay
- for the count rate or activity of a source to halve.

The half-life of a source can be found from a graph of its count rate or activity against time.

To find the reduction in activity after a given number of half-lives:

1 calculate the activity after each half-life

2 subtract the final activity from the original activity.



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

(HT only) Net decline can be given as a ratio: net daecline = $\frac{\text{reduction in activity}}{\text{original activity}}$

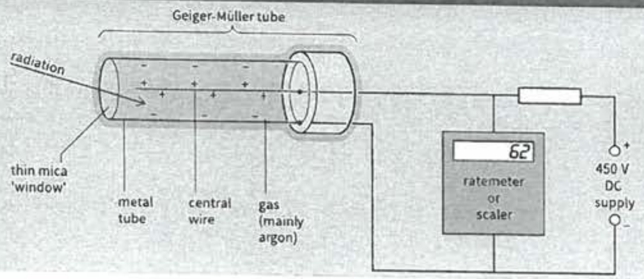
Activity and count rate

The **activity** of a radioactive source is the rate of decay of an unstable nucleus, measured in becquerel (Bq).

1 Bq = 1 *decay per second*

Detectors (e.g., **Geiger-Müller tubes**) record a **count rate** (number of decays detected per second).

count rate after *n* half-lives = $\frac{\text{initial count rate}}{2^n}$



Key terms

Make sure you can write a definition for these key terms.

atom alpha activity atomic number beta count rate electron gamma Geiger-Müller tube half-life ionisation irradiation isotope mass number net decline neutron plum pudding model proton radiation dose radioactive decay

Chapter 7: Radioactivity

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P7 questions	Answers
1	Describe the basic structure of an atom.	nucleus containing protons and neutrons, around which electrons orbit in fixed energy levels/shells
2	Describe the plum pudding model of the atom.	sphere of positive charge with negative electrons embedded in it
3	What charges do protons, neutrons, and electrons carry?	protons = positive, neutrons = no charge, electrons = negative
4	Why do atoms have no overall charge?	equal numbers of positive protons and negative electrons
5	What is the radius of an atom?	around 1×10^{-10} m
6	What is ionisation?	process which adds or removes electrons from an atom
7	What is the mass number of an element?	number of protons + number of neutrons
8	Which particle do atoms of the same element always have the same number of?	protons
9	What are isotopes?	atoms of the same element (same number of protons) with different numbers of neutrons
10	What were the two main conclusions from the alpha particle scattering experiment?	• most of the mass of an atom is concentrated in the nucleus • nucleus is positively charged
11	What are the three types of nuclear radiation?	alpha, beta, and gamma
12	Which type of nuclear radiation is the most ionising?	alpha
13	What is the range in air of alpha, beta, and gamma radiation?	a few cm, 1 m, and unlimited, respectively
14	What are the equation symbols for alpha and beta particles?	${}^{4}_{2}\alpha$ and ${}^{0}_{-1}\beta$
15	What is meant by the half-life of a radioactive source?	time taken for half the unstable nuclei to decay or the time taken for the count rate to halve

Put paper here

Physics Equations Sheet

GCSE Combined Science: Trilogy (8464) and GCSE Combined Science: Synergy (8465)

FOR USE IN JUNE 2025 ONLY

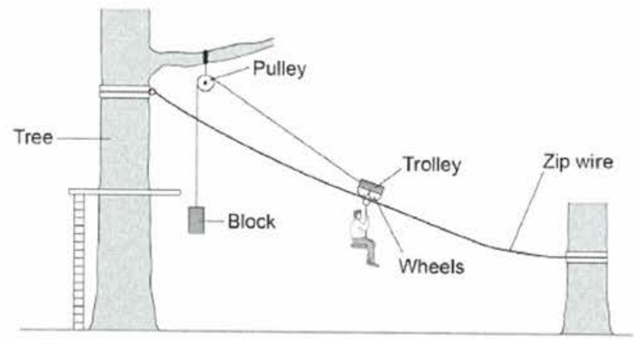
HT = Higher Tier only equations

kinetic energy = 0.5 × mass × (speed)^2	$E_k = \frac{1}{2} m v^2$
elastic potential energy = 0.5 × spring constant × (extension)^2	$E_e = \frac{1}{2} k e^2$
gravitational potential energy = mass × gravitational field strength × height	$E_p = m g h$
change in thermal energy = mass × specific heat capacity × temperature change	$\Delta E = m c \Delta\theta$
power = $\frac{\text{energy transferred}}{\text{time}}$	$P = \frac{E}{t}$
power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$
efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$	
efficiency = $\frac{\text{useful power output}}{\text{total power input}}$	
charge flow = current × time	$Q = I t$
potential difference = current × resistance	$V = I R$
power = potential difference × current	$P = V I$
power = (current)^2 × resistance	$P = I^2 R$
energy transferred = power × time	$E = P t$

	energy transferred = charge flow × potential difference	$E = Q\,V$
HT	**potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil**	$V_p I_p = V_s I_s$
	density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$
	thermal energy for a change of state = mass × specific latent heat	$E = m\,L$
	weight = mass × gravitational field strength	$W = m\,g$
	work done = force × distance (along the line of action of the force)	$W = F\,s$
	force = spring constant × extension	$F = k\,e$
	distance travelled = speed × time	$s = v\,t$
	acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$	$a = \frac{\Delta v}{t}$
	(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance	$v^2 - u^2 = 2\,a\,s$
	resultant force = mass × acceleration	$F = m\,a$
HT	**momentum = mass × velocity**	$p = m\,v$
	period = $\frac{1}{\text{frequency}}$	$T = \frac{1}{f}$
	wave speed = frequency × wavelength	$v = f\,\lambda$
HT	**force on a conductor (at right angles to a magnetic field) carrying a current = magnetic flux density × current × length**	$F = B\,I\,l$

Q1.

The figure below shows a person using a zip wire to move from a tree to the ground.



As the person moves down the zip wire, the block moves upwards.

(a) What happens to the gravitational potential energy of the person as the person accelerates down the zip wire?

Tick (✓) **one** box.

Decreases ☐

Stays the same ☐

Increases ☐

(1)

(b) What happens to the kinetic energy of the person as the person accelerates down the zip wire?

Tick (✓) **one** box.

Decreases ☐

Stays the same ☐

Increases ☐

(1)

(c) The block is 3.4 m above the ground when the person is at the bottom of the zip wire.

mass of block = 2.5 kg

gravitational field strength = 9.8 N/kg

Calculate the gravitational potential energy of the block.

Use the equation:

gravitational potential energy = mass × gravitational field strength × height

____

____

____

Gravitational potential energy = _______________ J

(2)

The trolley is a seat suspended from wheels which can roll along the zip wire.

(d) When the person reaches the end of the zip wire, the person gets off the trolley.

The block falls downwards pulling the trolley back to the top of the zip wire.

maximum speed of block = 4.8 m/s

mass of block = 2.5 kg

Calculate the maximum kinetic energy of the block.

Use the equation:

$$\text{kinetic energy} = 0.5 \times \text{mass} \times (\text{speed})^2$$

____

____

____

Maximum kinetic energy = _______________ J

(2)

(e) As the trolley moves, work is done against friction.

What is the effect of this?

Tick (✓) **one** box.

- Some energy is destroyed. ☐
- Some energy is transferred to the surroundings. ☐
- The total energy of the block and trolley increases. ☐

(1)

(f) The person oils the wheels on the trolley.

Explain how this will affect the speed of the person down the zip wire.

____

____

____

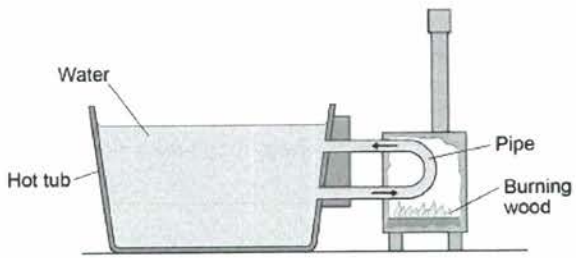
____

(2)

(Total 9 marks)

Q2.

The diagram below shows a wood-fired hot tub.



(a) What type of fuel is wood?

Tick (✓) **one** box.

- A non-renewable biofuel ☐
- A non-renewable fossil fuel ☐
- A renewable biofuel ☐
- A renewable fossil fuel ☐

(1)

(b) Give **two** environmental effects of using wood as an energy resource.

1. ____________________

____

2. ____________________

____

(2)

(c) Describe the change to the stores of energy of the wood, pipe and water as the water is heated.

Wood ____________________
–
____

Pipe ____________________

____

Water ____________________
–
____

(3)

(d) The temperature of the water reaches 42 °C

The temperature then stays constant even though the fire continues to burn.

Explain why the temperature of the water stays constant.

____

____

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____

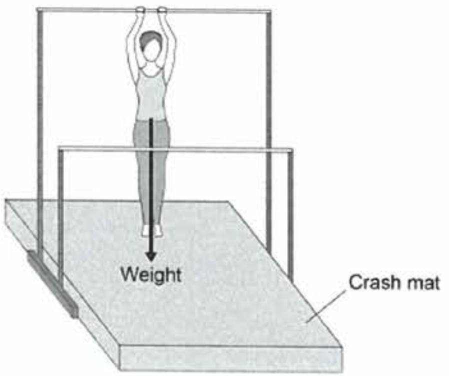
____

(2)
(Total 8 marks)

Q3.

The diagram shows a gymnast on a piece of gymnastic equipment.

The equipment consists of two bars at different heights.



(a) The gymnast exerts a downward force on the bar.

What is the size of the upward force acting on the gymnast from the bar?

Tick (✓) **one** box.

It is greater than the downward force.	☐
It is less than the downward force.	☐
It is the same size as the downward force.	☐

(1)

(b) Why is the weight of the gymnast represented by an arrow?

Tick (✓) **one** box.

Weight is a constant.	☐
Weight is a scalar.	☐
Weight is a unit.	☐
Weight is a vector.	☐

(1)

(c) The diagram above shows the weight of the gymnast acting from a point.

What name is given to this point?

Tick (✓) **one** box.

Centre of force	☐
Centre of mass	☐
Centre of tension	☐
Centre of weight	☐

(1)

(d) The gymnast has a mass of 45 kg

gravitational field strength = 9.8 N/kg

Calculate the weight of the gymnast.

Use the equation:

weight = mass × gravitational field strength

Weight = ____________ N

(2)

(e) The gymnast swings from one bar to the other bar several times.

Describe how the gravitational potential energy store and the kinetic energy store of the gymnast change as she moves between the bars.

(4)

(f) Falling on the crash mat reduces the average deceleration of the gymnast compared with falling on a hard surface.

Explain why reducing the deceleration is important to the gymnast.

(2)

(Total 11 marks)

Q4.

(a) A washing machine washes dirty clothes and then spins the clothes to remove some of the water.

(i) Use the correct words from the box to complete the sentence.

chemical	**electrical**	**kinetic**	**sound**

When the washing machine spins the clothes, ____________

energy is transferred into useful ____________ energy.

(2)

(ii) Name **one** type of energy the washing machine wastes when spinning the clothes.

(1)

(iii) What eventually happens to all the wasted energy?

Tick **one** box.

- The wasted energy is transferred to the clothes. ☐
- The wasted energy is transferred to the surroundings. ☐
- The wasted energy is trapped and is re-used. ☐

(1)

(b) The table shows information about two different washing machines, **A** and **B**.

	Washing machine A	Washing machine B
Cost to buy	£269	£249
Maximum wash load	8 kg	7 kg
Energy transferred in one wash cycle	0.7 kWh	1.2 kWh
Water used in one wash cycle	48 litres	50 litres

Use the information in the table to give **one** advantage and **one** disadvantage of washing machine **A** compared with washing machine **B**.

Advantage ______________________________

____

Disadvantage ______________________________

____

(2)
(Total 6 marks)

Q5.

Figure 1 shows a child's toy.

A child pushes down on the toy to compress the spring. The spring then launches the toy into the air.

Figure 1

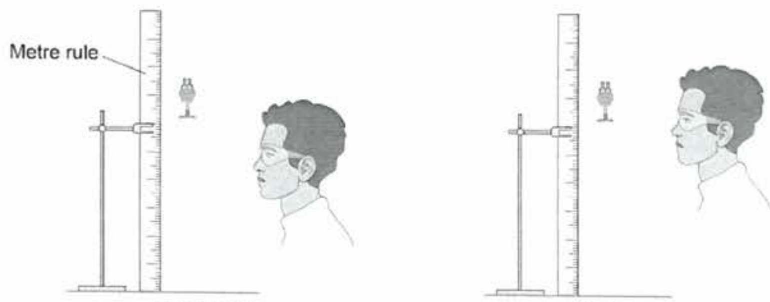
(a) A student measured the maximum height reached by the toy.

The student placed a vertical metre rule near the toy, and observed the height reached by the toy.

The student repeated the experiment, observing from a different position.

Figure 2 shows the toy at its maximum height and the two positions of the student.

Figure 2



Observing the toy from **position B** instead of **position A** affected the measurement of the maximum height reached by the toy.

Explain how.

____

____

____

____

(2)

(b) The greatest height reached by the toy was 64 cm.

The gravitational potential energy of the toy at this height was 0.049 J.

gravitational field strength = 9.8 N/kg

Calculate the mass of the toy.

Use the Physics Equations Sheet.

Give your answer to 2 significant figures.

____

____

____

____

____

____

____

Mass of toy (2 significant figures) = ______________ kg

(5)

(c) When the spring launches the toy into the air, the temperature of the air increases.

Explain why the child's toy on its own is **not** a closed system.

____

____

____

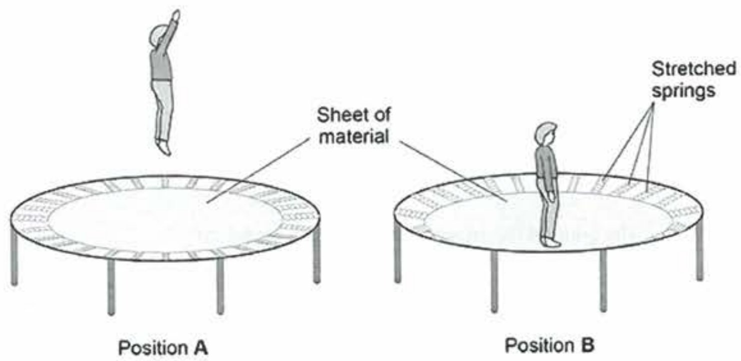
____

(2)
(Total 9 marks)

Q6.

A trampoline is made from a sheet of material held in place by stretched springs.

The figure below shows a child on a trampoline.



(a) Position **A** shows the child's maximum height above the trampoline.

Position **B** shows the lowest position reached by the child when landing on the trampoline.

Describe the changes to the stores of energy of the:

- child
- springs
- surroundings

as the child moves from position **A** to position **B**.

Child ____

–

____

____

____

____

Springs ____

–

____

____

Surroundings ____

–

____

____

(4)

(b) When the child is at position **A**, each trampoline spring is stretched by 0.056 m

The elastic potential energy of each spring is 4.9 J

When the child is at position **B**, the elastic potential energy of each spring increases to 8.1 J

Calculate the extension of each spring when the child is at position **B**.

Use the Physics Equations Sheet.

____

____

____

____

____

____

____

____

____

____

Extension = ______________ m

(5)

(c) As the child bounces on the trampoline the child does work.

What is the work done by the child equal to?

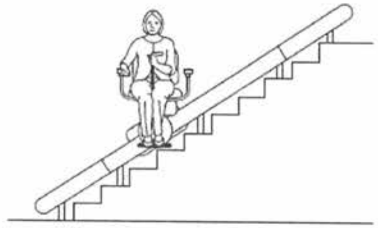
Tick (✓) **one** box.

The average force applied by the child	☐
The maximum force applied by the child	☐
The total energy store of the child	☐
The total energy transferred by the child	☐

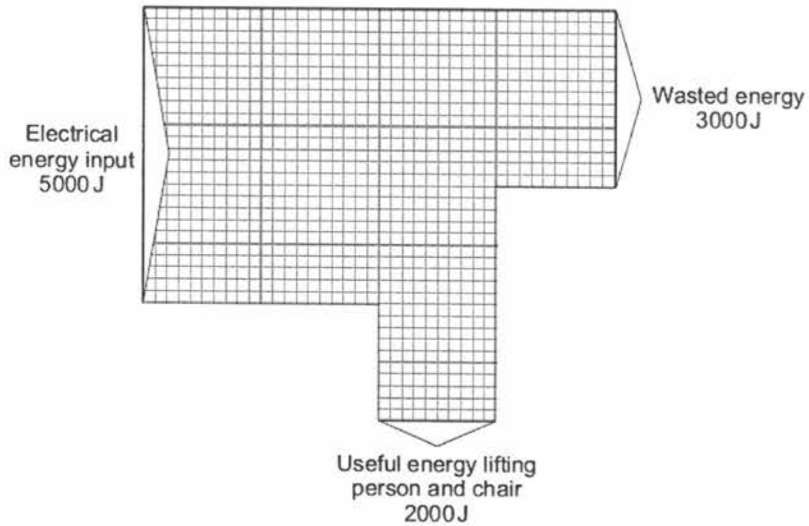
(1)
(Total 10 marks)

Q7.

A person uses a stairlift to go upstairs. The stairlift is powered by an electric motor.



The Sankey diagram shows the energy transfers for the electric motor.



(a) Complete the following sentence.

The electric motor wastes energy as ____________________ energy.

(1)

(b) Use the equation in the box to calculate the efficiency of the electric motor.

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

Show clearly how you work out your answer.

____

____

Efficiency = ____________________

(2)
(Total 3 marks)

Q8.

A student investigated how the area of a solar panel affected the output potential difference of the solar panel.

The student placed different sized solar panels under a lamp.

The photograph shows a solar panel under a lamp.

(a) Which variable should be controlled?

Tick (✓) **one** box.

The area of the solar panels ☐

The brightness of the lamp ☐

The output potential difference of the solar panels ☐

(1)

(b) The student measured the output potential difference using a voltmeter.

When the voltmeter was **not** connected, the reading on the voltmeter was 0.7 V

What name is given to this type of error?

Tick (✓) **one** box.

Zero error ☐

Random error ☐

Measurement error ☐

(1)

The table shows the results of the investigation.

Solar panel	Area of solar panel in cm^2	Output potential difference in volts			
		Test 1	Test 2	Test 3	Mean
A	10	2.5	2.4	2.6	2.5
B	20	5.0	5.0	4.9	5.0
C	30	7.5	11.9	7.5	7.5
D	50	12.4	12.6	12.5	12.5

(c) The readings for which solar panel show an anomalous result?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(d) The student did **not** have a solar panel with an area of 40 cm^2

Determine the most likely value for the mean output potential difference of a 40 cm^2 solar cell.

____

____

Mean output potential difference = ______________ V

(1)

(e) The total input energy transfer to one of the solar panels was 8.0 joules.

The useful output energy transfer was 0.96 joules.

Calculate the efficiency of the solar panel.

Use the equation:

$$\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$$

____

____

____

____

Efficiency = ____________________

(2)

(f) Solar power is a renewable energy resource.

Complete the sentence.

Choose the answer from the box.

burned	**replenished**	**consumed**

A renewable energy resource is one that is ____________________ as it is used.

(1)

(g) Some homes have solar panels which generate electricity.

On a sunny day the potential difference across a solar panel is 31 volts.

A charge of 490 coulombs flows through the solar panel.

Calculate the energy transferred by the solar panel.

Use the equation:

energy transferred = charge flow × potential difference

Give your answer to 2 significant figures.

____

____

____

____

Energy transferred = ____________________ J

(3)

(h) Why do solar panels on homes help reduce the environmental impact of using electrical devices?

Tick (✓) **one** box.

Less electricity is used in the home. ☐

Less fossil fuel is burned. ☐

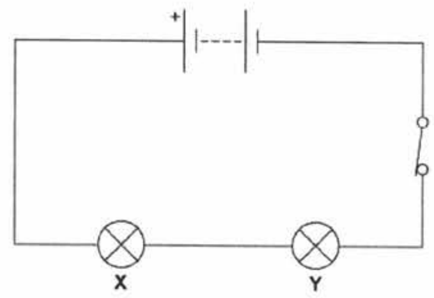
The electricity from the solar panels is cheaper. ☐

(1)

(Total 11 marks)

Q9.

The figure below shows a circuit diagram. The circuit contains a battery and two lamps, **X** and **Y**.



(a) How does the current in lamp **X** compare with the current in lamp **Y**?

Tick (✓) **one** box.

The current in lamp **X** is smaller. ☐

The current in both lamps is the same. ☐

The current in lamp **X** is greater. ☐

(1)

(b) Lamp **X** and lamp **Y** are **not** identical.

The potential difference across the battery is 4.5 V.

The potential difference across lamp **X** is 1.5 V.

Calculate the potential difference across lamp **Y**.

____

____

Potential difference across lamp **Y** = ____________________ V

(1)

The current in lamp **X** is 1.2 A.

The potential difference across lamp **X** is 1.5 V.

(c) Calculate the power of lamp **X**.

Use the equation:

power = potential difference × current

Power = ____________ W

(2)

(d) Calculate the resistance of lamp **X**.

Use the equation:

$$\text{resistance} = \frac{\text{potential difference}}{\text{current}}$$

Resistance = ____________ Ω

(2)

(e) The current in lamp **X** is 1.2 A.

Calculate the charge flow through lamp **X** in 40 seconds.

Use the equation:

charge flow = current × time

Charge flow = ____________ C

(2)

(f) The switch can be used to turn the lamps on and off.

Immediately after the lamps are switched on, the resistance of each lamp increases.

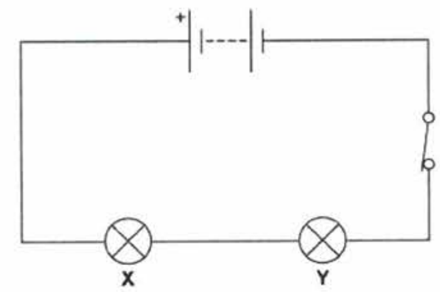
Why does the resistance of each lamp increase?

Tick (✓) **one** box.

- [ ] The current in the battery decreases.
- [ ] The potential difference across each lamp decreases.
- [ ] The power of the battery increases.
- [ ] The temperature of each lamp increases.

(1)

The figure above is repeated below.



(g) Lamp **Y** breaks.

What happens to lamp **X**?

Give a reason for your answer.

Tick (✓) **one** box.

- [ ] Lamp **X** gets brighter.
- [ ] Lamp **X** stays the same brightness.
- [ ] Lamp **X** no longer emits light.

Reason ______________________________

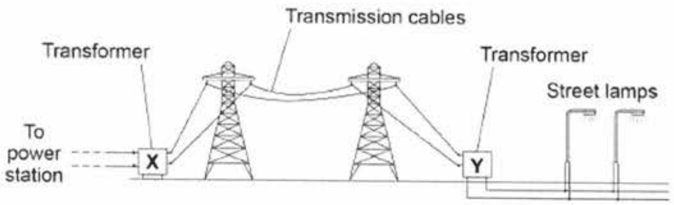
____

(2)
(Total 11 marks)

Q10.

Figure 1 shows how the National Grid transfers energy from a power station to some street lamps.

Figure 1



(a) Explain how transformer **X** increases the efficiency of the National Grid.

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(3)

(b) The potential difference across the primary coil in transformer **Y** is 400 000 V.

The potential difference across the secondary coil is 11 000 V.

The current in the primary coil is 660 A.

Calculate the current in the secondary coil of transformer **Y**.

Use the Physics Equations Sheet.

____

____

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____

____

Current in the secondary coil = ______________ A

(3)

(c) Why is the current in each street lamp less than the current in the secondary coil in transformer **Y**?

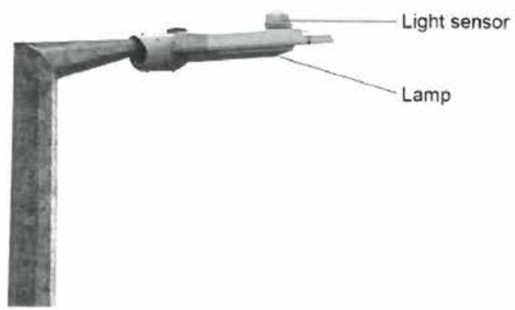
Tick (✓) **one** box.

Current is used up in the cables between **Y** and each street lamp.	☐
Some of the current is dissipated to the surroundings.	☐
The cables between **Y** and the street lamps have electrical resistance.	☐
The street lamps are connected in parallel.	☐

(1)

(d) **Figure 2** shows the top of a street lamp.

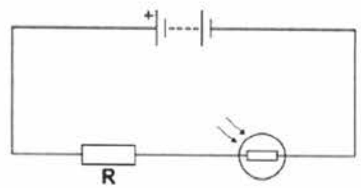
Figure 2



The light sensor detects if it is day or night.

Figure 3 shows part of the circuit in the light sensor.

Figure 3



Explain what happens to the potential difference across resistor **R** as the light intensity decreases.

____

____

____

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(3)

(e) When the current in resistor **R** is 20 mA, the power transferred by resistor **R** is 6.0 W.

Calculate the resistance of resistor **R**.

Use the Physics Equations Sheet.

____

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____

Resistance = ____________________ Ω

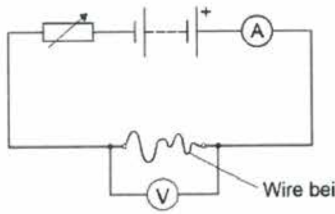
(4)

(Total 14 marks)

Q11.

A student investigated how the resistance of a piece of wire varies with its length.

(a) The diagram below shows the circuit used.



Explain why the student needed to adjust the variable resistor each time she changed the length of the wire.

____

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(3)

(b) The student recorded three measurements of the potential difference across a 0.10 m length of wire.

The table below shows the results.

Length in m	**Potential difference in V**			
	1	2	3	Mean
0.10	**X**	0.18	0.15	0.17

Calculate **X** in table above.

____

____

____

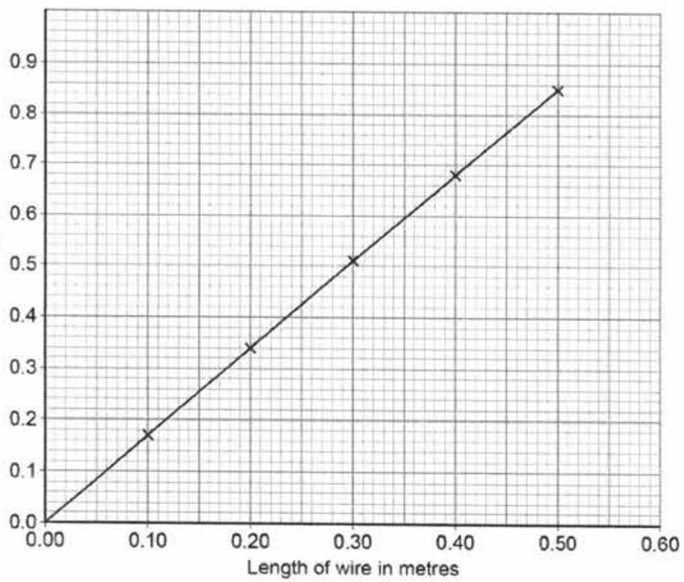
____

X = ____________________ V

(2)

(c) **Figure 1** shows the results for five different lengths of the wire.

Figure 1



Describe the relationship between the length of the wire and the resistance of the wire.

____

____

____

____

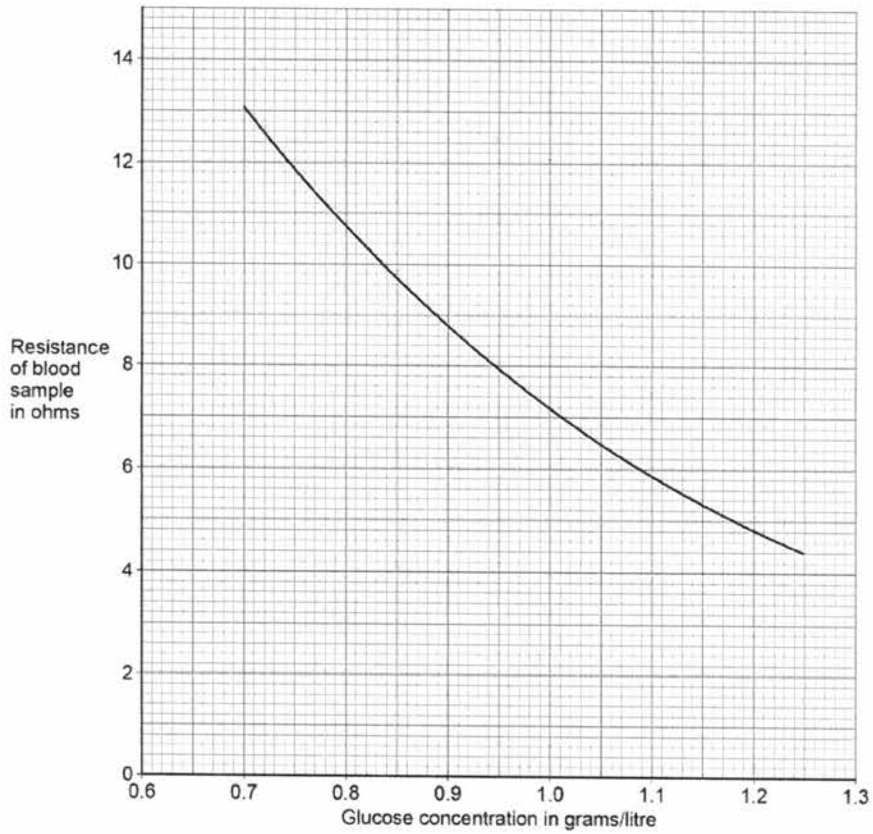
(2)

A glucometer uses the resistance of a blood sample to calculate the glucose concentration in a person's blood.

A blood sample is put into a small tube, which is put inside the glucometer. The blood then acts like a resistance wire.

Figure 2 shows the relationship between the resistance of a blood sample and the glucose concentration.

Figure 2



(d) The glucometer applies a potential difference of 0.90 volts across a blood sample.

The glucose concentration of the blood sample is 0.98 grams/litre.

Determine the current in the blood sample.

____

____

____

____

____

____

____

Current = ______________ A

(4)

(e) A new tube is used each time a blood sample is tested.

Explain why valid results are only obtained if each tube is identical.

____

____

____

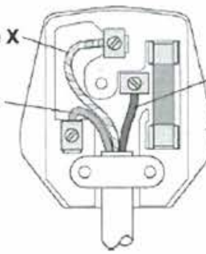
____

(2)
(Total 13 marks)

Q12.

Figure 1 shows a three pin plug connected to the cable of a metal toaster.

Figure 1



(a) Name wire **X**.

____

(1)

(b) What does wire **X** do?

Tick **one** box.

It provides extra energy to the toaster when needed.	☐
It completes the circuit in the toaster.	☐
It can prevent an electric shock from the toaster.	☐
It supplies the current to the toaster.	☐

(1)

(c) The toaster is plugged in to the mains electricity supply.

What is the potential difference between the live and neutral wires?

Tick **one** box.

0 V ☐ 120 V ☐ 230 V ☐ 460 V ☐

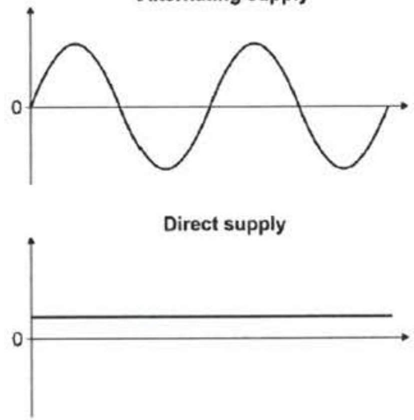
(1)

(d) Mains electricity is an alternating supply.

A battery is a direct supply.

Figure 2 shows an alternating supply and a direct supply.

Figure 2



Give **two** differences between the alternating supply and the direct supply.

1. ______________________________

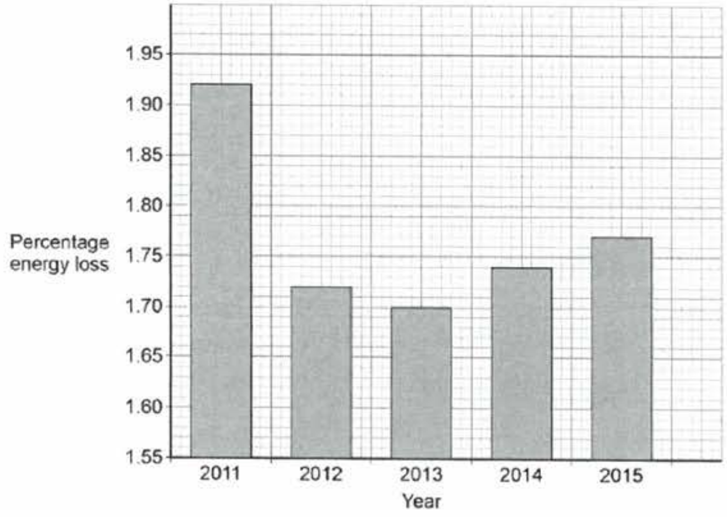
2. ______________________________

(2)

Energy is transferred to homes by the National Grid.

Figure 3 shows the percentage energy losses over the National Grid for different years.

Figure 3



(e) Describe the changes in percentage energy loss.

(2)

(f) Calculate the mean percentage energy loss per year in **Figure 3**.

Mean energy loss per year = ____________ %

(3)

(Total 10 marks)

Q13.

A student finds some information about energy-saving light bulbs.

(a) A 30W light bulb uses 600J of electrical energy in a certain period of time. In that time, it produces 450 J of light energy. The rest of the energy is wasted.

(i) Calculate the energy wasted by the light bulb in this period of time.

Wasted energy = ____________ J

(1)

(ii) What happens to the energy wasted by the light bulb?

(1)

(iii) Calculate the efficiency of this light bulb.

Efficiency = ____________

(2)

(iv) Calculate the period of time, in seconds, during which the 600 J is provided to the 30 W light bulb.

Time = ____________ s

(2)

(b) A company that makes light bulbs provides information about some of their products.

The table shows some of this information.

	Power in watts	Lifetime in hours	Cost of bulb in £
Filament bulb	60	1250	2.00
LED bulb	12	50 000	16.00

(i) Suggest why it is important to confirm this information independently.

____

(1)

(ii) A homeowner is thinking about replacing his filament bulbs with LED bulbs.

A 12 W LED bulb gives the same light output as a 60 W filament bulb.

Suggest reasons why the homeowner is likely to choose LED bulbs.

Use the information given in the table.

____

____

____

____

(2)

(iii) State **one** factor, other than efficiency, that is important when considering the choice of a bulb for lighting in the home.

____

____

(1)

(Total 10 marks)

Q14.

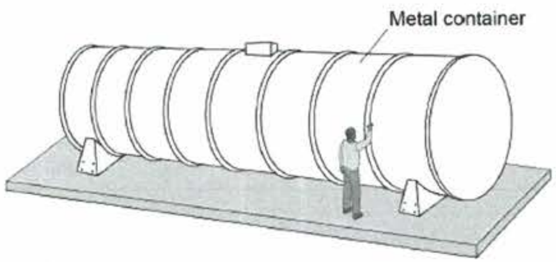
Data-storage computers get very hot.

Scientists investigated using the sea to cool data-storage computers.

The computers were set up inside a large metal container.

Figure 1 shows the metal container before it was lowered into the sea.

Figure 1



(a) Why is the container made of metal?

Tick (✓) **one** box.

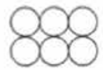
Metal has a high thermal conductivity.	☐
Metal is a good thermal insulator.	☐
Metal is a poor conductor of thermal energy.	☐

(1)

(b) The walls of the container are solid.

Figure 2 shows an arrangement of six particles in a solid.

Figure 2



The air inside the container is a gas.

Draw an arrangement of six particles in a gas in the box below.

(1)

(c) How does the air in the container exert pressure on the container?

Tick (✓) **one** box.

Air particles absorb energy from the container.	☐
Air particles collide with the walls of the container.	☐
Air particles expand to fill the container.	☐

(1)

(d) As the container is lowered into the sea, the temperature of the air in the container decreases.

Complete the sentence.

Choose the answer from the box.

decreases	**stays the same**	**increases**

When the temperature of the air in the container decreases, the average speed of the air particles ______________ .

(1)

(e) After the temperature of the air in the container had decreased, the computers were switched on.

The computers caused the temperature of the air to then increase.

Describe how the air pressure in the container changed as the temperature decreased and then increased.

(2)

(f) The container has a length of 12 m.

The container has a cross-sectional area of 7.5 m^2.

Calculate the volume of the container.

Use the equation:

volume = length × cross-sectional area

Volume = ______________ m^3

(1)

Use the Physics Equations Sheet to answer parts (g) and (h).

(g) Write down the equation that links density (ρ), mass (m) and volume (V).

(1)

(h) The average density of the container and its contents is 1100 kg/m^3.

Calculate the mass of the container and its contents.

Use your answer to part (f)

Mass = ______________ kg

(3)

(Total 11 marks)

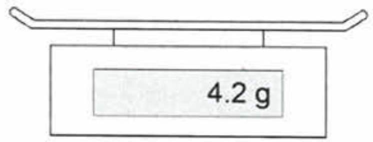
Q15.

A student determined the density of a cube made of bronze.

The student used a balance to measure the mass of the bronze cube.

Figure 1 shows the balance before the cube was added.

Figure 1



(a) What type of error is shown on the balance?

(1)

(b) How could the student get a correct value for the mass of the cube from the balance?

(1)

(c) The student measured the length of the bronze cube using Vernier callipers and then using a micrometer.

Table 1 shows the results.

Table 1

Equipment	Length in mm
Vernier callipers	20.1
Micrometer	20.14

Complete the sentence.

The results in **Table 1** show that the Vernier callipers and the micrometer have a different ____________________.

(1)

The student wanted to determine the density of a bronze coin.

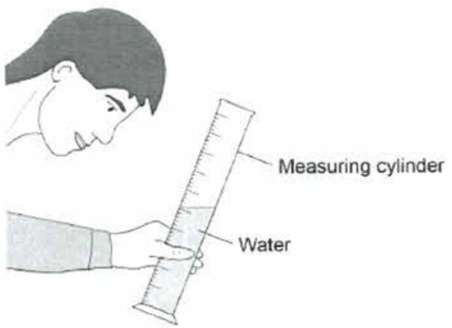
The student had several identical coins.

The volume of each coin was very small.

(d) The student added water to a measuring cylinder.

Figure 2 shows the student reading the volume of water in the measuring cylinder.

Figure 2



Give **two** changes the student should make to increase the accuracy of the volume measurement.

1 ____

____

2 ____

____

(2)

(e) Describe how the student could use a displacement method to determine an accurate value for the volume of a single coin.

____

____

____

____

____

____

(3)

(f) Old penny coins were made from a disc of bronze.

New penny coins are made from a disc of a different metal.

Figure 3 shows a disc of metal.

Figure 3

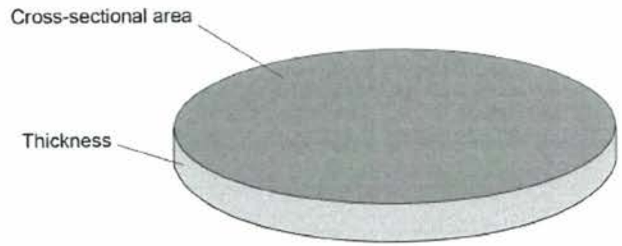


Table 2 shows information about the discs used to make each coin.

Table 2

Disc	Mass in g	Density in g/cm^3	Thickness in cm
Old penny	3.6	8.9	0.16
New penny	3.6	**X**	0.17

The discs used to make the old and the new coins have the **same** cross-sectional area.

Calculate value **X** in **Table 2**.

Give your answer to 2 significant figures.

The volume of a disc can be calculated using the equation:

volume of a disc = cross-sectional area × thickness

Density (2 significant figures) = ____________ g/cm^3

(5)

(Total 13 marks)

Q16.

A piece of steel is heated until it has all melted.

(a) Calculate the change in thermal energy when the temperature of the piece of steel is increased by 50 °C.

mass of steel = 4.0 kg

specific heat capacity of steel = 420 J/kg °C

Use the equation:

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

Change in thermal energy = ____________ J

(2)

(b) The internal energy of the steel increases as the steel is heated.

What is meant by 'internal energy of the steel'?

Tick (✓) **one** box.

- [ ] The change in energy of the steel particles as the steel melts.
- [ ] The energy added to the steel particles as they are heated.
- [ ] The total kinetic energy and potential energy of the steel particles.

(1)

(c) Solid steel cannot be poured.

Which statement about the particles in a solid gives the reason why?

Tick (✓) **one** box.

- [ ] The number of particles always stays the same.
- [ ] The particles are close together.
- [ ] The particles are in fixed positions.
- [ ] The particles have a fixed size.

(1)

(d) Complete the sentence.

Choose the answer from the box.

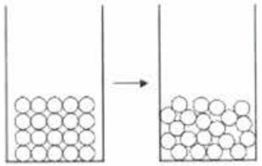
decreases	stays the same	increases

As the piece of solid steel melts, the mass of the steel ______________.

(1)

(e) Which diagram shows how the arrangement of particles changes when a solid melts and becomes a liquid?

Tick (✓) **one** box.



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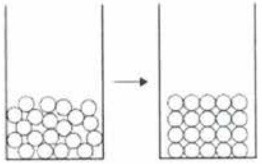

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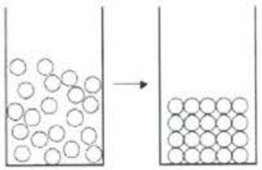


☐

(1)

(f) The density of steel decreases as it melts.

How does the spacing of the particles change as the steel melts?

____

____

(1)

(g) Complete the sentence.

Choose the answer from the box.

chemical	permanent	physical

Melting is an example of a ______________ change.

(1)

(h) Steel is a mixture of iron and a small amount of carbon.

The table below shows the mass of carbon in 1.0 kg of different types of steel.

Type of steel	Mass of carbon in 1.0 kg of steel
Low carbon	2.0 g
Medium carbon	4.5 g
High carbon	7.0 g

A 4.0 kg piece of steel contains 18 grams of carbon.

Determine which type of steel the 4.0 kg piece is made from.

You should include a calculation in your answer.

____

____

____

____

____

Type of steel ______________

(3)

(i) The 4.0 kg piece of solid steel was heated until it reached its melting point.

The additional energy required to melt the piece of steel was 280 000 J.

Calculate the specific latent heat of fusion of the steel.

Use the Physics Equations Sheet.

___

___

___

___

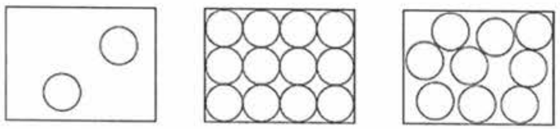
___

Specific latent heat of fusion of steel = ____________ J/kg

(3)
(Total 14 marks)

Q17.

(a) The diagrams, **X**, **Y** and **Z**, show how the particles are arranged in the three states of matter.



X **Y** **Z**

(i) Which **one** of the diagrams, **X**, **Y** or **Z**, shows the arrangement of particles in a liquid?

Write the correct answer in the box. ☐

(1)

(ii) Which **one** of the diagrams, **X**, **Y** or **Z**, shows the arrangement of particles in a gas?

Write the correct answer in the box. ☐

(1)

(b) Draw a ring around the correct answer in each box to complete each sentence.

(i) In a gas, the particles are

vibrating in fixed positions.
moving randomly.
not moving.

(1)

(ii) In a solid, the forces between the particles are

stronger than
equal to
weaker than

the forces between the particles in a liquid.

(1)

(c) The picture shows a puddle of water in a road, after a rain shower.

(i) During the day, the puddle of water dries up and disappears. This happens because the water particles move from the puddle into the air.

What process causes water particles to move from the puddle into the air?

Draw a ring around the correct answer.

condensation **evaporation** **radiation**

(1)

(ii) Describe **one** change in the weather which would cause the puddle of water to dry up faster.

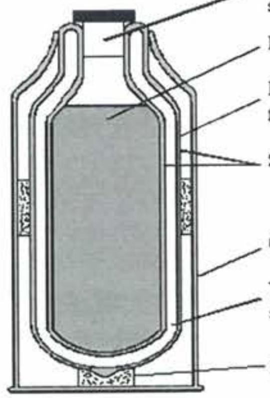
___

___

(1)
(Total 6 marks)

Q18.

The drawing shows a section of a vacuum flask.



(a) Heat is slowly "lost" from the hot liquid in the closed flask. It may be transferred by:

conduction	convention ion	evaporation	radiat

Choose from the words above to complete the following sentences. You may use a word once, more than once or not at all.

(i) The vacuum between the glass walls reduces

_______________ and _______________ **(2)**

(ii) The silvered surfaces of the glass walls reduce

_______________ **(1)**

(iii) The stopper in the opening of the flask reduces

_______________ and _______________ **(2)**

(iv) Heat is transferred by the air molecules, away from the vacuum flask, by

_______________ **(1)**

(v) The plastic of the plastic stopper is preferred to metal because it cuts down

_______________ **(1)**

(b) Mark **X** on the diagram of the vacuum flask where the liquid in the flask is hottest. **(1)**

(c) Explain, in terms of particles, how heat is conducted through a glass wall of the vacuum flask.

____

____

_______________ **(2)**

(Total 10 marks)

Q19.

A scientist cooled the air inside a container.

(a) The temperature of the air changed from 20 °C to 0 °C

The volume of the container of air stayed the same.

Explain how the motion of the air molecules caused the pressure in the container to change as the temperature decreased.

____

____

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____

_______________ **(3)**

(b) The air contained water that froze at 0 °C

The change in internal energy of the water as it froze was 0.70 kJ

The specific latent heat of fusion of water is 330 kJ/kg

Calculate the mass of ice produced.

Use the Physics Equations Sheet.

Mass of ice = ____________ kg

(3)

(c) The air also contained oxygen, nitrogen and carbon dioxide.

Oxygen boils at −183 °C and freezes at −218 °C
Nitrogen boils at −195 °C and freezes at −210 °C
Carbon dioxide sublimates at −78 °C

The scientist continued to cool the air to a temperature of −190 °C

What is the state of each substance at −190 °C?

Tick (✓) **one** box for **each** row of the table.

Substance	Solid	Liquid	Gas
Oxygen			
Nitrogen			
Carbon dioxide			

(2)

(d) The air also contained a small amount of argon.

As the temperature of the air decreased from 20 °C to −190 °C the argon changed from a gas to a liquid to a solid.

Explain the changes in the arrangement and movement of the particles of the argon as the temperature of the air decreased.

(6)

(Total 14 marks)

Q20.

The particle model can be used to explain the properties of gases.

(a) Describe the direction of motion of the particles in a gas.

(1)

(b) Explain why heating a gas increases the average speed of the gas particles.

(3)

(c) Water can exist as either a liquid or a gas at 100 °C.

Explain why a mass of gaseous water at 100 °C contains more energy than an equal mass of liquid water at 100 °C.

(2)

(d) Water vapour is a gas. Gases change state when they cool.

The figure below shows condensation on a cold bathroom mirror.

© Dwight Eschliman/Getty Images

A volume of 2.5×10^{-5} m^3 of condensation forms on the mirror.

Density of water = 1000 kg / m^3

Specific latent heat of vaporisation of water = 2.26×10^6 J / kg.

Calculate the energy released when the condensation forms.

Energy released = ____________ J

(5)

(e) Central heating boilers burn gas and use the energy released to heat water.

Modern condensing central heating boilers take advantage of the energy that is released when water condenses.

Waste water vapour produced when the water is heated in the boiler is used to preheat the cold water entering the boiler.

Give some of the arguments in favour of condensing boilers compared to older non-condensing boilers.

(4)

(Total 15 marks)

Q21.

Some people used to think that radioactive substances had health benefits.

100 years ago, a company made toothpaste containing the radioactive isotopes radium-228 and radium-226.

Figure 1 shows the symbols for these isotopes.

Figure 1

$^{228}_{88}Ra$ $^{226}_{88}Ra$

(a) How are atoms of radium-228 different from atoms of radium-226?

Tick (✓) **one** box.

Radium-228 atoms have one more neutron and one more proton. ☐

Radium-228 atoms have two more neutrons and two more protons. ☐

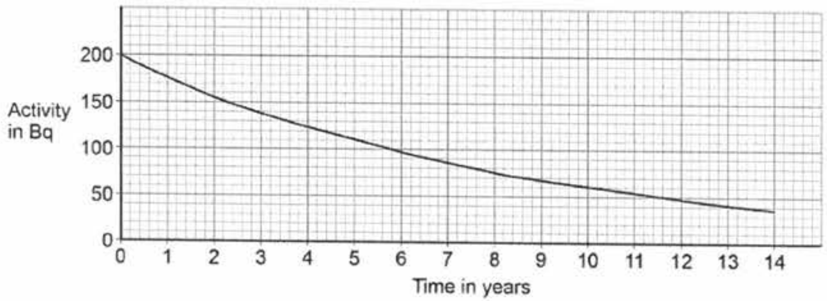
Radium-228 atoms have two more neutrons. ☐

Radium-228 atoms have two more protons. ☐

(1)

(b) **Figure 2** shows how the activity of a sample of radium-228 changed over time.

Figure 2



What is the approximate half-life of radium-228?

Tick (✓) **one** box.

6 years ☐

7 years ☐

14 years ☐

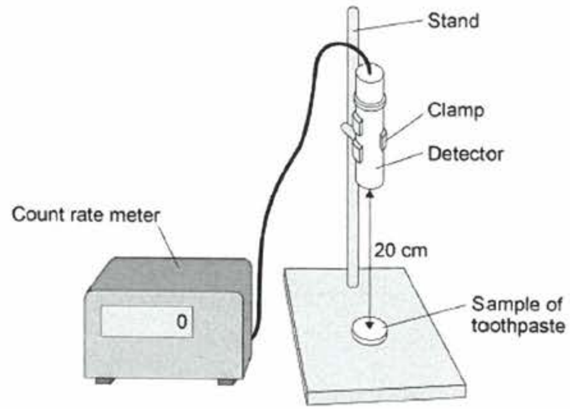
100 years ☐

(1)

A scientist investigated whether the toothpaste in four tubes of the 100-year-old toothpaste is equally radioactive.

Figure 3 shows the equipment used.

Figure 3



(c) When the equipment was arranged as shown in **Figure 3**, it was **not** possible to detect alpha particles from the toothpaste.

Suggest how the scientist adjusted the equipment to detect alpha particles from the toothpaste.

___

___

(1)

(d) The scientist adjusted the equipment and determined the activity of the toothpaste from each tube.

The table below shows the results.

Tube	Activity in Bq
A	3150
B	2940
C	3180
D	3050

What was the range of activities shown in above table?

From __________ Bq to __________ Bq

(1)

(e) What was the independent variable in the investigation?

Tick (✓) **one** box.

The activity of the toothpaste ☐

The mass of toothpaste used ☐

The temperature of the toothpaste ☐

The tube of toothpaste used ☐

(1)

(f) What was the dependent variable in the investigation?

Tick (✓) **one** box.

The activity of the toothpaste ☐

The mass of toothpaste used ☐

The temperature of the toothpaste ☐

The tube of toothpaste used ☐

(1)

(g) When the toothpaste was new, it caused a risk to health because of the nuclear radiation emitted.

What happened to the risk to health from the toothpaste after 100 years?

____

____

(1)

(h) Which property makes nuclear radiation hazardous?

Tick (✓) **one** box.

Nuclear radiation is ionising. ☐

Nuclear radiation is penetrating. ☐

Nuclear radiation is too small to see. ☐

Nuclear radiation makes objects radioactive. ☐

(1)

(Total 8 marks)

Q22.

A smoke detector contains a source of alpha radiation in a plastic case.

(a) A source of beta radiation in a smoke detector would be more hazardous than a source of alpha radiation.

Explain why.

____

____

____

____

(2)

(b) Actinium (Ac) is one source of alpha radiation.

An actinium (Ac) nucleus emits an alpha particle (α) and turns into a francium (Fr) nucleus.

This can be represented as:

$$^{A}_{Z}\text{Ac} \longrightarrow {}^{223}_{87}\text{Fr} + \alpha$$

Determine the values of **A** and **Z**.

____

A = ____________

Z = ____________

(2)

(c) A teacher wanted to find out what nuclear radiation is emitted from a source.

The teacher placed different barriers between the source and a detector.

The teacher recorded the count for 30 seconds after each barrier was put in place.

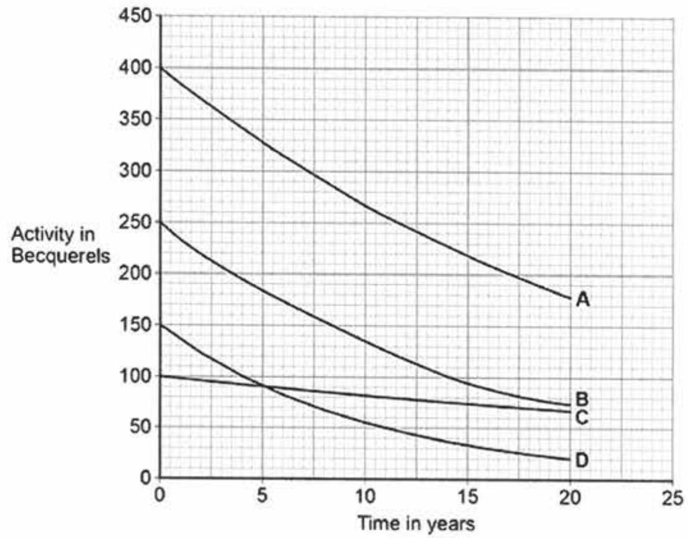
The table below shows the results.

Barrier	**Thickness in millimetres**	**Count after 30 seconds**
None		985
Paper	0.1	149
Aluminium	5.0	0
Lead	20.0	0

Explain what nuclear radiation was emitted by the source.

(4)

(d) The graph below shows how the activity of four different radioactive isotopes, **A**, **B**, **C** and **D**, changes over time.



Write the isotopes **A**, **B**, **C** and **D** in order of increasing stability of their nuclei.

Explain your answer.

Least stable ______ ______ ______ ______ **Most stable**

Explanation ____________

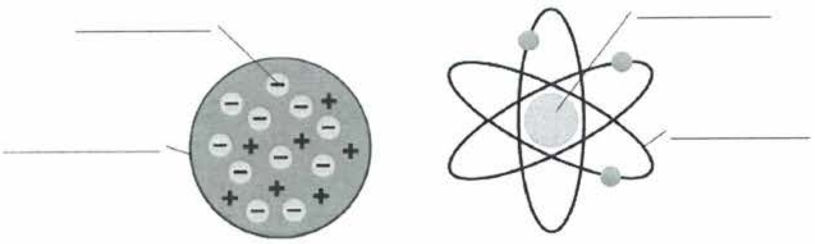
(3)

(Total 11 marks)

Q23.

Figure 1 shows two models of the atom.

Figure 1



(a) Write the labels on **Figure 1**

Choose the answers from the box.

atom	**electron**	**nucleus**
neutron	**orbit**	**proton**

(4)

(b) Explain why the total positive charge in every atom of an element is always the same.

____

____

____

____

(2)

(c) The results from the alpha particle scattering experiment led to the nuclear model.

Alpha particles were fired at a thin film of gold at a speed of 7% of the speed of light.

Determine the speed of the alpha particles.

Speed of light = 300 000 000 m/s

____

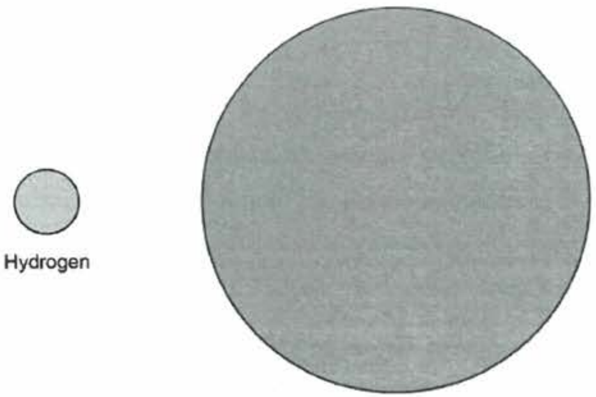
____

Speed = ____________ m/s

(2)

(d) **Figure 2** shows two atoms represented as solid spheres.

Figure 2



A hydrogen atom has a radius of 2.5×10^{-11} m

Determine the radius of a magnesium atom.

Use measurements from **Figure 2**

____

____

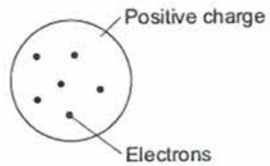
Radius = ____________ m

(2)

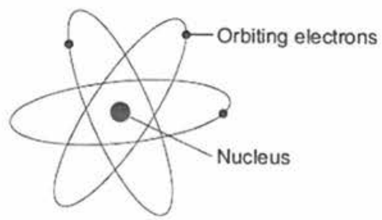
(Total 10 marks)

Q24.

In the early part of the 20th century, scientists used the 'plum pudding' model to explain the structure of the atom.



Following work by Rutherford and Marsden, a new model of the atom, called the 'nuclear' model, was suggested.



Describe the differences between the two models of the atom.

____

____

____

____

____

____

____

____

(Total 4 marks)

Q25.

Different radioactive isotopes emit different types of nuclear radiation.

A polonium-210 (Po) nucleus emits an alpha particle (α) and turns into a lead (Pb) nucleus.

This can be represented by the equation:

$${}^{210}_{84}\mathrm{Po} \longrightarrow {}^{A}_{Z}\mathrm{Pb} + \alpha$$

(a) What is the value of A in the equation?

Tick (✓) **one** box.

A = 206 ☐ A = 208 ☐ A = 210 ☐ A = 211 ☐

(1)

(b) What is the value of Z in the equation?

Tick (✓) **one** box.

Z = 80 ☐ Z = 82 ☐ Z = 85 ☐ Z = 86 ☐

(1)

(c) A strontium-89 nucleus (Sr) emits a beta particle (β) and turns into an yttrium nucleus (Y).

This can be represented by the equation:

$${}^{89}_{38}\mathrm{Sr} \longrightarrow {}^{A}_{Z}\mathrm{Y} + \beta$$

What are the values of A and Z in the equation?

A = ____________

Z = ____________

(2)

(d) Gamma radiation is another type of nuclear radiation.

What does gamma radiation consist of?

Tick (✓) **one** box.

High energy neutrons	☐
Electromagnetic waves	☐
Particles with no charge	☐
Positively charged ions	☐

(1)

(e) Explain the differences between the properties of alpha, beta and gamma radiations.

____

____

____

____

____

____

____

____

____

(6)
(Total 11 marks)

Q26.

Atoms are very small and most of their mass is concentrated in the nucleus.

Electrons orbit at different distances from the nucleus.

(a) A nucleus is much smaller than an atom.

Approximately how many times smaller is a nucleus than an atom?

Tick **one** box.

100 ☐

1000 ☐

10 000 ☐

100 000 ☐

(1)

(b) The electrons in an atom can only orbit at specific distances from the nucleus.

State what causes an electron's distance from the nucleus to increase or decrease.

Increase ______________________________

Decrease ______________________________

(2)

(c) Atoms have different atomic numbers and mass numbers.

In terms of sub-atomic particles, describe the difference between an atom's atomic number and its mass number.

(2)

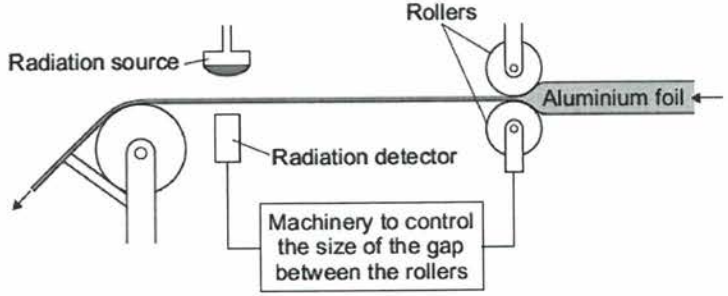
(d) Transmutation is the name given to a process where one element changes into another.

Explain and compare how two different types of radioactive decay can cause transmutation.

(4)
(Total 9 marks)

Q27.

The diagram shows a system used to control the thickness of aluminium foil as it is being rolled. A radiation source and detector are used to monitor the thickness of the foil.



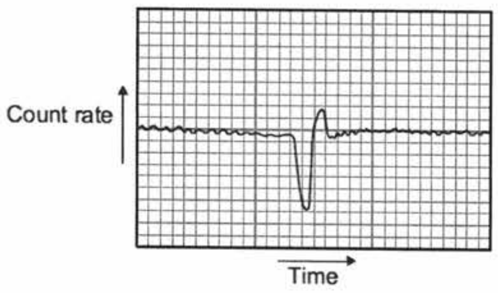
(a) Which type of source, alpha, beta or gamma, should be used in this control system?

____

Explain why each of the other two types of source would **not** be suitable.

____ **(3)**

(b) The chart shows how the count rate recorded by the detector varies over a short period of time.



Use the graph to explain how the thickness of the foil changes, and how the control system responds to this change.

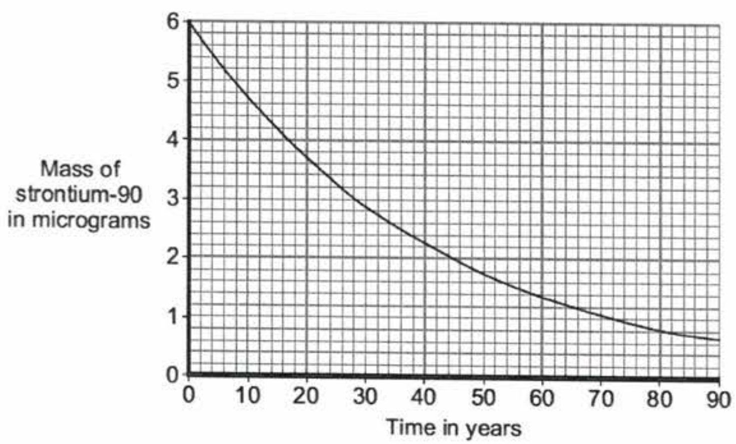
____

____

____

____ **(2)**

(c) When first used, the radiation source contains 6 micrograms of strontium-90. The graph shows how the mass of the strontium-90 will decrease as the nuclei decay.



The control system will continue to work with the same source until 75 % of the original strontium-90 nuclei have decayed.

After how many years will the source need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

____

____

____

Number of years = ______________ **(2)**

(Total 7 marks)

Mark schemes

Q1.

(a) decreases 1

(b) increases 1

(c) $E_p = 2.5 \times 9.8 \times 3.4$ 1

$E_p = 83.3$ (J)
allow 83 (J) 1

(d) $E_k = 0.5 \times 2.5 \times 4.8^2$ 1

$E_k = 28.8$ (J)
allow 29 (J) 1

(e) some energy is transferred to the surroundings 1

(f) speed will increase 1

(because work done against) friction decreases 1

[9]

Q2.

(a) a renewable biofuel 1

(b) any two from

- burning wood causes air pollution
  allow creates smoke
- burning wood may lead to deforestation
  ignore cutting down trees
- destruction of habitats
- burning wood is carbon-neutral
  allow does not contribute to global warming or the greenhouse effect or climate change

2

(c) the chemical store of energy of the wood decreases
both the store of energy and what happens to the store are required 1

the internal/thermal store of energy of the pipe increases 1

the internal/thermal store of energy of the water increases 1

(d) energy is dissipated (to the surroundings)
allow energy is transferred/lost to the surroundings 1

at the same rate that energy is transferred to the water 1

[8]

Q3.

(a) it is the same size as the downward force 1

(b) weight is a vector 1

(c) centre of mass 1

(d)
an answer of 441 (N) scores ***2*** *marks*

W = 45 × 9.8 1

W = 441 (N)
allow 440 (N) 1

(e) **Level 2:** Some logically linked reasons are given. There may also be a simple judgement. 3–4

Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear. 1–2

No relevant content 0

Indicative content

- as height changes gravitational potential energy changes
- gravitational potential energy decreases when moving to the lower bar
- as speed changes kinetic energy changes
- kinetic energy increases when moving to the lower bar
- transfer from gravitational potential energy to kinetic energy as height decreases

- the sum of the kinetic energy and gravitational potential energy is constant

(f) reduces the force exerted
ignore impact 1

the risk of injury to gymnast is reduced
allow so the gymnast does not get injured 1

[11]

Q4.

(a) (i) electrical
answers must be in the correct order 1

kinetic 1

(ii) any **one** from:
- thermal (energy)
- sound (energy).

allow "heat" (energy) 1

(iii) The wasted energy is transferred to the surroundings 1

(b) *advantage of A:*
answers must be comparative 1

any **one** from:
- bigger wash load
- uses less energy
  allow uses less electricity
- uses less water.

disadvantage of A:
higher cost (to buy) 1

[6]

Q5.

(a) the measurement will be more accurate
allow parallax error is reduced 1

because (in position B) the eye is level with (the maximum height of) the toy 1

(b) 64 cm = 0.64 m 1

0.049 = $m \times 9.8 \times 0.64$

allow a correct substitution using an incorrectly / not converted height 1

$$m = \frac{0.049}{9.8 \times 0.64}$$

allow a correct rearrangement using their incorrectly / not converted height 1

m = 0.0078125 (kg)
allow an answer consistent with their incorrectly / not converted height 1

m = 0.0078 (kg)
this mark can only be scored if the equation $E_p = m\,g\,h$ has been used 1

(c) energy from the toy is dissipated (to the surroundings / air)
allow energy from the toy is transferred to the surroundings / air 1

(but) in a closed system the total energy remains constant 1

[9]

Q6.

(a) **Child**
gravitational potential energy decreases 1

kinetic energy increases **and** then decreases to zero 1

Springs
elastic potential energy increases
ignore references to kinetic energy of the springs 1

Surroundings
internal / thermal store of energy increases
allow energy is dissipated
allow (average) kinetic energy of the particles increases 1

ignore descriptions of energy transfers before the child reaches position A

(b) **At position A**
$4.9 = 0.5 \times k \times 0.056^2$ 1

$$k = \frac{2 \times 4.9}{0.056^2} = 3125 \text{ (N/m)}$$

1

At position B
$8.1 = 0.5 \times 3125 \times e^2$

*allow a correct substitution of an incorrectly calculated value of k using 0.056 m **and** 4.9 J* 1

$e = \sqrt{\left(\frac{2 \times 8.1}{3125}\right)}$

allow $e^2 = 0.005184$

allow a correct re-arrangement using an incorrectly calculated value of k 1

$e = 0.072$ (m)

allow an answer consistent with their calculated value of k 1

(c) the total energy transferred by the child 1

[10]

Q7.

(a) heat / thermal
or / and
sound

*do **not** accept noise*

other forms of energy eg light negates answer 1

(b) 0.4
or
40 %

*allow **1** mark for $\frac{2000}{5000}$*
or
equivalent fraction
*an answer 0.4 % gains **1** mark*
*answers 0.4 or 40 given with any unit gains **1** mark*
*40 without % gains **1** mark* 2

[3]

Q8.

(a) the brightness of the lamp 1

(b) zero error 1

(c) C 1

(d) 10.0

allow 10 1

(e) $\frac{0.96}{8.0}$ 1

= 0.12

allow 12% 1

*an answer of 0.12 or 12% scores **2** marks*

(f) replenished 1

(g)

*an answer of 15 000 (J) scores **3** marks*

E = 490 × 31 1

E = 15 190

allow 15 200 if correct substitution is seen 1

E = 15 000 (J)

allow an answer to 2 s.f. consistent with their calculated value of E using E=QV 1

(h) less fossil fuel is burned 1

[11]

Q9.

(a) the current in both lamps is the same 1

(b) (4.5 - 1.5 =) 3 (V)

allow (4.5 - 1.5 =) 3.0 (V) 1

(c) $P = 1.5 \times 1.2$ 1

1.8 (W) 1

(d) $R = \frac{1.5}{1.2}$ 1

1.25 (Ω)

allow 1.3 (Ω)

1

(e) $Q = 1.2 \times 40$

1

48 (C)

1

(f) the temperature of each lamp increases

1

(g) lamp **X** no longer emits light

1

because the circuit is no longer complete

dependent on MP1

allow because there is no current

1

[11]

Q10.

(a) potential difference is increased

*allow transformer **X** is a step up transformer*

1

(and) current decreases

1

(so) energy/power losses in the transmission cables decrease

allow (so) there is less heating in the transmission cables

1

(b) $11\,000 \times I_s = 400\,000 \times 660$

1

$$I_s = \frac{400\,000 \times 660}{11\,000}$$

1

$I_s = 24\,000$ (A)

1

(c) the street lamps are connected in parallel

1

(d) resistance (of the LDR) increases

allow resistance (of the circuit) increases

1

(so) the current decreases

allow so the LDR has a greater (share of the) potential difference

1

(so) the potential difference across R decreases

dependent on MP1

1

(e) 20 mA = 0.020 A

1

$6.0 = 0.020^2 \times R$

allow a correct substitution using an incorrectly / not converted value of current.

1

$$R = \frac{6.0}{0.020^2}$$

allow a correct re-arrangement using their incorrectly / not converted value of current.

1

$R = 15000$ (Ω)

allow an answer consistent with their incorrectly / not converted value of current

OR

20 mA = 0.020 A (1)

$$V = \frac{6.0}{0.020} = 300 \text{ (1)}$$

$$R = \frac{300}{0.020} \text{ (1)}$$

$R = 15000$ (Ω) (1)

1

[14]

Q11.

(a) (the variable resistor) changes the resistance of the circuit

1

to keep the current the same

1

so the temperature of the wire is kept constant

allow to control the temperature of the wire

1

(b) $0.17 = \frac{X+0.18+0.15}{3}$

allow $X = 3 \times 0.17 - 0.18 - 0.15$

1

X = 0.18 (V)

1

(c) resistance is directly proportional to length

allow length is directly proportional to resistance

allow as length increases resistance increases for 1 mark

allow positive correlation for 1 mark

2

(d) resistance = 7.5 (Ω)

allow a range from 7.4 to 7.6

1

0.90 = I × 7.5

allow their value of R read from the graph correctly substituted

1

$I = \frac{0.90}{7.5}$

allow a correct re-arrangement using their value of R read from the graph

1

I = 0.12 (A)

allow a value consistent with their value of R read from the graph

1

(e) the length/width/volume (of the blood sample) affects the resistance of the blood sample

allow length/width/volume (of the blood sample) should be a control variable

allow shape/size of the tube should be a control variable

ignore amount of blood

1

so only glucose concentration affects resistance

1

[13]

Q12.

(a) earth

1

(b) it can prevent an electric shock from the toaster

1

(c) 230 V

1

(d) (the potential difference) for the alternating supply changes direction

allow current

1

(the potential difference) for the alternating supply changes magnitude

allow current

allow converse

allow potential difference of alternating supply is greater

1

(e) there is an overall decrease

allow there is an decrease in percentage energy loss until 2013

1

but there is a (small) increase since 2013

1

(f) 1.92, 1.72, 1.70, 1.74, 1.77

1

(1.92 + 1.72 + 1.70 + 1.74 + 1.77)/5

1

1.77(%)

*an answer of 1.77(%) scores **3** marks*

1

[10]

Q13.

(a) (i) 150

1

(ii) transferred to the surroundings by heating

reference to sound negates mark

1

(iii) 0.75

*450 / 600 gains **1** mark*

*accept 75% for **2** marks*

*maximum of **1** mark awarded if a unit is given*

2

(iv) 20 (s)

*correct answer with or without working gains **2** marks*

*correct substitution of 600 / 30 gains **1** mark*

2

(b) (i) to avoid bias

1

(ii) use less power and last longer

1

1 LED costs £16, 40 filament bulbs cost £80

or

filament costs (5 times) more in energy consumption

1

(iii) any **one** from:

- availability of bulbs
- colour output
- temperature of bulb surface

1

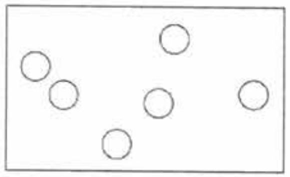
[10]

Q14.

(a) metal has a high thermal conductivity 1

(b) 6 particles all spread apart irregularly within the box

e.g.



1

(c) air particles collide with the walls of the container 1

(d) decreases 1

(e) (the pressure) decreased as temperature decreased 1

(the pressure) increased as temperature increased

*allow **2** marks for it decreased then increased* 1

(f) 90 (m^3) 1

(g) $\text{density} = \frac{\text{mass}}{\text{volume}}$

or

$\rho = \frac{m}{V}$ 1

(h) $1100 = \frac{m}{90}$

*allow ecf from part **(f)*** 1

mass = 90 × 1100 1

99 000 (kg) 1

[11]

Q15.

(a) zero error

allow systematic error 1

(b) reset the balance to zero g

allow subtract the reading shown on the balance from the reading taken 1

(c) resolution

this answer only 1

(d) place the measuring cylinder on a horizontal surface 1

view with eye in line with the level of the water

allow read from the bottom of the meniscus 1

(e) add several coins to the measuring cylinder

allow a minimum of 5 coins if a number of coins is given 1

measure the change in the water level in the measuring cylinder 1

divide by the number of coins added 1

(f) $8.9 = \frac{3.6}{\text{area} \times 0.16}$

allow $8.9 = \frac{3.6}{\text{volume}}$ 1

$\text{area} = \frac{3.6}{8.9 \times 0.16}$

allow area = 2.5(28…) (cm^2) 1

$\text{density} = \frac{3.6}{2.528 \times 0.17}$

allow $\frac{3.6}{\text{their calculated area} \times 0.17}$ 1

density = 8.37… (g/cm^3)

allow a correct calculation using their calculated area 1

density = 8.4 g/cm^3

this mark can only be scored for a correct rounding of a value of density calculated using correct equations

1

[13]

Q16.

(a) $\Delta E = 4.0 \times 420 \times 50$ 1

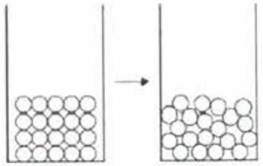
$\Delta E = 84\,000$ (J) 1

(b) the total kinetic energy and potential energy of the steel particles 1

(c) the particles are in fixed positions 1

(d) stays the same 1

(e)



1

(f) (the space between the particles) increases
allow the particles move further apart 1

(g) physical 1

(h) mass per kg $= \frac{18}{4.0}$ 1

mass per kg = 4.5 g 1

medium carbon
dependent on MP2

OR

mass in 4.0 kg of medium carbon steel = 4.5 × 4.0 (1)
allow mass in 4.0 kg of low carbon steel = 8 (g)
allow mass in 4.0 kg of high carbon steel = 28 (g)

mass in 4.0 kg of medium carbon steel = 18 g (1)
dependent on MP1

medium carbon (1)
dependent on MP2

1

(i) $280\,000 = 4.0 \times L$ 1

$L = \frac{280\,000}{4.0}$ 1

$L = 70\,000$ (J/kg) 1

[14]

Q17.

(a) (i) Z 1

(ii) X 1

(b) (i) moving randomly 1

(ii) stronger than 1

(c) (i) evaporation 1

(ii) any **one** from:

- becomes windy
- temperature increases
accept (becomes) sunny
"the sun" alone is insufficient
- less humid

1

[6]

Q18.

(a) (i) conduction 1

convection
they may be in either order 1

(ii) radiation 1

(iii) evaporation 1

convection
they may be in either order

(iv) convection 1

(v) conduction 1

(b) in the middle above halfway up (above line joining top of spacers) 1

below the surface of the liquid

(c) by particles vibrating more 1

*particles shake more **or** move more*

do not credit they start vibrating

they pass on the energy **or** vibrations 1

do not credit heat

1

[10]

Q19.

(a) pressure decreased 1

because molecules have less (kinetic) energy 1

allow less speed/velocity

so fewer collisions (with the wall/container each second) 1

allow collide with less force

allow less force on the walls

(b) $0.70 = m \times 330$ 1

or

$700 = m \times 330\,000$

$m = \frac{0.70}{330}$

or

$m = \frac{700}{330\,000}$

allow correct rearrangement using converted value(s) of E to J and/or L to J/kg 1

m = 0.0021 (kg)

allow 0.0021(212121...)

allow correct calculation using converted value(s) of E and/or L 1

*an answer of 0.0021(212121...) scores **3** marks*

***3** marks can only be awarded for m = 0.0021(212121...) (kg)*

(c)

Substance	Solid	Liquid	Gas
Oxygen		✓	
Nitrogen			✓
Carbon dioxide	✓		

2 correct answers scores **1** mark.
if more than one tick in a row, neither can score a mark 2

(d) **Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account. 5–6

Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear. 3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking. 1–2

No relevant content 0

Indicative content

cooling

- as the argon cools the particles slow down
- particles in a liquid move slower than particles in a gas
- particles in a solid move slower than particles in a liquid
- as the liquid/solid cools the particles get closer together
- as the liquid/solid cools the density increases

gas to liquid

- particles change from being spread apart to touching each other
- particles will (collide with other particles more often and) change direction more often

liquid to solid

- particles change from a random arrangement to a regular pattern
- particles change from moving freely to fixed positions
- particles change from moving freely/randomly to vibrating

explanation

- (internal) energy (of the argon) decreases
- (kinetic) energy (of the particles) decreases with temperature
- (potential) energy (of the particles) changes with change of state (of the argon)

- forces between particles in a gas are negligible/zero
- attractive forces act between atoms when they are close to each other
- attractive forces between particles are stronger in a solid than in a liquid

to access level 3 there must be an explanation of changes to arrangement and movement of particles during either cooling or a change of state

[14]

Q20.

(a) random

accept in all directions

description must be of random motion 1

(b) heating increases the temperature of the gas 1

temperature is proportional to kinetic energy 1

if kinetic energy increases speed increases 1

(c) energy is needed to change the state of the water 1

to break the bonds 1

(d) $1000 = m / 2.5 \times 10^{-5}$ 1

$m = 2.5 \times 10^{-5} \times 1000$ 1

m = 0.025 (kg) 1

E = 0.025 × 2 260 000 1

E = 56 500 (J) 1

*allow 56 500 (J) without working shown for **5** marks*
***0** marks awarded for E = m × L*

(e) any **four** from:

- because the water is preheated) the change in temperature of the water is less
- so less energy is used to heat the water ($E=mc\Delta\theta$)
- therefore they (condensing boilers) are more efficient
- so less energy is wasted
- less gas is burned to heat the same amount of water
- less waste gas (CO_2) is produced by the boiler **or** (because less gas is used) they are cheaper to run / save money

4

[15]

Q21.

(a) radium-228 atoms have two more neutrons 1

(b) 6 years 1

(c) decrease the distance between the toothpaste and the detector 1

(d) 2940

answers may be in either order

3180 1

(e) the tube of toothpaste used 1

(f) the activity of the toothpaste 1

(g) there is less risk 1

(h) nuclear radiation is ionising 1

[8]

Q22.

(a) beta radiation is more penetrating (than alpha radiation)

allow beta radiation can pass through the case (but alpha radiation cannot)

allow beta radiation can travel further (in air than alpha radiation)

*do **not** allow beta radiation is more ionising* 1

so beta could irradiate people passing near the smoke detector

allow beta radiation can pass through skin 1

(b) A = 227 1

Z = 89 1

(c) (some) radiation is stopped by paper 1

so the source emits alpha radiation

MP2 dependent on MP1

and (some) radiation passes through paper but is stopped by aluminium 1

so the source emits beta radiation (but does not emit gamma) 1

MP4 dependent on MP3

1

(d) D B A C

all four letters must be in the correct order

explanation only scores if correct order given 1

explanation

a substance with a longer half-life has more stable nuclei

allow the more stable a nucleus, the less likely it is to decay (in a given time) 1

so answers are in order of increasing half-life 1

[11]

Q23.

(a) electron 1

atom 1

nucleus 1

orbit 1

(b) positive charge is provided by protons 1

(every atom of the same element contain the) same number of protons

*do **not** accept same number of protons and neutrons*

ignore reference to electrons 1

(c) $v = 300\,000\,000 \times \left(\frac{7}{100}\right)$

allow any correct method of determining 7% of 300 000 000 1

v = 21 000 000 (m/s)

allow 2.1×10^7 (m/s) 1

*an answer of 21 000 000 scores **2** marks*

(d) $r = 6 \times 2.5 \times 10^{-11}$

allow a ratio in the range of 5.7–6.3 or measurements that would give this range, correctly substituted 1

$r = 1.5 \times 10^{-10}$ (m)

allow 1.4×10^{-10} to 1.6×10^{-10}

*their ratio $\times 2.5 \times 10^{-11}$ correctly calculated scores **1** mark*

*an answer in the range 1.4×10^{-10} to 1.6×10^{-10} scores **2** marks* 1

[10]

Q24.

any **two** pairs from:

to gain credit it must be clear which model is being described

*do **not** accept simple descriptions of the diagram without comparison*

- nuclear model mass is concentrated at the centre / nucleus (1)

  *accept the nuclear model has a nucleus / the plum pudding model does not have a nucleus for **1** mark*

  plum pudding model mass is evenly distributed (1)

- nuclear model positive charge occupies only a small part of the atom (1)

  plum pudding model positive charge spread throughout the atom (1)

- nuclear model electrons orbit some distance from the centre (1)

  accept electrons in shells / orbits provided a valid comparison is made with the plum pudding model

  plum pudding electrons embedded in the (mass) of positive (charge) (1)

  *do **not** accept electrons at edge of plum pudding*

- nuclear model the atom mainly empty space (1)

  plum pudding model is a 'solid' mass (1)

[4]

Q25.

(a) A = 206 1

(b) Z = 82 1

(c)

numbers must be in this order

89 1

39 1

(d) electromagnetic waves 1

(e) **Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account. 5–6

Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear. 3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking. 1–2

No relevant content 0

Indicative content

alpha radiation

- an alpha particle is the same as a helium nucleus
- alpha is the least penetrating
- alpha is stopped by paper or skin
- alpha has the shortest range in air
- alpha will travel a few cm in air
- because alpha is most ionising
- because alpha has a charge of +2

beta radiation

- a beta particle is an electron (emitted from the nucleus)
- beta penetrates less than gamma and more than alpha
- beta is stopped by a thin sheet of aluminium
- beta has a shorter range than gamma
- beta will travel up to 1m in air
- because beta is more ionising that gamma and less ionising than alpha
- because beta has a charge of -1

gamma radiation

- gamma radiation is an electromagnetic wave
- gamma is the most penetrating
- gamma is reduced/stopped by several cm of lead or thick concrete
- gamma has the largest range in air
- gamma will travel very large distances in air
- because gamma is least ionising
- because is uncharged

to access level 3 the answer should compare alpha, beta and gamma radiation and provide some explanation of their properties

[11]

Q26.

(a) 10 000 1

(b) **Increase**

absorb electromagnetic radiation 1

Decrease

emit electromagnetic radiation 1

(c) atomic number is the number of protons 1

mass number is the number of protons and neutrons 1

(d) **Level 2 (3–4 marks):**
A clear comparison, with logical structure.

Level 1 (1–2 marks):
Fragmented points, with no logical structure.

0 marks:
No relevant content

Indicative content

Beta decay

- Atomic number increases by one
- When a neutron decays into a proton

Alpha decay

- Atomic number decreases by two
- When an alpha particle is emitted

Comparison

Both change number of protons (hence new element / transmutation)
Beta decay increases atomic number and alpha decay decreases (explicit)

NB No credit is given for different number of protons = new element.

4

[9]

Q27.

(a) beta 1

alpha: would not pass through (the aluminium / foil) 1

gamma: no change in count rate when thickness changes
must be a connection between detection / count rate /

passing through and change in thickness

1

(b) foil thickness increases then decreases (then back to normal / correct thickness)

a description of count rate changes is insufficient

1

gap between rollers decreases, then increases (then back to correct size)
or
pressure from rollers increases then decreases

accept tightness for pressure

answers may link change in thickness and gap width for full credit ie:

foil thickness increases so gap between rollers decreases (1)

foil thickness decreases so gap between rollers increases (1)

1

(c) 56 (years)

accept any value between 55-57 inclusive

allow ***1*** *mark for correct calculation of mass remaining as 1.5 (micrograms)*

allow ***1*** *mark for a mass of 4.5 micrograms plus correct use of graph with an answer of 12*

maximum of ***1*** *compensation mark can be awarded*

2

[7]