Caroline Chisholm School
Ambition Confidence Success
Everyone Every Lesson Every Opportunity

AQA GCSE PHYSICS PAPER 1

REVISION BOOKLET

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

AQA 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 45 mins	100

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 **Required Practical: Thermal insulation** – Use different materials and different thickness of the same material to insulate identical beakers of hot water, and measure the change in temperature of the water at regular intervals *(Physics only)*
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 - Gas pressure and volume *(Physics only)* **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 - Nuclear radiation in medicine *(Physics only)* - Nuclear fission *(Physics only)* - Nuclear fusion *(Physics only)* - Nuclear issues *(Physics only)*	

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 energy and elastic energy 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 particles	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.	
Energy transfer by radiation	I can compare the cooling and heating of different coloured surfaces.		I can describe the cooling of objects in terms of the rate of emission of radiation.		I can explain why objects stop cooling in terms of the rate of absorption and emission of radiation.	
	I can state that an object cools by emitting IR radiation and heats by absorbing IR radiation.		I can describe the heating of objects in terms of the rate of absorption of radiation.		I can apply the concepts of absorption and emission of IR radiation to explain why an object maintains a constant temperature.	
	I can measure the difference in cooling of objects of different colours.		I can describe the cooling of an object over a period of time.		I can describe the changes in the rate of cooling of objects of different colours and temperatures.	
Radiation and the greenhouse effect	I can state that infrared radiation is electromagnetic radiation with a wavelength shorter than red light.		I can compare the emission of infrared radiation with a wavelength shorter than red light.		I can describe factors that affect the rate of emission of infrared radiation, including temperature and surface area.	
	I can state that an object cools by emitting infrared radiation and heats by absorbing infrared radiation.		I can outline the evidence that changes in the concentration of atmospheric gases are the likely cause of global warming.		I can apply the concepts of absorption and emission of infrared radiation to explain why an object maintains a constant temperature.	
	I can describe the greenhouse effect in simple terms.		I can describe the greenhouse effect in terms of absorption and emission of radiation.		I can fully explain the greenhouse effect in terms of absorption, emission, and wavelengths of electromagnetic radiation.	

P2 Energy Transfer by Heating – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
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 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.	

P4 Electric Circuits – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Electrical charges	I can label the constituents on an atom (proton, neutron, and electron) on a diagram.		I can compare the electrical properties of protons, neutrons, electrons, and ions.		I can describe the shape of the field and lines of force around a point charge or charged sphere.	
	I can describe the interactions between positively and negatively charged objects.		I can use the concept of electric fields to explain why charged objects interact.		I can apply the concept of electric fields to explain in detail why the force between charged objects decreases with distance.	
	I can state that objects can become electrically charged by the action of frictional forces.		I can describe how objects become charged in terms of electron transfer.		I can explain why sparks can be produced by charged materials in terms of charge build-up.	
Electric circuits	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.	

P4 Electric Circuits – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
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.	
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.	
Gas pressure and volume	I can state that the temperature of a gas is related to the kinetic energy of the gas particles.		I can describe how the pressure of a gas can change when it is compressed or allowed to expand.		I can explain in terms of particle behaviour why the pressure of a gas increases when its volume decreases.	
	I can state that the pressure of a gas increases when it is compressed (at a constant temperature).		I can use the relationship pV = constant to calculate the constant.		I can calculate the pressure or volume of a gas.	
	I can state that forces are required to compress a gas.		I can explain why the temperature of a gas increases when it is compressed.		I can solve a variety of problems in which gas pressure or volume changes.	

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.	
Nuclear reactions	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 state that isotopes are atoms of the same element with different atomic masses.		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.	
Nuclear radiation in medicine	I can name some medical applications for radioactive substances.		I can explain why alpha, beta, or gamma radiation is chosen for a particular medical application.		I can describe the use of radioactive implants and the hazards associated with the technique.	
	I can state that the larger the dose of radiation, the more likely harm will be caused.		I can describe how gamma rays can be used to destroy cancerous cells and the damage they may cause to healthy tissue.		I can discuss the factors that need to be taken into account when selecting a medical tracer for a diagnostic test.	
	I can describe some precautions used during diagnoses or treatments involving radioactive substances.		I can explain how precautions to reduce exposure to patients and medical staff work.		I can explain how a medical tracer is used including the function of a gamma camera.	
Nuclear fission	I can state that nuclear fission is the breaking of a large nucleus to form two smaller nuclei.		I can describe induced nuclear fission in terms of neutron impacts and release.		I can explain how a steady-state induced fission reaction can be maintained.	
	I can distinguish between induced fission and spontaneous fission.		I can explain how an escalating induced fission reaction occurs.		I can explain the differences between naturally occurring isotopes and enriched nuclear fuels.	
	I can label the key components of a nuclear reactor.		I can outline the function of the moderator, control rods, and coolant.		I can explain the operation of a nuclear fission reactor, including the choices of appropriate materials.	
Nuclear fusion	I can state that nuclear fusion is the energy releasing process in the Sun.		I can outline the process of nuclear fusion.		I can explain why it is difficult to carry out controlled nuclear fusion on Earth.	
	I can state that the Sun fuses (joins together) hydrogen nuclei into helium nuclei.		I can complete a nuclear equation showing simple fusion processes.		I can construct a variety of nuclear equations showing nuclear fusion.	
	I can state that very high temperatures and pressures are required for fusion to take place.		I can describe the key design features of a nuclear fusion reactor.		I can compare the operation of a nuclear fission reactor and a nuclear fusion reactor.	

P7 Radioactivity – Paper 1

Lesson	Aiming for 4		Aiming for 6		Aiming for 8	
Nuclear issues	I can identify sources of radiation, including medical and background radiation.		I can compare the risks and damage associated with alpha, beta, and gamma radiation.		I can discuss the risks and benefits of nuclear power compared to other methods of electricity generation.	
	I can describe the type of damage caused by large-scale nuclear accidents.		I can describe how damage caused by radioactive material can be reduced.		I can describe and explain the safety precautions that need to take place after a large nuclear accident.	
	I can state that nuclear waste is very dangerous and must be stored safely for very long periods of time.		I can discuss the difficulties associated with the handling and storage of nuclear waste.		I can evaluate in detail a variety of storage or disposal solutions for nuclear waste.	

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) x 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

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

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

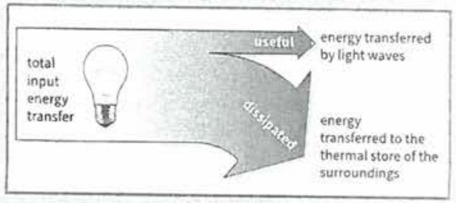
or

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

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

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*:

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

L or

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

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	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?	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?	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.	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.	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.	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.	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.	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.	watt (W)
14	A motor is 30% efficient. What does that mean?	30% of the energy is usefully transferred and 70% is dissipated

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Chapter 2: Energy transfer by heating

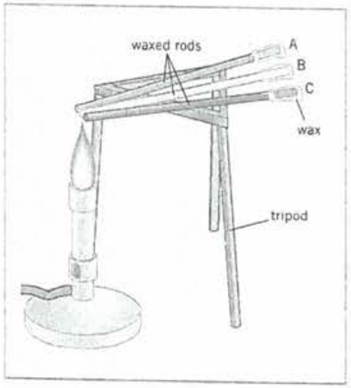
Knowledge organiser

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.

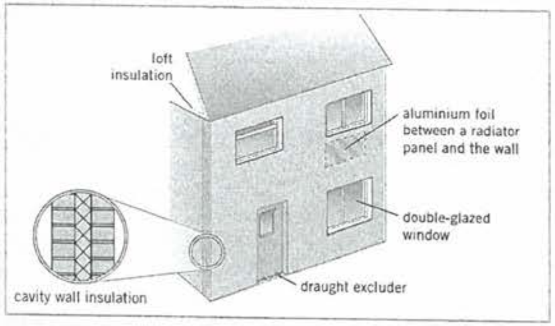
lower thermal conductivity = lower rate of heat loss

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.

Infrared radiation

Infrared radiation is part of the **electromagnetic spectrum**.

All objects **emit** (give out) and **absorb** (take in) infrared radiation.

The higher the temperature of an object, the more infrared radiation it emits in a given time.

A good absorber of infrared radiation is also a good emitter.

For an object at a constant temperature:

- infrared radiation emitted = infrared radiation absorbed
- infrared radiation is emitted across a continuous range of wavelengths.

An object's temperature will increase if it absorbs infrared radiation at a higher rate than it emits it. This rule applies to the planet Earth.

Black bodies

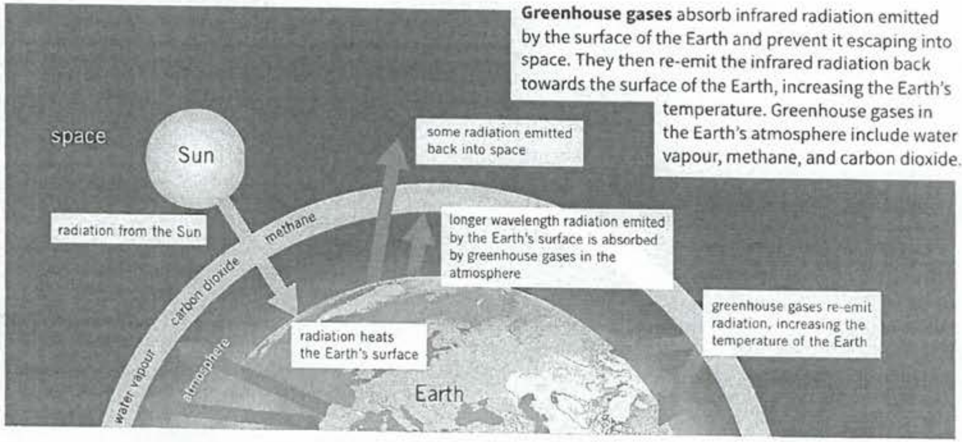
A **black body** is a theoretical object that absorbs 100% of the radiation that falls on it.

A perfect black body would not reflect or transmit any radiation, and would also be a perfect emitter of radiation.

Radiation and the Earth's temperature

The temperature of the Earth depends on lots of factors, including the rate at which visible light and infrared radiation are reflected, absorbed, and emitted by the Earth's atmosphere and surface.

Greenhouse gases absorb infrared radiation emitted by the surface of the Earth and prevent it escaping into space. They then re-emit the infrared radiation back towards the surface of the Earth, increasing the Earth's temperature. Greenhouse gases in the Earth's atmosphere include water vapour, methane, and carbon dioxide.



Human activities such as burning fossil fuels, deforestation, and livestock farming are increasing the amount of greenhouse gases in the Earth's atmosphere. This is causing the Earth's temperature to increase – a major cause of climate change.

Key terms

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

absorb | black body | electromagnetic spectrum | emit | greenhouse gas | infrared radiation | 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
6	What is infrared radiation?	type of electromagnetic radiation
7	What is the relationship between the temperature of an object and its emission of infrared radiation?	the higher the temperature of an object, the more infrared radiation emitted in a given time
8	What can you tell about an object that absorbs and emits infrared radiation at the same rate?	it is at a constant temperature
9	Compare the amount of infrared radiation emitted and absorbed by an object that is increasing in temperature.	more infrared radiation absorbed than emitted
10	What is a black body?	theoretical object that absorbs 100% of the radiation that falls on it, does not reflect or transmit any radiation, and is also the best emitter of radiation
11	Name three greenhouse gases.	water vapour, carbon dioxide, methane
12	What human activities increase the levels of greenhouse gases released?	(for example) deforestation, burning fossil fuels, livestock farming
13	Why do greenhouse gases increase the Earth's temperature?	Earth's surface absorbs and re-emits radiation from the Sun, which greenhouse gases then absorb – they re-emit this radiation back towards Earth's surface
14	To determine the specific heat capacity of a substance, what do you need to measure?	The mass, temperature rise, and the time taken

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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

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Chapter 4: Electric circuits

Knowledge organiser

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.

Static charge

Insulating materials can become charged when they are rubbed with another insulating material. This is because electrons are transferred from one material to the other. Materials that gain electrons become negatively charged and those that lose electrons become positively charged.

Positive charges do not usually transfer between materials.

Electric charge is measured in coulombs C.

Sparks

If two objects have a very strong electric field between them, electrons in the air molecules will be strongly attracted towards the positively charged object. If the electric field is strong enough, electrons will be pulled away from the air molecules and cause a flow of electrons between the two objects – this is a **spark**.

Drawing electric fields

A charged object creates an **electric field** around itself.

If a charged object is placed in the electric field of another charged object it experiences **electrostatic force**. This means that the two charged objects exert a non-contact force on each other:

- like charges repel each other
- opposing charges attract each other.

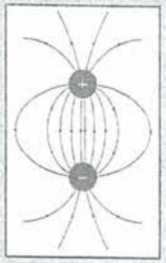
The electric field, and the force between two charged objects, gets stronger as the distance between the objects decreases.

Drawing electric fields

Electric fields can be represented using a diagram with field lines. These show the direction of the force that a small positive charge would experience when placed in the electric field.

When drawing electric fields, make sure:

- field lines meet the surface of charged objects at 90°
- arrows always point away from positive charges and towards negative charges.



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)

Key terms

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

ampere
charge
coulomb
current
electric field
electrostatic force
LDR
parallel
potential difference
resistance
series
static
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.

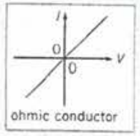
The resistance of an electrical component can be found by measuring the current and potential difference:

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

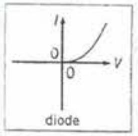
$V = IR$

Current-potential difference graphs

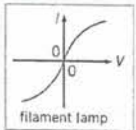
A graph of current through a component against the p.d. across it (I–V graph), is known as the component characteristic.



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.

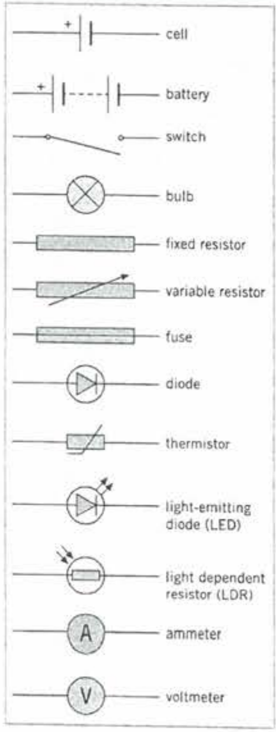


As more current flows through the filament, its temperature increases. The atoms in the wire vibrate more, and collide more often with electrons flowing through it, so resistance increases as temperature increases. The resistance of a thermistor decreases and temperature increases. The resistance of 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:

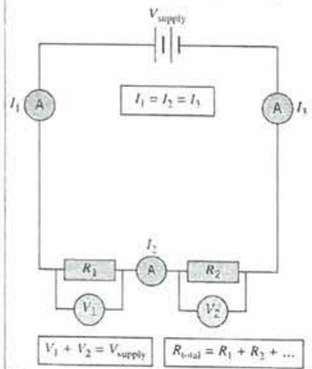
$$\text{resistance} = \frac{1}{\text{gradient}}$$

Circuit components



Series circuits

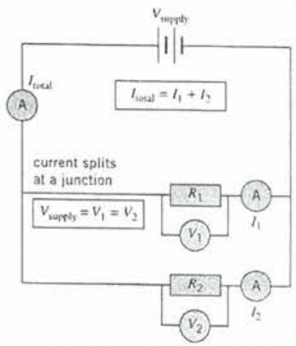
In a series circuit, the components are connected one after the other in a single loop. If one component in a series circuit stops working the whole circuit will stop working.



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	How does a material become charged?	becomes negatively charged by gaining electrons and becomes positively charged by losing electrons
2	What will two objects carrying the same type of charge do if they are brought close to each other?	repel each other
3	What is an electric field?	region of space around a charged object in which another charged object will experience an electrostatic force
4	What happens to the strength of an electric field as you get further from the charged object?	it decreases
5	What is electric current?	rate of flow of charge
6	What units are charge, current, and time measured in?	coulombs (C), amperes (A), seconds (s) respectively
7	What is the same at all points when charge flows in a closed loop?	current
8	What must there be in a closed circuit so that electrical charge can flow?	source of potential difference (p.d.)
9	Which two factors does current depend on and what are their units?	resistance in ohms (Ω), p.d. in volts (V)
10	What happens to the current if the resistance is increased but the p.d. stays the same?	current decreases
11	What is an ohmic conductor?	conductor where current is directly proportional to the voltage so resistance is constant (at constant temperature)
12	What happens to the resistance of a filament lamp as its temperature increases?	resistance increases
13	What happens to the resistance of a thermistor as its temperature increases?	resistance decreases
14	What happens to the resistance of a light-dependent resistor when light intensity increases?	resistance decreases
15	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
16	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

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Chapter 5: Electricity in the home

Knowledge organiser

Mains electricity

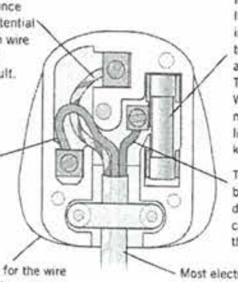
A cell or a battery provides a **direct current (dc)**. The current only flows in one direction and is produced by a **direct potential difference**.

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.

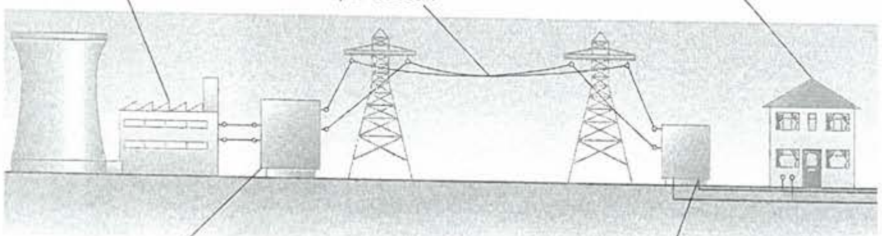
Plugs



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)

$$P = IV$$

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)

$$P = I^2R$$

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

$$V_p I_p = V_s I_s$$

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:

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:

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

$$E = QV$$

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

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.)?	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?	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?	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?	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?	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?	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?	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?	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

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)

Internal energy

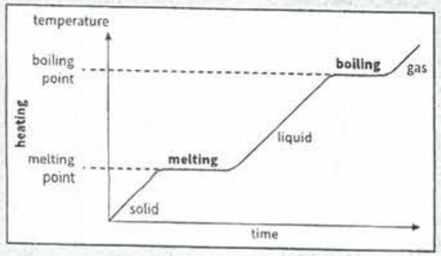
Heating a substance increases its **internal energy**.

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.

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.

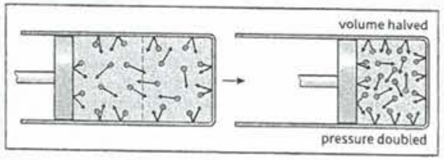
If a gas is compressed quickly, for example, in a bicycle pump, its temperature can rise. This is because

- 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.

The relationship between volume and pressure in gases

If the volume of a fixed mass of gas at a constant temperature is decreased, the pressure increases because

- the distance the particles travel between each impact with a container wall is smaller
- the number of impacts per second increases, so the total force of impacts increases.



Similarly, if the volume is increased, the pressure decreases. This is because

- the distance the particles travel between each impact with a wall of the container is greater
- the number of impacts per second decreases, so the total force of the impacts decreases.

The pressure and volume of a fixed mass of gas at a constant temperature are linked by the equation:

$$\text{pressure (Pa)} \times \text{volume (m}^3) = \text{constant}$$

$$p \times V = \text{constant}$$

Rearranging this equation gives:

$$p = \frac{\text{constant}}{V} \quad \text{and} \quad V = \frac{\text{constant}}{p}$$

This shows that pressure is inversely proportional the volume of a gas.

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?	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?	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?	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?	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?	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?	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
13	What causes the pressure of a gas on a surface?	the force of the gas particles hitting the surface
14	Give two reasons why the pressure of a gas in a sealed container increases if its temperature is increased.	the molecules move faster so they hit the surfaces with more force and the number of impacts per second increases, so the total force of the impacts increases
15	Give two reasons why the temperature of a gas increases if it is compressed quickly.	the force applied to compress the gas results in work being done to the gas, and the energy gained by the gas is not transferred quickly enough to the surroundings
16	Explain why the pressure of a fixed mass of gas decreases if the volume is increased and kept at constant temperature.	the distance the particles travel between each impact with a wall of the container is greater, so the number of impacts per second decreases, so the total force of the impacts decreases

Put paper here

Chapter 7: Radioactivity 1

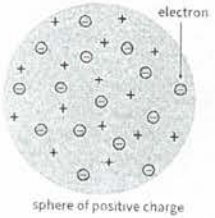
Knowledge organiser

Dalton's model

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

Plum pudding model

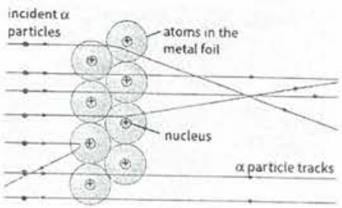
The discovery of negatively charged electrons led to the plum pudding model – a cloud of positive charge with electrons embedded in it.



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

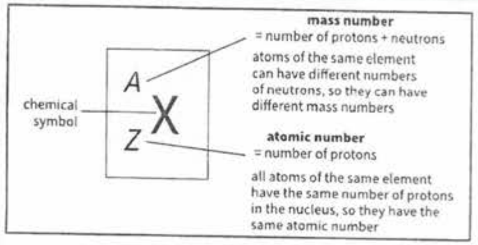
Bohr suggested the electrons orbit at specific distances called energy levels.

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	${}^{A}_{Z}X \rightarrow {}^{A}_{Z}X + {}^{0}_{0}\gamma$

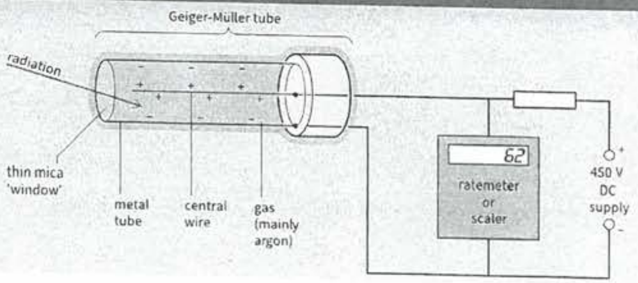
Activity and count rate

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).

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



Half-life

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

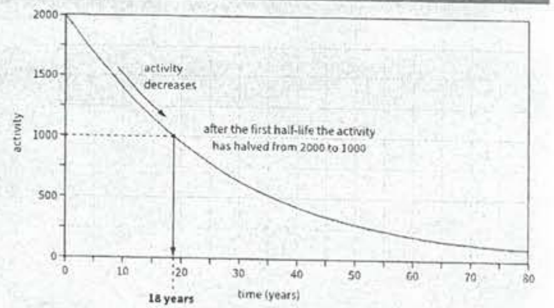
- for half the number of unstable nuclei in a sample to decay
- for the count rate or activity of a source to halve.

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: $\text{net daecline} = \frac{\text{reduction in activity}}{\text{original activity}}$

Chapter 7: Radioactivity 2

Knowledge organiser

Ionising radiation

Living cells can be damaged or killed by ionising radiation.

The risk depends on the half-life of the source and the type of radiation.

Alpha radiation is very dangerous inside the body because it affects all the surrounding tissue. Outside the body it only affects the skin and eyes because it cannot penetrate further.

Beta and gamma radiation are dangerous outside and inside the body because they can penetrate into tissues.

Radiation dose

Radiation dose, measured in sievert (Sv), measures the health risk of exposure to radiation. It depends on the type and amount of radiation.

Background radiation

Background radiation is radiation that is around us all the time. It comes from:

- natural sources like rocks and cosmic rays
- nuclear weapons and nuclear accidents.

Background radiation is always present but the levels are higher in some locations and in some jobs.

Nuclear waste

When fuel rods are removed from the reactor, they are stored in large tanks in water for up to a year until they cool down.

Machines are then used to open up fuel rods and extract the unused plutonium and uranium. Any material that is left then has to be stored securely as they have lots of radioactive isotopes with long half-lives. This is done to prevent radioactive contamination.

Irradiation versus contamination

irradiation	when an object is exposed to nuclear radiation	cause harm through ionisation	prevented by shielding, removing, or moving away from the source of radiation
contamination	when atoms of a radioactive material are on or in an object		object remains exposed to radiation as long as it is contaminated contamination can be very difficult to remove

Nuclear radiation in medicine

Exploration of internal organs

Gamma-emitting **tracers** are injected or swallowed by a patient. Gamma cameras can then create an image showing where the tracer has gone.

The half-life of the tracer must be short enough so that most of the nuclei will decay shortly after the image is taken to limit the patient's radiation dose (normally about six hours).

Control or destruction of unwanted tissue

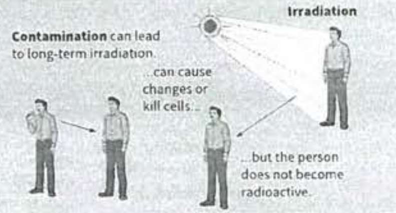
1. Narrow beams of gamma radiation can be focused on tumour cells to destroy them. Gamma is used because it can penetrate tumours from outside the body.
2. Beta- or gamma-emitting implants can be surgically placed inside (or next to) tumours. Their half-lives must be long enough to be effective, but short enough that it does not continue to irradiate the patient after treatment.

Protection against irradiation and contamination

You can protect against irradiation and contamination by:

- maintaining a distance from the radiation source
- limiting time near the source
- shielding from the radiation.

Studies on the effects of radiation should be published, shared with other scientists, and checked by **peer review** as they are important for human health.



Nuclear fission

Nuclear fission is when a large unstable nucleus absorbs an extra neutron and splits into two smaller nuclei of roughly equal size.

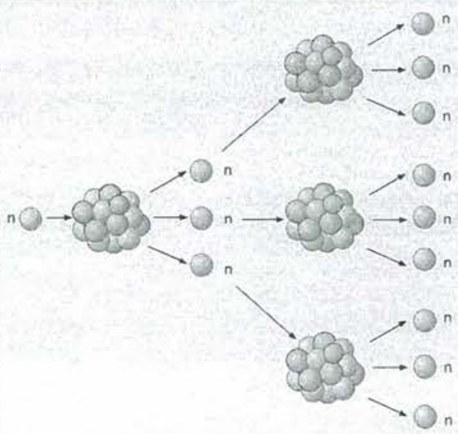
During nuclear fission:

- gamma radiation is emitted and energy is released
- two or three neutrons are emitted that can go on to cause a **chain reaction**.

The chain reaction in a power station reactor is controlled by absorbing neutrons.

Nuclear explosions are uncontrolled chain reactions.

On rare occasions an unstable nucleus splits apart without absorbing a neutron. This is called **spontaneous fission**.



Nuclear fusion

Nuclear fusion is when two light nuclei join to make a heavier one.

Some of the mass is converted to energy and transferred as radiation.

Nuclear fusion in the sun's core releases energy. A fusion reactor has to be at a very high temperature so the nuclei can overcome their repulsion.

Nuclear fusion in the future

Future fusion reactors could meet energy needs for a growing population. This is because:

- The fuel for fusion reactors is easily available as heavy hydrogen is naturally present in sea water.
- The product, helium, is an unreactive gas and non-radioactive so is harmless.
- The energy released could be used to generate electricity in the future.

Key terms

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

atom alpha activity atomic number background radiation beta chain reaction contamination count rate electron fission fusion gamma Geiger-Müller tube half-life ionisation irradiation isotope mass number net decline neutron plum pudding model proton peer review radiation dose radioactive decay spontaneous tracer

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.	Put paper here	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?	Put paper here	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?	Put paper here	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?	Put paper here	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?	Put paper here	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?	Put paper here	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?	Put paper here	time taken for half the unstable nuclei to decay or the time taken for the count rate to halve
16	What is radioactive contamination?		unwanted presence of substances containing radioactive atoms on or in other materials
17	Where does background radiation come from?	Put paper here	rocks, cosmic rays, fallout from nuclear weapons testing, nuclear accidents
18	Why are gamma-emitting sources used for medical tracers and imaging?		gamma rays pass through the body without causing much damage to cells
19	What is nuclear fusion?	Put paper here	when two light nuclei join to make a heavier one
20	How does nuclear fission occur?		an unstable nucleus absorbs a neutron, it splits into two smaller nuclei, and emits two or three neutrons plus gamma rays

AQA

Physics Equations Sheet
GCSE Physics (8463)
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	$E = Q V$
density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$

	thermal energy for a change of state = mass × specific latent heat	$E = m\,L$
	For gases: pressure × volume = constant	$p\,V = constant$
	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	$F = k\,e$
	moment of a force = force × distance (normal to direction of force)	$M = F\,d$
	pressure = $\frac{\text{force normal to a surface}}{\text{area of that surface}}$	$p = \frac{F}{A}$
HT	**pressure due to a column of liquid = height of column × density of liquid × gravitational field strength**	$\boldsymbol{p = h\,\rho\,g}$
	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**	$\boldsymbol{p = m\,v}$
HT	**force =** $\boldsymbol{\frac{\textbf{change in momentum}}{\textbf{time taken}}}$	$\boldsymbol{F = \frac{m\,\Delta v}{\Delta t}}$
	period = $\frac{1}{\text{frequency}}$	$T = \frac{1}{f}$
	wave speed = frequency × wavelength	$v = f\,\lambda$
	magnification = $\frac{\text{image height}}{\text{object height}}$	
HT	**force on a conductor (at right angles to a magnetic field) carrying a current = magnetic flux density × current × length**	$\boldsymbol{F = B\,I\,l}$
HT	$\boldsymbol{\frac{\textbf{potential difference across primary coil}}{\textbf{potential difference across secondary coil}} = \frac{\textbf{number of turns in primary coil}}{\textbf{number of turns in secondary coil}}}$	$\boldsymbol{\frac{V_p}{V_s} = \frac{n_p}{n_s}}$
HT	**potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil**	$\boldsymbol{V_p\,I_p = V_s\,I_s}$

Q1.

The diagram below shows a cyclist riding along a flat road.

(a) Complete the sentence.

Choose answers from the box.

chemical	**elastic potential**	**gravitational potential**	**kinetic**

As the cyclist accelerates, the ____________________ energy store in the cyclist's body decreases and the ____________________ energy of the cyclist increases.

(2)

(b) The mass of the cyclist is 80 kg. The speed of the cyclist is 12 m/s.

Calculate the kinetic energy of the cyclist.

Use the equation:

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

Kinetic energy = ____________________ J

(2)

(c) When the cyclist uses the brakes, the bicycle slows down.

This causes the temperature of the brake pads to increase by 50 °C.
The mass of the brake pads is 0.040 kg.
The specific heat capacity of the material of the brake pads is 480 J/kg °C.

Calculate the change in thermal energy of the brake pads.

Use the equation:

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

Change in thermal energy = ____________________ J

(2)

(d) How is the internal energy of the particles in the brake pads affected by the increase in temperature?

Tick **one** box.

Decreased ☐

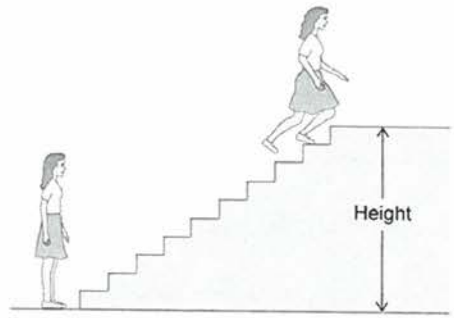
Increased ☐

Not affected ☐

(1)
(Total 7 marks)

Q2.

The figure below shows a girl doing an experiment to determine her power output by running to the top of some stairs.



(a) The mass of the girl was 60.0 kg.

The height of the stairs was 175 cm.

The girl ran to the top of the stairs in 1.40 s.

gravitational field strength = 9.8 N/kg

Calculate the power output of the girl.

Use the Physics Equations Sheet.

Power = ______ W

(5)

(b) The **total** power output of the girl was greater than the answer to part (a).

Suggest **two** reasons why.

1. ______

2. ______

(2)

(c) A boy took more than 1.40 s to run up the same stairs.

The power output of the boy was the same as the power output of the girl.

What conclusion can be made about the boy's mass?

Tick (✓) **one** box.

The boy's mass was greater than the girl's mass. ☐

The boy's mass was lower than the girl's mass. ☐

The boy's mass was the same as the girl's mass. ☐

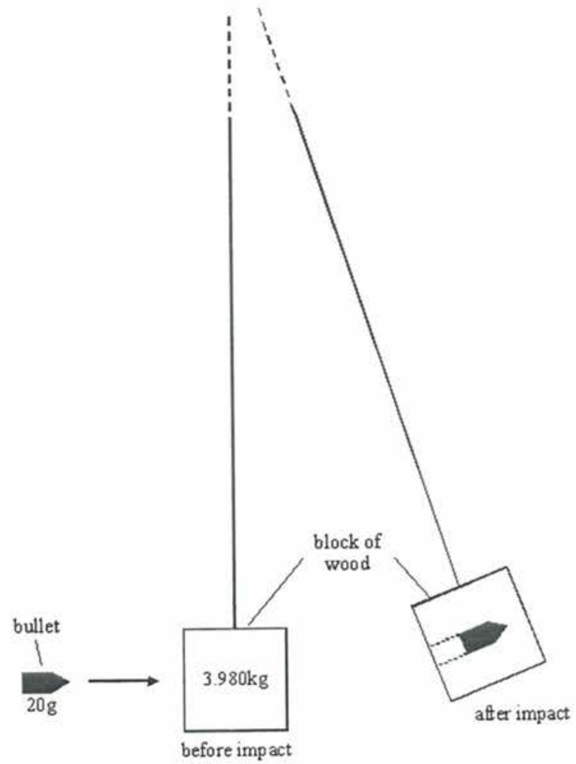
(1)
(Total 8 marks)

Q3.

(a) When an object is moving it is said to have momentum.
Define momentum.

(1)

(b) The diagram below shows one way of measuring the velocity of a bullet.



A bullet is fired into a block of wood suspended by a long thread.
The bullet stops in the wooden block.
The impact of the bullet makes the block swing.
The velocity of the wooden block can be calculated from the distance it swings.

In one such experiment the block of wood and bullet had a velocity of 2 m/s **immediately after** impact. The mass of the bullet was 20 g and the mass of the wooden block 3.980 kg.

(i) Calculate the combined mass of the block of wood and bullet.

Mass ____________

(1)

(ii) Calculate the momentum of the block of wood and bullet **immediately after** impact.

Momentum ____________

(3)

(iii) State the momentum of the bullet **immediately before** impact.

(1)

(iv) Calculate the velocity of the bullet **before** impact.

Velocity ____________ m/s

(3)

(v) Calculate the kinetic energy of the block of wood and bullet **immediately after** impact.

Kinetic energy ____________ J

(3)

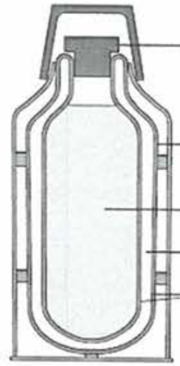
(vi) The kinetic energy of the bullet before the impact was 1600 joules. This is much greater than the kinetic energy of the bullet and block just after the impact.
What has happened to the rest of the energy?

(1)
(Total 13 marks)

Q4.

(a) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The diagram shows the structure of a vacuum flask.



A vacuum flask is designed to reduce the rate of energy transfer by heating processes.

Describe how the design of a vacuum flask keeps the liquid inside hot.

(6)

(b) Arctic foxes live in a very cold environment.

© Purestock/Thinkstock

Arctic foxes have small ears.

How does the size of the ears help to keep the fox warm in a cold environment?

____

____

____

____

____

(2)

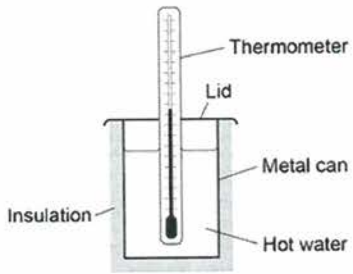
(Total 8 marks)

Q5.

A student investigated the insulating properties of different materials.

Figure 1 shows some of the equipment used by the student.

Figure 1



This is the method used:

1. Wrap insulating material around the can.
2. Put a fixed volume of boiling water in the can.
3. Place the lid on the top of the can.
4. Measure the time taken for the temperature of the water to decrease by a fixed amount.
5. Repeat steps 1 – 4 using the same thickness of different insulating materials.

(a) Identify the independent variable and the dependent variable in this investigation.

Independent variable ______________________________

Dependent variable ______________________________

(2)

The student used two different types of thermometer to measure the temperature changes.

Figure 2 shows a reading on each thermometer.

Figure 2

(b) What is the resolution of thermometer **B**?

Resolution = ______________ °C

(1)

(c) Thermometer **A** is more likely to be misread.

Give **one** reason why.

____

____

____

(1)

(d) For one type of insulating material, the temperature of the water decreased from 85.0 °C to 65.0 °C.

The energy transferred from the water was 10.5 kJ.

specific heat capacity of water = 4200 J/kg °C

Calculate the mass of water in the can.

Use the Physics Equations Sheet.

Mass = ______________ kg

(3)

(e) The table below shows the results for two insulating materials.

Material	Time for temperature to decrease by 20 °C in seconds
X	450
Y	745

Explain how the results in above table can be used to compare the thermal conductivity of the two materials.

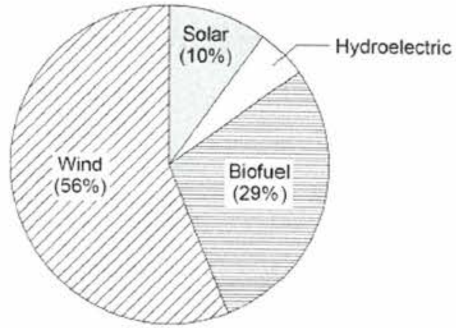
(2)
(Total 9 marks)

Q6.

The UK uses renewable energy resources to generate some of its electricity.

Figure 1 shows the proportion of electricity generated by different renewable energy resources in the UK in 2020.

Figure 1



(a) Calculate the percentage of electricity generated using hydroelectric power.

Percentage = ______________ %

(2)

A remote village in the UK uses a hydroelectric generator to provide electricity.

(b) The mass of water that passes through the hydroelectric generator each day is 2 500 000 kg.

The change in vertical height of the water is 15.0 m.

gravitational field strength = 9.8 N/kg

Calculate the decrease in gravitational potential energy of the water.

Use the equation:

gravitational potential energy = mass × gravitational field strength × height

Decrease in gravitational potential energy = ______________ J

(2)

Use the Physics Equations Sheet to answer parts (c) and (d).

(c) Write down the equation which links energy (E), power (P) and time (t).

______________________________ **(1)**

(d) The hydroelectric generator transfers electrical power of 3000 W to the village.

Calculate the energy transferred to the village in 60 minutes.

____

____

____

____

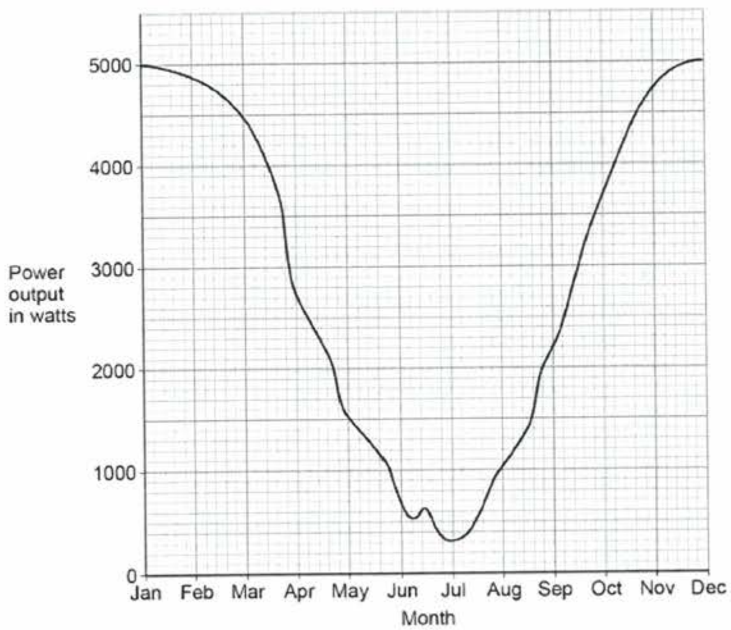
____

Energy transferred = ______________ J **(3)**

(e) The hydroelectric generator is turned by falling river water.

Figure 2 shows how the power output of the hydroelectric generator varied during one year.

Figure 2



Explain **one** reason why the power output varied.

____

____

____

____

______________________________ **(2)**

(Total 10 marks)

Q7.

Light bulbs are labelled with a power input.

(a) What does power input mean?

Tick (✓) **one** box.

The charge transferred each second by the bulb.	☐
The current through the bulb.	☐
The energy transferred each second to the bulb.	☐
The potential difference across the bulb.	☐

(1)

(b) Write down the equation which links current, potential difference and power.

______________________________ **(1)**

(c) A light bulb has a power input of 40 W

The mains potential difference is 230 V

Calculate the current in the light bulb.

____

____

____

Current = ______________ A **(3)**

The following table shows information about three different light bulbs.

Light bulb	Total power input in watts	Useful power output in watts	Efficiency
P	6.0	5.4	0.90
Q	40	2.0	0.05
R	9.0	**X**	0.30

(d) Write down the equation which links efficiency, total power input and useful power output.

____

(1)

(e) Calculate the value of **X** in the table above.

____

____

____

____

X = ____________________ W

(3)

(f) In addition to power input, light bulbs should also be labelled with the rate at which they emit visible light.

Suggest why.

____

____

____

____

(2)
(Total 11 marks)

Q8.

Figure 1 shows a lift inside a building.

Figure 1

(a) The motor in the lift does 120 000 J of work in 8.0 seconds.

Calculate the power output of the motor in the lift.

Use the equation:

$$\text{Power output} = \frac{\text{work done}}{\text{time}}$$

____

____

____

____

Power output = ____________________ W

(2)

(b) The power input to the motor is greater than the power output.

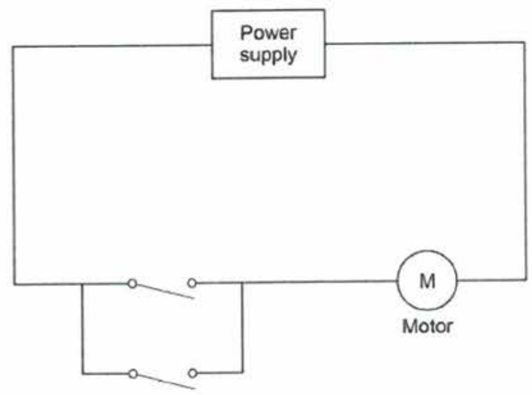
Tick **two** reasons why.

Energy is transferred in heating the surroundings.	☐
Friction causes energy to be transferred in non-useful ways.	☐
The motor is connected to the mains electricity supply.	☐
The motor is more than 100% efficient.	☐
There are only four people in the lift.	☐

(2)

(c) **Figure 2** shows part of the circuit that operates the lift motor.

Figure 2



The lift can be operated using either of the two switches.

Explain why.

____

____

____

____

____

(2)

(d) Write down the equation that links gravitational field strength, gravitational potential energy, height and mass.

____

____

(1)

(e) The lift goes up 14 m. The total mass of the people in the lift is 280 kg.

gravitational field strength = 9.8 N/kg

Calculate the increase in gravitational potential energy of the people in the lift.

Give your answer to 2 significant figures.

____

____

____

____

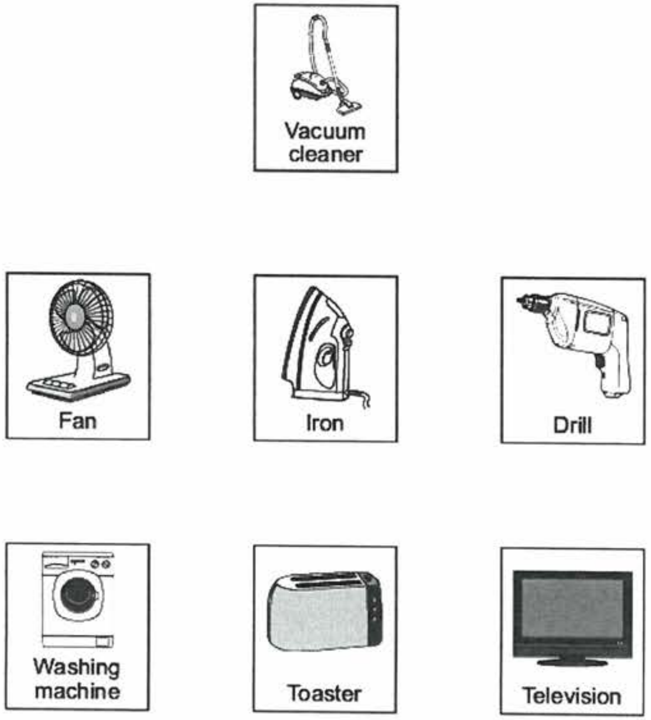
Increase in gravitational potential energy = _______________ J

(3)

(Total 10 marks)

Q9.

The appliances shown below transfer electrical energy to other types of energy.



(a) The vacuum cleaner is designed to transfer electrical energy to kinetic energy.

Three more of the appliances are also designed to transfer electrical energy to

kinetic energy. Which **three**?

Draw a ring around each correct appliance.

3

(b) Which **two** of the following statements are true?

Tick (✓) **two** boxes.

Appliances only transfer part of the energy usefully.	☐
The energy transferred by appliances will be destroyed.	☐
The energy transferred by appliances makes the surroundings warmer.	☐
The energy output from an appliance is bigger than the energy input.	☐

(2)

(Total 5 marks)

Q10.

Different energy sources are used to generate electricity.

(a) Use words from the box to match the correct energy source to each of the descriptions given in the table.

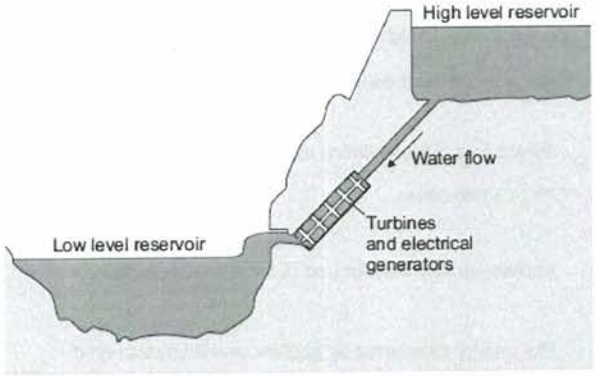
biofuel	coal	geothermal	nuclear	waves

Description	Energy source
Energy from the Earth's core is used to heat water.	
Fission of uranium nuclei is used to heat water.	
Gases from rotting plant material are burned to heat water.	

(3)

(b) Energy can be stored in a pumped storage power station.

The figure shows a pumped storage power station.



When electricity is needed, the water in the high level reservoir is allowed to flow to the low level reservoir. The flowing water generates electricity.

Use the correct answer from the box to complete each sentence.

electrical	**gravitational potential**	**kinetic**	**nuclear**	**sound**

The water in the high level reservoir stores ____________ energy.

The flowing water has ____________ energy.

The water turns the turbine which is connected to the generator.

The generator produces some ____________, this is wasted energy.

(3)

(c) The total power input to a pumped storage power station is 600 MW.

The useful power output is 540 MW.

(i) Calculate the efficiency of this pumped storage power station.

Efficiency = ____________

(2)

(ii) Calculate how much power is wasted by the pumped storage power station.

Power = ____________ MW

(1)

(iii) How is the temperature of the surroundings affected by the energy wasted by the pumped storage power station?

(1)

(Total 10 marks)

Q11.

Nuclear power stations generate electricity through nuclear fission. Electricity can also be generated by burning shale gas.

(a) Shale gas is natural gas trapped in rocks. Shale gas can be extracted by a process called fracking. There is some evidence that fracking causes minor earthquakes. Burning shale gas adds carbon dioxide to the atmosphere.

Describe the advantages of nuclear power compared with the use of shale gas to generate electricity.

(3)

(b) What is the name of **one** fuel used in nuclear power stations?

(1)

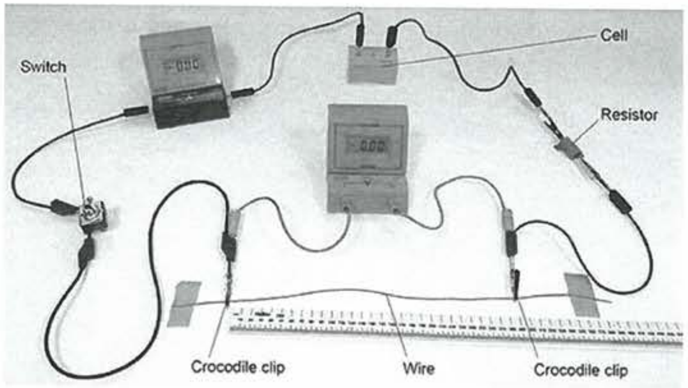
(c) Describe the process of nuclear fission.

(4)
(Total 8 marks)

Q12.

A student investigated how the length of a wire affects the resistance of the wire at constant temperature.

The figure below shows the circuit used.



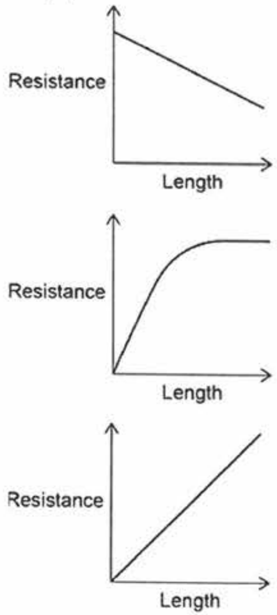
(a) The student plotted a graph of resistance against the length of wire.

Describe a method the student could have used to collect the data needed to plot the graph.

(6)

(b) Which graph shows the relationship between the resistance of a wire at constant temperature and its length?

Tick (✓) **one** box.



(1)

(c) The student used a cell that had a potential difference of 1.50 V.

Explain why the cell was **not** an electrical hazard to the student in the investigation.

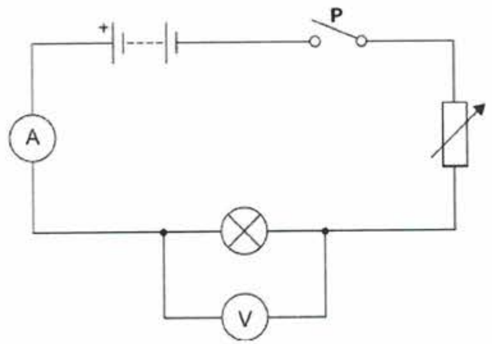
(2)
(Total 9 marks)

Q13.

A student investigated how the current in a filament lamp varies with the potential difference across the lamp.

Figure 1 shows the circuit used.

Figure 1



(a) What is component **P**?

______________________________ **(1)**

(b) Complete the sentences.

Choose answers from the box.

charge	**current**	**energy**	**potential difference**	**power**

The ammeter in the circuit measures ____________.

The voltmeter in the circuit measures ____________.

(2)

(c) How will **increasing** the resistance of the variable resistor in **Figure 1** affect each of the following quantities?

Tick (✓) **one** box in **each** row.

Quantity	Decreases	Stays the same	Increases
Current in the circuit			
Potential difference across the lamp			
Total resistance of the circuit			

(3)

(d) A charge flow of 15 coulombs passed through the filament lamp in a time of 60 seconds.

Calculate the current in the lamp.

Use the equation:

$$\text{current} = \frac{\text{charge flow}}{\text{time}}$$

Current = ____________ A

(2)

(e) When the current in the filament lamp is 0.12 A, the potential difference across the lamp is 6.0 V.

Calculate the resistance of the filament lamp.

Use the equation:

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

Resistance = ____________ Ω

(2)

(f) The student repeated the investigation after replacing the lamp with a resistor at constant temperature and then a diode.

The student plotted a graph for each component.

Draw **one** line from each component to its graph.

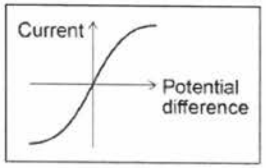
Component

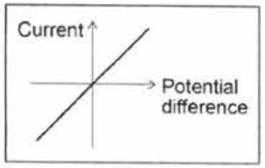
Diode

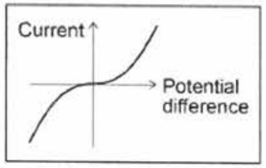
Filament lamp

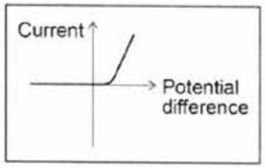
Resistor

Graph









(2)

(g) **Figure 2** shows an ammeter.

The ammeter is **not** connected to a circuit.

Figure 2

What type of error does the ammeter display?

Tick (✓) **one** box.

A positive error ☐

A random error ☐

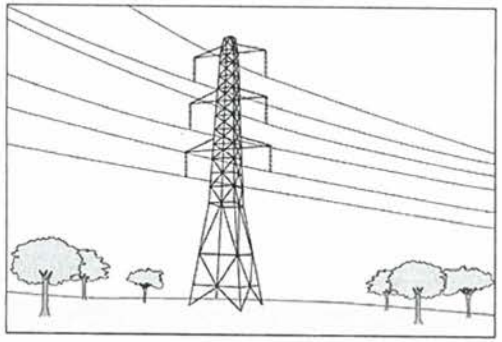
A zero error ☐

(1)
(Total 13 marks)

Q14.

Figure 1 shows some overhead power cables in the National Grid.

Figure 1



(a) Explain the advantage of transmitting electricity at a very high potential difference.

(3)

(b) It is dangerous for a person to fly a kite near an overhead power cable.

Figure 2 shows a person flying a kite.

Figure 2

The person could receive a fatal electric shock if the kite was very close to, but not touching the power cable.

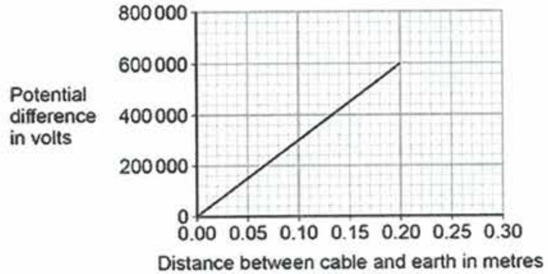
Explain why.

(3)

A scientist investigated how the potential difference needed for air to conduct charge varies with the distance between a cable and earth.

Figure 3 shows the results.

Figure 3



(c) The data in **Figure 3** gives the relationship between potential difference and distance when the air is dry.

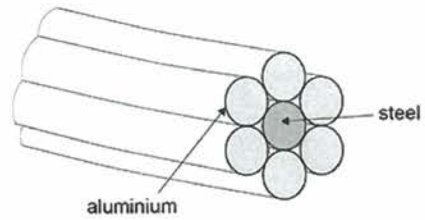
When the humidity of air increases the air becomes a better conductor of electricity.

Draw a line on **Figure 3** to show how the potential difference changes with distance if the humidity of the air increases.

(2)

(d) **Figure 4** shows a cross-section through a power cable.

Figure 4



A 1 metre length of a single aluminium wire is a better conductor than a 1 metre length of the steel wire.

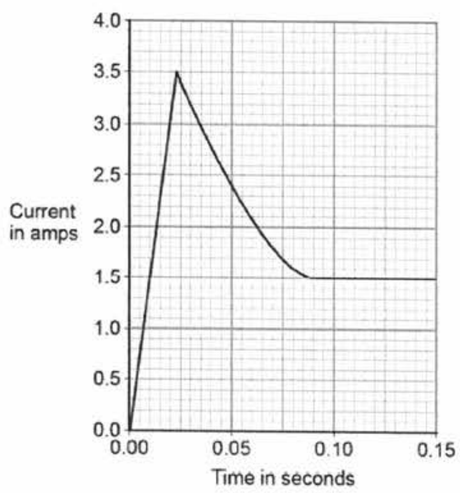
The individual wires behave as if they are resistors connected in parallel.

Explain why the current in the steel wire is different to the current in a single aluminium wire.

(2)
(Total 10 marks)

Q15.

The graph below shows how the current through a filament lamp changes after the lamp is switched on.



(a) The normal current through the filament lamp is 1.5 A.

For how many seconds is the current through the filament lamp greater than 1.5 A?

Tick **one** box.

0.01 s ☐

0.08 s ☐

0.09 s ☐

0.14 s ☐

(1)

(b) Why might the filament inside a lamp melt when the lamp is first switched on?

(1)

(c) The lamp is connected to a 24 V power supply. The current through the lamp is 1.5 A.

Calculate the power of the lamp.

Use the equation:

power = potential difference × current

Power = ______________ W

(2)

(d) LED lamps are much more efficient than filament lamps.

What does this statement mean?

Tick **one** box.

LED lamps have a similar power output to filament lamps.	☐
LED lamps waste a smaller proportion of the input energy than filament lamps.	☐
LED lamps have a higher power input than filament lamps.	☐
LED lamps waste a larger proportion of the input energy than filament lamps.	☐

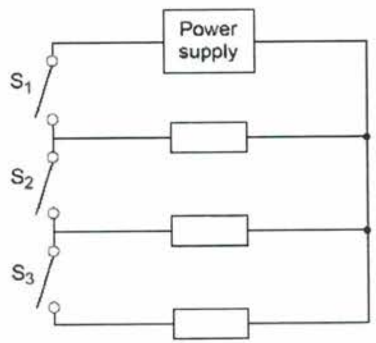
(1)
(Total 5 marks)

Q16.

A hair dryer contains three heating elements.

The figure below shows the circuit diagram for the heating elements in the hair dryer.

In the figure the heating elements are represented by resistor symbols.



(a) Complete the sentence.

The three resistors in above diagram are connected in ______________ with the power supply.

(1)

(b) Which switch must always be closed for the hair dryer to work?

Tick (✓) **one** box.

S_1	☐
S_2	☐
S_3	☐

(1)

(c) Which switches must be closed for the hair dryer to work at maximum power output?

Tick (✓) **one** box.

S_1 and S_2	☐
S_1 and S_3	☐
S_1, S_2 and S_3	☐

(1)

Use the Physics Equations Sheet to answer parts (d) and (e).

(d) Write down the equation which links energy transferred (*E*), power (*P*) and time (*t*).

____

(1)

(e) The heating elements have a maximum power output of 1200 W.

The energy transferred to the heating elements to reach normal operating temperature is 3600 J.

Calculate the time taken for the heating elements to reach normal operating temperature at maximum power output.

____

____

____

____

____

____

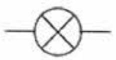
Time = __________ s

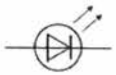
(3)

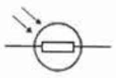
(f) The hair dryer has LEDs to indicate the power setting.

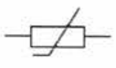
What is the circuit symbol for an LED?

Tick (✓) **one** box.

 ☐

 ☐

 ☐

 ☐

(1)
(Total 8 marks)

Q17.

A student investigated how the current in a circuit varied with the number of lamps connected in parallel in the circuit.

Figure 1 shows the circuit with three identical lamps connected in parallel.

Figure 1

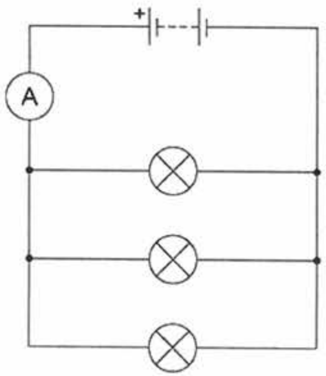
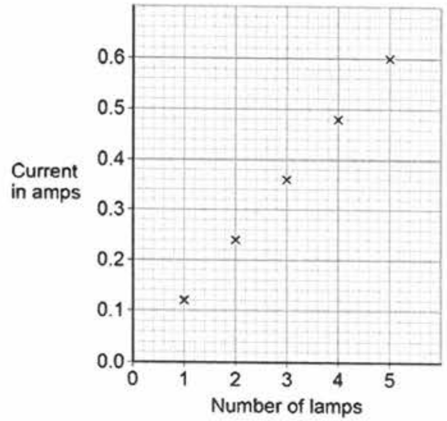


Figure 2 shows the results.

Figure 2



(a) Complete the sentences.

Choose answers from the box.

Each answer can be used once, more than once or not at all.

decreased	**stayed the same**	**increased**

As the number of lamps increased, the current ________________.

As the number of lamps increased, the total resistance of the circuit

________________ .

As the number of lamps increased, the potential difference across the battery

________________ .

(3)

(b) When there were three lamps in the circuit the ammeter reading kept changing between 0.35 A and 0.36 A.

What type of error would this lead to?

Tick (✓) **one** box.

Random error ☐

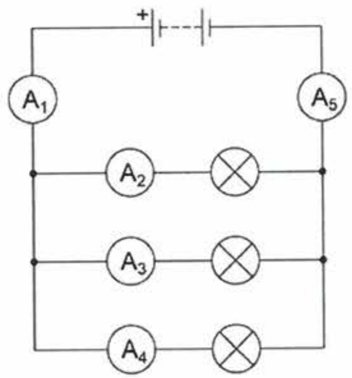
Systematic error ☐

Zero error ☐

(1)

Figure 3 shows a circuit with five ammeters and three identical lamps.

Figure 3



(c) Complete the table below to show the readings on ammeters A_2 and A_5.

Ammeter	**A_1**	**A_2**	**A_3**	**A_4**	**A_5**
Current in amps	0.36		0.12	0.12	

(2)

(d) The resistance of one lamp is 15 Ω.

The current in the lamp is 0.12 A.

Calculate the power output of the lamp.

Use the equation:

$$\text{power} = (\text{current})^2 \times \text{resistance}$$

Power = ______________ W

(2)

(Total 8 marks)

Q18.

(a) Complete the sentence. Choose answers from the box.

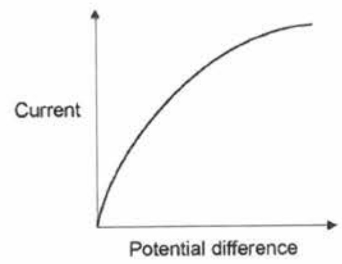
charge	**potential difference**	**power**	**temperature**	**time**

The current through an ohmic conductor is directly proportional to the ______________ across the component, provided that the ______________ remains constant.

(2)

(b) **Figure 1** shows a current − potential difference graph for a filament lamp.

Figure 1



Explain how the resistance of a filament lamp changes as the potential difference across it increases.

(3)

(c) Many householders are replacing their filament lamps with LED lamps which are more energy efficient.

What does more energy efficient mean?

___

___

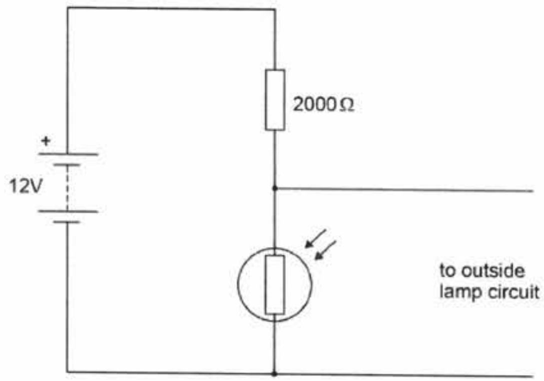
___

(1)

A Light Dependent Resistor (LDR) is used to turn on an outside lamp when it gets dark.

Part of the circuit is shown in **Figure 2**.

Figure 2



(d) The light intensity decreases.

What happens to the potential difference across the LDR and the current in the LDR?

Potential difference ___

Current ___

(2)

(e) What is the resistance of the LDR when the potential difference across it is 4 V?

Give a reason for your answer.

Explain your answer.

Resistance = ___ Ω

Reason ___

___

___

(2)

(f) Calculate the current through the LDR when the resistance of the LDR is 5000 Ω.

Give your answer to 2 significant figures.

___

___

___

___

Current = ___ A

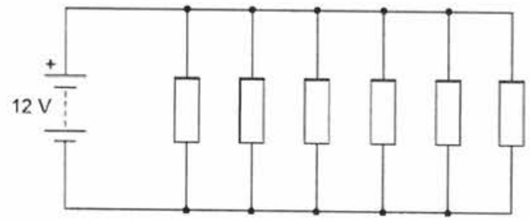
(4)

(Total 14 marks)

Q19.

The figure below shows an electrical circuit used to heat the windscreen of a car.

Each resistor in the circuit represents a heating element.



(a) The 12 V battery supplies direct potential difference.

What is meant by 'direct potential difference'?

___

___

___

(1)

Use the Physics Equations Sheet to answer parts (b) and (c).

(b) Which equation links charge flow (Q), energy (E) and potential difference (V)?

Tick (✓) **one** box.

$E = \frac{V}{Q}$ ☐

$E = QV$ ☐

$E = \frac{Q}{V}$ ☐

$E = \frac{V^2}{Q}$ ☐

(1)

(c) Calculate the charge flow through the 12 V battery when the battery transfers 5010 J of energy.

____

____

____

____

____

Charge flow = _______________ C

(3)

(d) Ice forms on the windscreen at a temperature of 0 °C.

The electrical circuit transfers 5010 J of energy to the ice.

A mass of 0.015 kg of ice melts.

Calculate the specific latent heat of fusion of water.

Use the Physics Equations Sheet.

____

____

____

____

____

Specific latent heat of fusion of water = _______________ J/kg

(3)

(e) The electrical circuit was left switched on while the ice changed from a solid to a liquid and increased in temperature to 5 °C.

Explain the changes in the arrangement **and** movement of the particles as the ice melted and the temperature increased to 5 °C.

____

____

____

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____

____

(6)

(Total 14 marks)

Q20.

Most electric kettles use the ac mains electricity supply.

(a) Complete the sentence.

The ac mains supply has a potential difference that continuously

_______________ polarity

(1)

Figure 1 gives the power output of three electric kettles.

Figure 1

A

2500 W

B

1800 W

C

2.8 kW

A student investigated how the power output of a kettle affected the time taken to boil a fixed volume of water.

The water in all three kettles had an initial temperature of 25 °C.

(b) What type of variable was the time?

Tick **one** box.

Control ☐

Dependent ☐

Independent ☐

(1)

(c) Which kettle will boil the water in the shortest time?

Give a reason for your answer.

Kettle ____________________

Reason ____________________

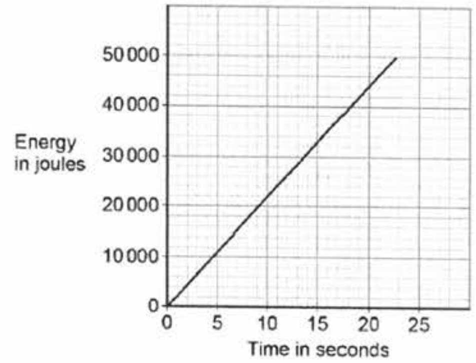
____

____

(2)

(d) **Figure 2** shows how the amount of energy transferred by a kettle varies with time.

Figure 2



The power output of the kettle is given by the gradient of the graph.

Calculate the power output of the kettle.

____

____

Power output = ____________ W

(2)

(e) Write down the equation that links charge flow, current and time.

____

(1)

(f) Calculate the current through the kettle when 2400 coulombs of charge flows in 250 seconds.

____

____

____

____

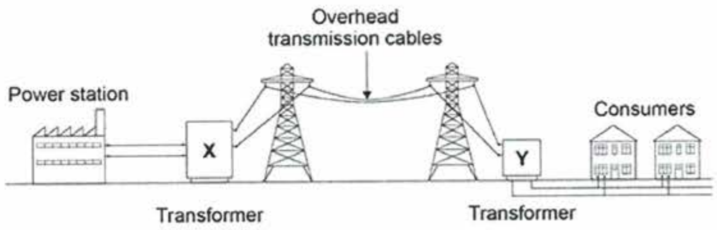
Current = ____________ A

(3)

(Total 10 marks)

Q21.

The figure below shows how electricity is supplied to consumers by the National Grid.



(a) Explain why transformer **X** is used in the National Grid.

(4)

(b) Explain why transformer **Y** is used in the National Grid.

(2)

(c) The town of Hornsdale in Australia has electricity supplied by a huge battery.

On one day the battery transferred 3.24×10^{11} J of energy to the town.

The potential difference of the town s electricity supply is 230 V.

Calculate the charge flow to the town on this day.

Use the Physics Equations Sheet.

Give your answer to **3** significant figures.

Charge flow (3 significant figures) = ____________ C

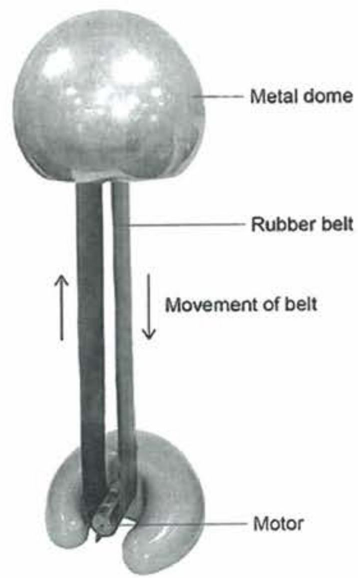
(4)

(Total 10 marks)

Q22.

Figure 1 shows a static electricity generator.

Figure 1



The rubber belt is turned by a motor.

As the rubber belt moves, charge is transferred from the rubber belt to the metal dome.

Figure 2 shows a student touching the metal dome of the static electricity generator.

The dome is negatively charged.

Figure 2

(a) Complete the sentence.

Choose the answer from the box.

negative	**neutral**	**positive**

When the student touches the negatively charged metal dome the student s hair

gains a ______________________ charge.

(1)

(b) Complete the sentence.

Choose the answer from the box.

attraction	**gravity**	**repulsion**

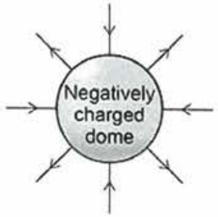
The hair on the student s head stands up because the strands of hair experience

forces of ______________________ .

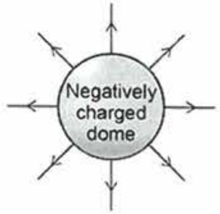
(1)

(c) Which of the following diagrams shows the electric field pattern around the negatively charged metal dome?

Tick (✓) **one** box.



☐



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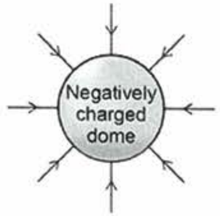
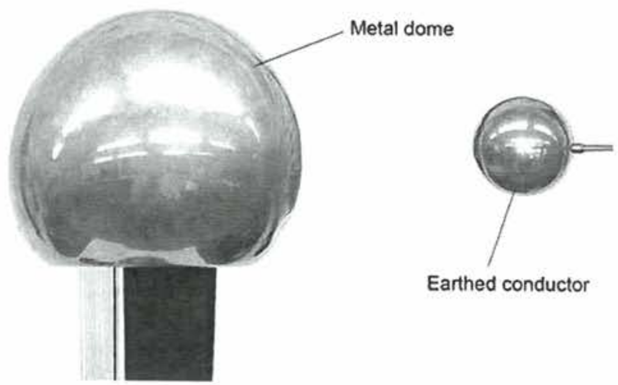


☐

(1)

Figure 3 shows the negatively charged metal dome and an earthed conductor.

Figure 3



(d) The air between the dome and the earthed conductor is an insulator.

Complete the sentence.

Choose the answer from the box.

efficiency	**resistance**	**temperature**

The air between the dome and the earthed conductor has

a high ____________________.

(1)

The earthed conductor is moved closer to the metal dome.

A spark jumps from the dome to the earthed conductor.

(e) Complete the sentence.

Choose the answer from the box.

earthed	**ionised**	**neutral**

The spark jumps because the air around the charged dome has

become ____________________.

(1)

(f) Which particles are transferred when the spark jumps from the negatively charged metal dome to the earthed conductor?

Tick (✓) **one** box.

Electrons ☐

Neutrons ☐

Protons ☐

(1)

(g) The potential difference between the metal dome and earth is 300 000 V.

When the spark jumps there is a charge flow of 0.000 002 C.

Calculate the energy transferred by the spark.

Use the equation:

energy transferred = charge flow × potential difference

____

____

____

Energy transferred = ____________________ J

(2)

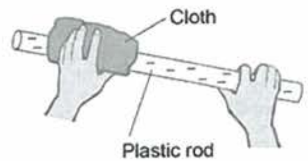
(Total 8 marks)

Q23.

Figure 1 shows a plastic rod being rubbed with a cloth.

The plastic rod becomes negatively charged.

Figure 1



(a) Complete the sentences.

Choose answers from the box.

Each answer may be used once, more than once or not at all.

electrons	**neutrons**	**protons**

The plastic rod becomes charged because it gains ____________________.

The cloth also becomes charged because it loses ____________________.

(2)

(b) What charge is left on the cloth?

Tick (✓) **one** box.

A negative charge ☐

A neutral charge ☐

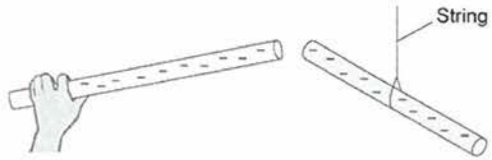
A positive charge ☐

(1)

(c) The negatively charged plastic rod is put near another negatively charged plastic rod that is hanging from a string.

Figure 2 shows the two rods.

Figure 2



What force is exerted on the two rods?

Tick (✓) **one** box.

Give a reason for your answer.

A force of attraction ☐

A force of repulsion ☐

There is no force ☐

Reason ______________________________

____

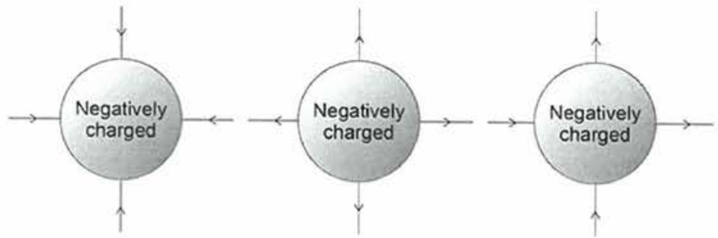
____

(2)

(d) There is an electric field around any charged object.

Which diagram shows the electric field pattern around a negatively charged sphere?

Tick (✓) **one** box.

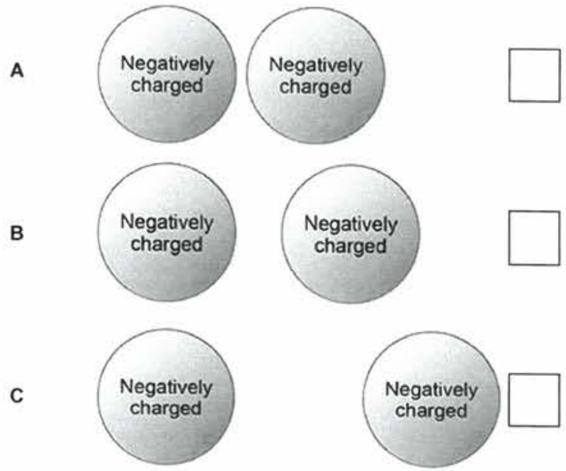


☐ ☐ ☐

(1)

(e) In which position do two charged spheres experience the greatest electrostatic force?

Tick (✓) **one** box.



(1)
(Total 7 marks)

Q24.

Figure 1 shows a student after rubbing a balloon on his hair.

The balloon and hair have become charged.

Figure 1

(a) Describe the force that acts on the student's hair in **Figure 1**.

(2)

(b) An earthed conductor was brought near the charged student.
A spark jumped between the conductor and the student.

The potential difference between the conductor and the student was 2.5 kV
The energy transferred by the spark was 0.0050 J

Calculate the charge transferred by the spark.

Charge = ____________ C

(3)

(c) A defibrillator can transfer a charge to regulate a person's heartbeat.

Figure 2 shows a defibrillator.

Figure 2

When the defibrillator is in use, a potential difference of 4800 V is applied across the person's chest.

A charge of 0.16 coulombs passes through the person's chest in 4.0 ms

Calculate the resistance of the person's chest.

Resistance = ____________ Ω

(5)

(Total 10 marks)

Q25.

(a) A student takes off his nylon fleece and feels a small electric shock.
He realises that this happens because his fleece becomes charged.

Explain why the fleece becomes charged.

(2)

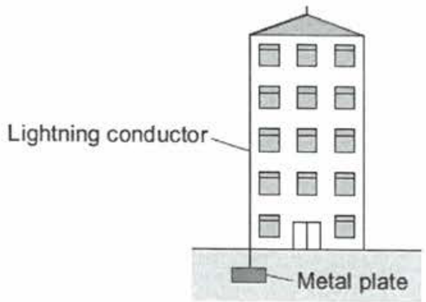
(b) Only **two** of the following statements are correct.

Put a tick (✓) in the boxes next to the **two** correct statements.

Positively charged objects repel negatively charged objects.	☐
Electrical charges move easily through metals.	☐
Static electricity is safe; it never causes any danger.	☐
An electric current is a flow of electrical charge.	☐

(2)

(c) The diagram shows a lightning conductor attached to the side of a tall building.



If the building is struck by lightning, charge flows to earth through the lightning conductor.

(i) Which of the materials in the list is used to make the lightning conductor?

Draw a ring around your answer.

copper **glass** **plastic**

Give a reason for your answer.

____

____

____

(2)

(ii) Complete the sentence by drawing a ring around the correct line in the box.

The resistance of the lightning conductor is

higher than the same as lower than	the resistance of the building.

(1)

(iii) It is almost impossible to test different designs of lightning conductor in controlled experiments during a lightning storm.

Suggest a reason why.

____

____

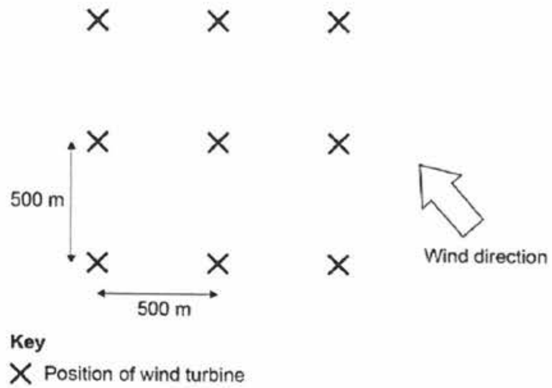
(1)

(Total 8 marks)

Q26.

The wind turbines in a wind farm must have a minimum distance of 500 m between them for maximum efficiency.

The diagram shows the position of nine wind turbines in a wind farm.



(a) Suggest **one** way in which the layout of this wind farm ensures maximum efficiency when the wind direction changes.

____

____

____ **(1)**

The average mass of air passing through the blades of one wind turbine is 51 000 kg per second.

The density of air is 1.2 kg / m^3

(b) Write down the equation that links density, mass and volume.

____ **(1)**

(c) Calculate the volume of air passing through the blades of one wind turbine in one second.

Give the unit.

Give your answer to 2 significant figures.

____

____

____

____

____

____

Volume in one second = ____________ Unit ____________ **(5)**

(d) The average power output from one of the wind turbines in the diagram is 1.6×10^6 W

The average power output of a nuclear power station is 2.4×10^9 W

Calculate the number of wind turbines needed to generate power equal to one nuclear power station.

____

____

____

Number of wind turbines = ____________ **(2)**

(e) The UK requires a minimum electrical power of 2.5×10^{10} W at any time.

Give **two** reasons why wind turbines alone are unlikely to be used to meet this requirement.

1. ____

____

2. ____

____ **(2)**

(Total 11 marks)

Q27.

(a) A company is developing a system which can heat up and melt ice on roads in the winter. This system is called 'energy storage'.

During the summer, the black surface of the road will heat up in the sunshine.

This energy will be stored in a large amount of soil deep under the road surface. Pipes will run through the soil. In winter, cold water entering the pipes will be warmed and brought to the surface to melt ice.

The system could work well because the road surface is black.

Suggest why.

____

____ **(1)**

(b) (i) What is meant by specific latent heat of fusion?

____

____

____

____ **(2)**

(ii) Calculate the amount of energy required to melt 15 kg of ice at 0 °C.

Specific latent heat of fusion of ice = 3.4×10^5 J/kg.

____

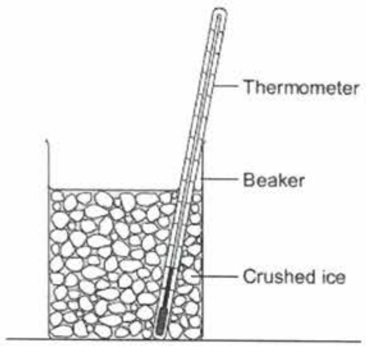
____

Energy = ____________ J **(2)**

(c) Another way to keep roads clear of ice is to spread salt on them. When salt is added to ice, the melting point of the ice changes.

A student investigated how the melting point of ice varies with the mass of salt added.

The figure below shows the equipment that she used.



The student added salt to crushed ice and measured the temperature at which the ice melted.

(i) State **one** variable that the student should have controlled.

____

____

(1)

(ii) During the investigation the student stirred the crushed ice.

Suggest **two** reasons why.

Tick (✓) **two** boxes.

	Tick (✓)
To raise the melting point of the ice	
To lower the melting point of the ice	
To distribute the salt throughout the ice	
To keep all the ice at the same temperature	
To reduce energy transfer from the surroundings to the ice	

(2)

(iii) The table below shows the data that the student obtained.

Mass of salt added in grams	0	10	20
Melting point of ice in °C	0	-6	-16

Describe the pattern shown in the table.

____

____

(1)

(d) Undersoil electrical heating systems are used in greenhouses. This system could also be used under a road.

A cable just below the ground carries an electric current. One greenhouse system has a power output of 0.50 kW.

Calculate the energy transferred in 2 minutes.

____

____

____

Energy transferred = ____________ J

(3)

(e) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

A local council wants to keep a particular section of a road clear of ice in the winter.

Describe the advantages and disadvantages of keeping the road clear of ice using:

- energy storage
- salt
- undersoil electrical heating.

____

____

____

____

____

____

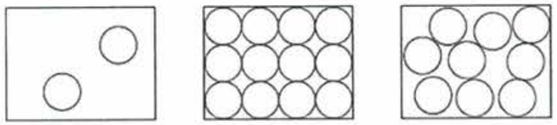
____

Extra space

(6)
(Total 18 marks)

Q28.

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



(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.

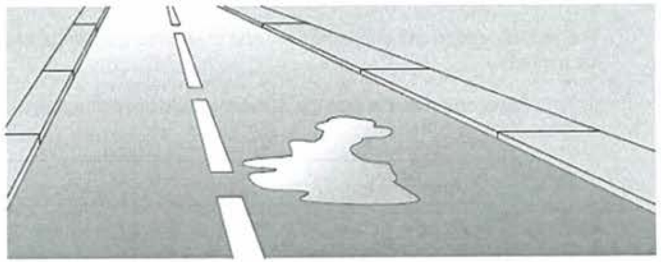
(i) In a gas, the particles are [vibrating in fixed positions. / moving randomly. / not moving.]

(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)

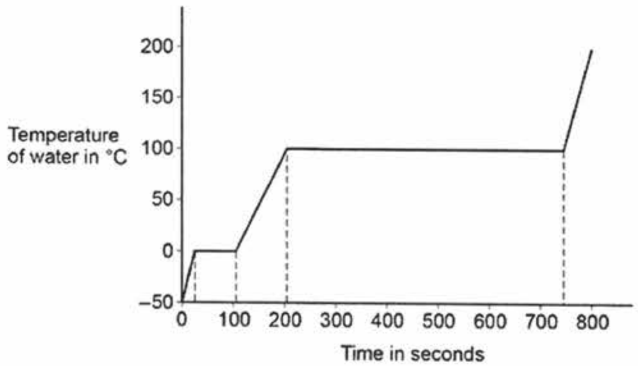
Q29.

A student investigated how the temperature of a lump of ice varied as the ice was heated.

The student recorded the temperature until the ice melted and then the water produced boiled.

The figure below shows the student's results.

The power output of the heater was constant.



(a) The specific heat capacity of ice is less than the specific heat capacity of water.

Explain how the figure above shows this.

____

____

____

____

(2)

(b) The specific latent heat of fusion of ice is less than the specific latent heat of vaporisation of water.

Explain how the figure above shows this.

____

____

____

____

(2)

(c) A second student did the same investigation and recorded the temperature until the water produced boiled.

In the second student's investigation more thermal energy was transferred to the surroundings.

Describe **two** ways the results of the experiment in the figure above would have been different.

1 ____

____

____

____

2 ____

____

____

____

(2)

(d) When the water was boiling, 0.030 kg of water turned into steam.

The energy transferred to the water was 69 kJ.

Calculate the specific latent heat of vaporisation of water.

Give the unit.

____

____

____

____

____

____

____

Specific latent heat of vaporisation = ______________

Unit ____________

(5)

(Total 11 marks)

Q30.

The table gives information about some methods of conserving energy in a house.

Conservation method	Installation cost in £	Annual saving on energy bills in £
Cavity wall insulation	500	60
Hot water tank jacket	10	15
Loft insulation	110	60
Thermostatic radiator valves	75	20

(a) Explain which of the methods in the table is the most cost effective way of saving energy over a 10 year period. To obtain full marks you must support your answer with calculations.

____

____

____

____

(3)

(b) Describe what happens to the energy which is 'wasted' in a house.

____

____

____

____

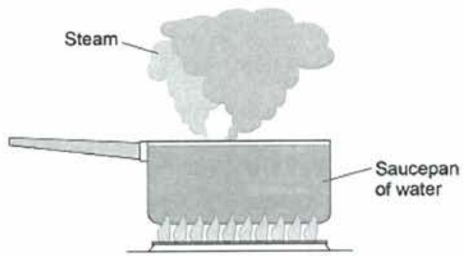
(2)

(Total 5 marks)

Q31.

Figure 1 shows water being heated. Eventually the water changed into steam.

Figure 1



(a) Complete the sentences.

Choose answers from the box.

Each answer may be used once, more than once or not at all.

greater than	less than	the same as

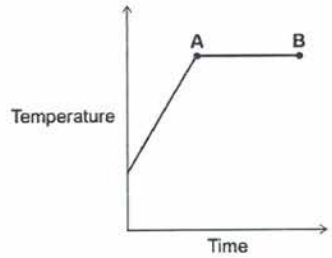
The distance between the particles in steam is ____________________ the distance between the particles in liquid water.

The density of steam is ____________________ the density of liquid water.

(2)

Figure 2 shows how the temperature of the water varied with time.

Figure 2



(b) What is the name of the process that is taking place between points **A** and **B**?

Give a reason for your answer.

Process ______________________________

Reason ______________________________

–

____

(2)

(c) A mass of 0.063 kg of water was turned into steam.

The specific latent heat of vaporisation of water is 2 260 000 J/kg

Calculate the thermal energy transferred to the water to turn it into steam.

Use the equation:

thermal energy for a change of state = mass ×specific latent heat

____

____

____

Energy = ______________________________ J

(2)

(d) The mass of the steam was 0.063 kg

The volume of the steam was 0.105 m^3

Calculate the density of steam.

Use the equation:

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

Choose the unit from the box.

kg	**m^3 / kg**	**kg / m^3**

____

____

____

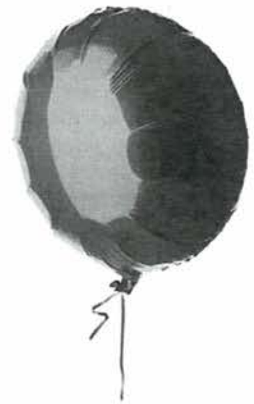
Density = ______________________________ Unit ______________________________

(3)

(Total 9 marks)

Q32.

The photograph below shows a balloon filled with helium gas.



(a) Which statements describe the movement of the gas particles in the balloon?

Tick (✓) **two** boxes.

The particles all move in a predictable way.	☐
The particles move at the same speed.	☐
The particles move in circular paths.	☐
The particles move in random directions.	☐
The particles move with a range of speeds.	☐
The particles vibrate about fixed positions.	☐

(2)

(b) The pressure of the helium in the balloon is 100 000 Pa.

The volume of the balloon is 0.030 m^3.

The balloon is compressed at a constant temperature causing the volume to decrease to 0.025 m^3.

No helium leaves the balloon.

Calculate the new pressure in the balloon.

New pressure = ______________ Pa

(4)

(c) The temperature of the helium in the balloon was increased.

The mass and volume of helium in the balloon remained constant.

Explain why the pressure exerted by the helium inside the balloon would increase.

(4)

(Total 10 marks)

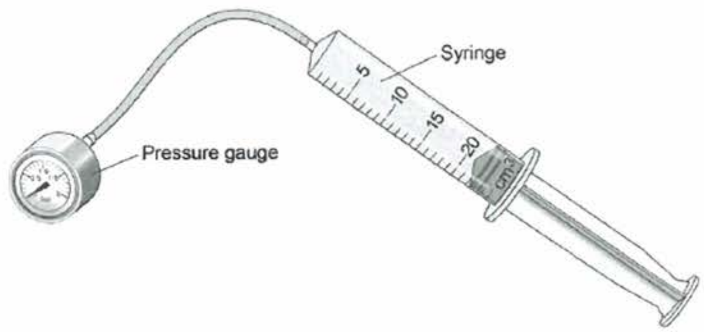
Q33.

A student investigated how the pressure of a gas varied with the volume of the gas.

The mass and temperature of the gas were constant.

Figure 1 shows the equipment the student used.

Figure 1



(a) What is the resolution of the syringe?

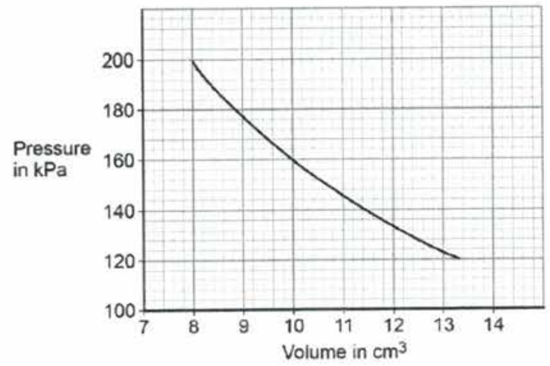
______________ cm^3

(1)

The student compressed the gas in the syringe and read the pressure from the pressure gauge.

Figure 2 shows the student's results.

Figure 2



(b) What conclusion can the student make from the data in **Figure 2**?

Use data from **Figure 2** in your answer.

Give the reason for your answer.

____

____

____

____

____

____

(3)

(c) Explain why the pressure in the gas increases as the gas is compressed.

____

____

____

____

____

____

____

____

____

____

(4)
(Total 8 marks)

Q34.

Some isotopes emit nuclear radiation.

(a) Carbon-12 and carbon-14 are both isotopes of carbon.

Complete the sentences.

Choose answers from the box.

alpha particles	**electrons**	**neutrons**	**protons**

The nucleus of a carbon-12 atom and the nucleus of a carbon-14 atom have the **same** number of ______________.

The nucleus of a carbon-12 atom and the nucleus of a carbon-14 atom have a **different** number of ______________.

(2)

(b) Different radioactive isotopes have different half-lives.

What does 'half-life' mean?

Tick (✓) **one** box.

- Half the time taken for all of the nuclei in a sample to decay. ☐
- The time taken for half the nuclei in a sample to decay. ☐
- The time taken for one nucleus to split in half. ☐

(1)

(c) **Table 1** shows the half-life of some different isotopes of carbon.

Table 1

Isotope	Half-life in seconds
Carbon-15	2.45
Carbon-16	0.75
Carbon-17	0.19
Carbon-18	0.09

Which isotope is the least stable?

Tick (✓) **one** box.

- Carbon-15 ☐
- Carbon-16 ☐
- Carbon-17 ☐
- Carbon-18 ☐

(1)

(d) Workers in nuclear power stations must be aware of nuclear irradiation and radioactive contamination.

Draw **one** line from each term to an example of the term.

Term	**Example**
	Exposure to a beam of gamma rays
Radioactive contamination	
	Exposure to ultraviolet radiation from the Sun
	Accidental transfer of plutonium onto a human body
Nuclear irradiation	
	Using a mobile phone

(2)

(e) Why are workers required to walk across a sticky floor before leaving the nuclear power station?

Tick (✓) **one** box.

To remove alpha particles from their shoes. ☐

To remove gamma radiation from their shoes. ☐

To remove radioactive dust from their shoes. ☐

(1)

(f) The places where people work and live contribute to the nuclear radiation they are exposed to.

Table 2 shows the mean daily dose of radiation caused by two different jobs.

Table 2

Job	Mean daily dose in mSv
Aeroplane pilot	0.072
Nuclear power station worker	0.00050

Calculate the number of days a nuclear power station worker must work before receiving the same dose that an aeroplane pilot receives in one day.

___

___

___

Number of days = ___

(2)

(g) The process of nuclear fission takes place in nuclear power stations.

The process of nuclear fusion takes place in the Sun.

Draw **one** line from each process to its fuel.

Process	**Fuel**
	Hydrogen
Nuclear fission	
	Iron
	Lead
Nuclear fusion	
	Uranium

(2)

(Total 11 marks)

Q35.

Scientists developed new models of the atom as new particles were discovered.

(a) Draw **one** line from each particle to the year it was discovered.

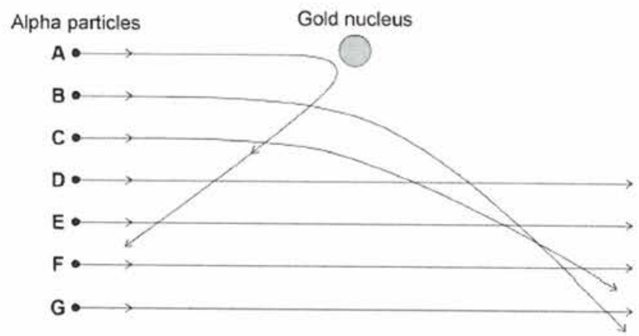
Particle	Year of discovery
Electron	1897
Neutron	1911
Nucleus	1920
Proton	1932

(2)

The nucleus was discovered using an alpha particle scattering experiment.

Alpha particles were directed at a sheet of gold foil.

The figure below shows the paths taken by seven alpha particles, **A**, **B**, **C**, **D**, **E**, **F** and **G**.



(b) Explain why alpha particle **A** takes the path shown in the figure above.

____

____

____

____

(2)

(c) Explain why the path of alpha particle **B** is more tightly curved than the path of alpha particle **C**.

____

____

____

____

(2)

(d) What can be deduced about the atom from the paths taken by alpha particles **D**, **E**, **F** and **G** in the figure above?

Tick (✓) **one** box.

The atom contains a nucleus. ☐

The atom contains protons, neutrons and electrons. ☐

The atom is mostly empty space. ☐

(1)

(e) How is the Bohr model of the atom different from the nuclear model of the atom?

____

____

____

(1)

(f) Explain how an electron can move up and down between energy levels in an atom.

____

____

____

____

(2)

(Total 10 marks)

Q36.

Some isotopes emit nuclear radiation.

(a) Carbon-14 and carbon-12 are isotopes of carbon.

Compare the structure of an atom of carbon-14 with the structure of an atom of carbon-12.

____

____

____

____

____

____

(3)

(b) Carbon-14 is a radioactive isotope.

Carbon-14 has a half-life of 5700 years.

What does 'a half-life of 5700 years' mean?

____

____

____

(1)

The table below gives the half-life of some other radioactive isotopes.

Isotope	Half-life in seconds
Nitrogen-18	0.62
Nitrogen-17	4.17
Fluorine-17	64.37
Fluorine-18	6584.34

(c) A sample of fluorine-17 has an activity that is one quarter of its original activity.

Calculate the age of the sample of fluorine-17.

____

____

____

Age = ____________ s

(2)

(d) All of the isotopes in the table above emit beta radiation.

Explain which isotope would cause the biggest risk to a person's health based only on the half-life of each isotope.

____

____

____

____

____

____

(3)

(e) People who work in the nuclear power industry need to be aware of irradiation and contamination.

Describe the difference between irradiation and contamination.

____

____

____

____

____

(2)

(f) Give **one** health risk to a person working close to a source of nuclear radiation.

____

(1)

(g) Workers in nuclear power stations are monitored to check the radiation they emit.

A worker stands 1 cm away from a radiation detector.

The amount of radiation the worker emits is recorded.

Explain why the worker needs to stand close to the radiation detector.

____

____

____

____

(2)

(h) Workers in the nuclear power industry are exposed to nuclear radiation.

Pilots on aircraft are exposed to cosmic radiation from space.

daily dose caused by working in a nuclear power station = 0.00050 mSv

hourly dose from cosmic rays to a pilot while flying = 0.0030 mSv

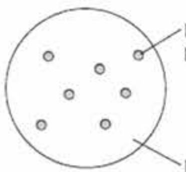
Calculate the number of days it takes for a nuclear power station worker to receive the same dose as a pilot flying for 24 hours.

Number of days = ____________

(3)
(Total 17 marks)

Q37.

(a) Over 100 years ago, scientists thought the atom was like a 'plum pudding'. The diagram below shows the plum pudding model of the atom.



The scientists knew that an atom has negatively charged particles. They also knew that an atom has no overall charge.

What did the scientists conclude about the **charge** on the 'pudding part' of the atom?

(1)

(b) Two scientists named Rutherford and Marsden devised an experiment to investigate the plum pudding model of the atom. The experiment involved firing alpha particles at a thin sheet of gold. The scientists measured how many of the alpha particles were scattered.

Using the plum pudding model, the scientists predicted that only a few of the alpha

particles would be scattered by more than 4°.

Over several months, more than 100 000 measurements were made.

(i) The results from this experiment caused the plum pudding model to be replaced by a new model of the atom.

Explain why.

(2)

(ii) Suggest **one** reason why other scientists thought this experiment provided valid evidence for a new model of the atom.

(1)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Describe the model now used for the structure of an atom.

In your answer you should:
- give details of the individual particles that make up an atom
- include the relative masses and relative charges of these particles.

Do **not** include a diagram in your answer.

(6)

(Total 10 marks)

Q38.

(a) Atoms of the isotope bismuth-212 decay by emitting either an alpha particle or a beta particle.
The equation represents what happens when an atom of bismuth-212 decays by beta emission into an atom of polonium-212.

$$^{212}_{83}\mathrm{Bi} \longrightarrow {}^{212}_{84}\mathrm{Po} + \text{beta particle}$$

(i) The bismuth atom and the polonium atom have the same mass number (212).

What is the *mass number* of an atom?

(1)

(ii) Beta decay does **not** cause the mass number of an atom to change.

Explain why not.

(2)

(b) When an atom of bismuth-212 emits an alpha particle, the atom decays into an atom of thallium.

An alpha particle is the same as a helium nucleus.
The symbol below represents an alpha particle.

$$^{4}_{2}\mathrm{He}$$

(i) The equation below represents the alpha decay of bismuth-212.

Complete the equation by writing the correct number in each of the two boxes.

$$^{212}_{83}\mathrm{Bi} \longrightarrow {}^{\boxed{}}_{\boxed{}}\mathrm{Tl} + {}^{4}_{2}\mathrm{He}$$

(2)

(ii) It is impossible for the alpha decay of bismuth-212 to produce the same element as the beta decay of bismuth-212.

Explain why.

(2)

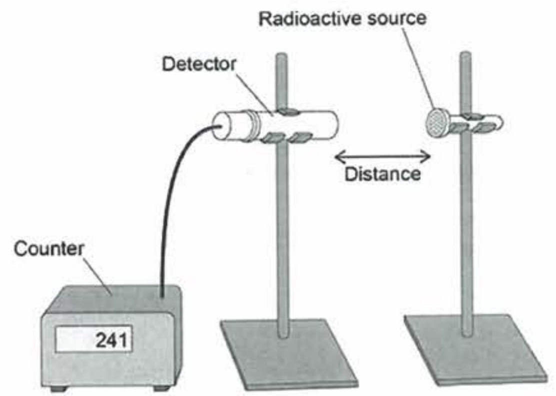
(Total 7 marks)

Q39.

A teacher investigated the radiation emitted by two different radioactive sources, **A** and **B**.

Figure 1 shows a radiation detector positioned near one of the radioactive sources.

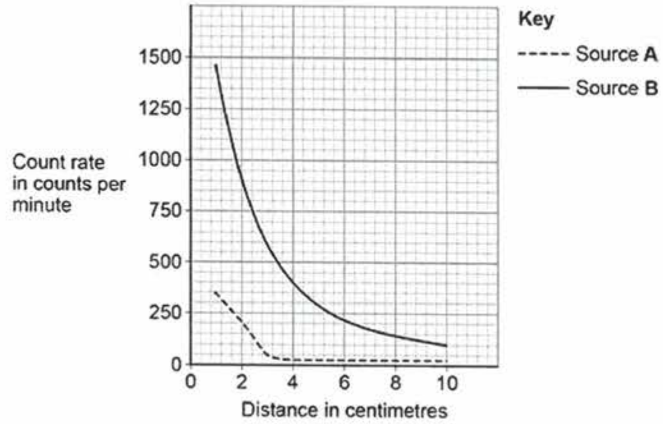
Figure 1



The teacher measured the count rate at different distances for each radioactive source.

Figure 2 shows the results.

Figure 2



(a) Explain how **Figure 2** shows that Source **A** only emits alpha radiation.

(3)

(b) **Figure 2** can **not** be used to determine if Source **B** emits beta radiation or gamma radiation.

Explain how an absorbing material could be used to show which type of radiation is emitted by Source **B**.

(2)

The teacher took safety precautions during the experiment.

(c) Suggest **one** safety precaution the teacher would have taken to reduce the radiation dose the teacher received.

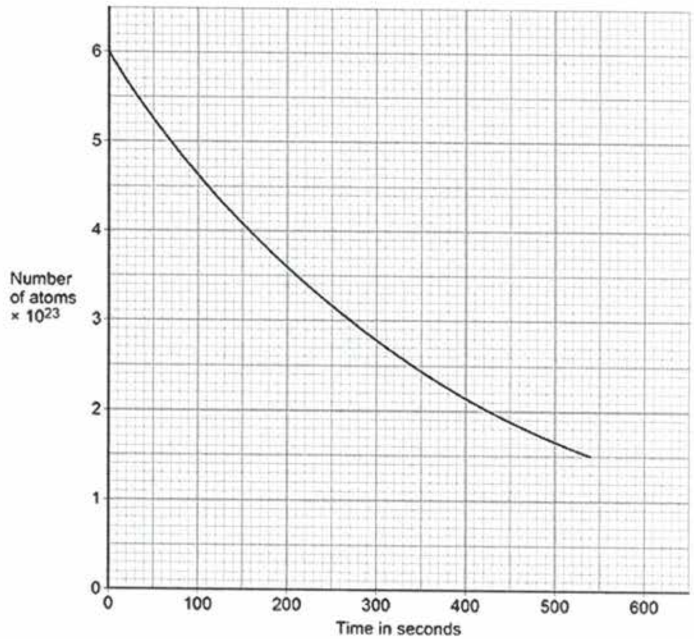
(1)

(d) Suggest **one** safety precaution that the teacher would have taken to avoid becoming contaminated.

(1)

(e) **Figure 3** shows how the number of atoms of a radioactive element in a sample varied with time.

Figure 3



Activity is the rate at which a source of unstable nuclei decays.

Determine the activity of the radioactive sample at 300 seconds.

Give the unit.

Activity = ______________ Unit ________

(4)
(Total 11 marks)

Q40.

Radioactive waste from nuclear power stations is a man-made source of background radiation.

(a) Give **one** other man-made source of background radiation.

(1)

Nuclear power stations use the energy released by nuclear fission to generate electricity.

(b) Give the name of **one** nuclear fuel.

(1)

(c) Nuclear fission releases energy.

Describe the process of nuclear fission inside a nuclear reactor.

(4)

(d) A new type of power station is being developed that will generate electricity using nuclear fusion.

Explain how the process of nuclear fusion leads to the release of energy.

(2)

(e) Nuclear fusion power stations will produce radioactive waste. This waste will have a much shorter half-life than the radioactive waste from a nuclear fission power station.

Explain the advantage of the radioactive waste having a shorter half-life.

(2)
(Total 10 marks)

Q41.

Nuclear fission and nuclear fusion are two processes that release energy.

(a) (i) Use the correct answer from the box to complete each sentence.

Geiger counter	**nuclear reactor**	**star**

Nuclear fission takes place within a ______________ .

Nuclear fusion takes place within a ______________ .

(2)

(ii) State **one** way in which the process of nuclear fusion differs from the process of nuclear fission.

(1)

(b) The following nuclear equation represents the fission of uranium-235 (U-235).

$$^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{236}_{92}U \longrightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n + \text{energy}$$

Chemical symbols:

Ba - barium

Kr - krypton

(i) Use the information in the equation to describe the process of nuclear fission.

____

____

____

____

____

____

____

____

(4)

(ii) An isotope of barium is Ba-139.
Ba-139 decays by beta decay to lanthanum-139 (La-139).

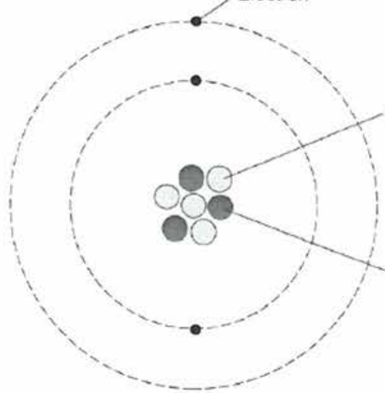
Complete the nuclear equation that represents the decay of Ba-139 to La-139.

$$ {}^{139}_{\_\_}\mathrm{Ba} \longrightarrow {}^{139}_{\_\_}\mathrm{La} + \_\_ $$

(3)
(Total 10 marks)

Q42.

The diagram shows a lithium atom.



(a) What is the mass number of this lithium atom?

Tick **one** box.

3 ☐ 4 ☐ 7 ☐ 10 ☐

(1)

(b) What is the atomic number of a lithium atom?

Tick **one** box.

3 ☐ 4 ☐ 7 ☐ 10 ☐

Give a reason for your answer.

____

____

(2)

(c) Complete the sentence.

Choose the answer from the box.

circles	**levels**	**rings**

The electrons in an atom orbit in different energy ____________ .

(1)

(d) Some atomic nuclei are unstable and decay by emitting an alpha particle or a beta particle.

Complete the symbols for an alpha particle and a beta particle.

Use answers from the box.

–1	**0**	**1**	**2**	**4**

Alpha $^{\square}_{\square}\mathrm{He}$

Beta $^{0}_{\square}\mathrm{e}$

(3)

(e) Doctors may use nuclear radiation to diagnose certain types of illness.

The table below gives data about three radiation sources used.

Each source emits beta radiation.

Radiation source	Half-life in minutes
Carbon-11	20
Nitrogen-13	10
Oxygen-15	2

Explain why oxygen-15 is likely to pose the least risk to a patient.

____

____

____

____

(2)

(Total 9 marks)

Q43.

Different radioactive isotopes have different values of half-life.

(a) What is meant by the 'half-life' of a radioactive isotope?

____

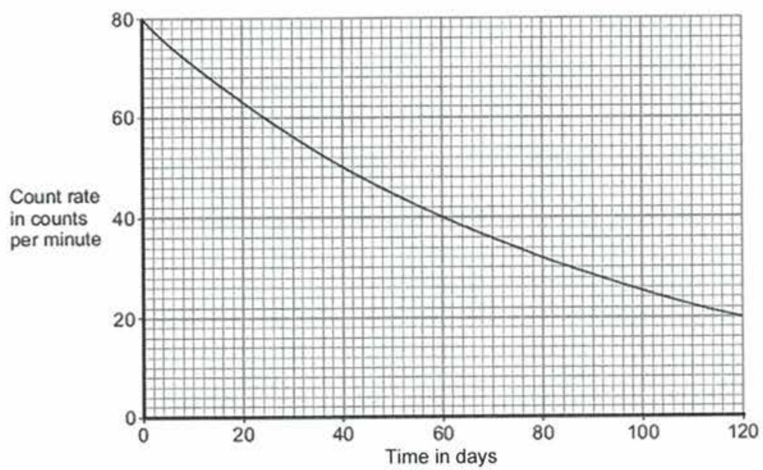
____

____

(1)

(b) **Figure 1** shows how the count rate from a sample of a radioactive isotope varies with time.

Figure 1



Use information from **Figure 1** to calculate the half-life of the radioactive isotope.

Show clearly on **Figure 1** how you obtain your answer.

Half-life = ______________ days

(2)

(c) The table below shows data for some radioactive isotopes that are used in schools.

Radioactive isotope	Type of radiation emitted	Half-life in years
Americium-241	Alpha and gamma	460
Cobalt-60	Gamma	5
Radium-226	Alpha, beta and	1600

	gamma	
Strontium-90	Beta	28
Thorium-232	Alpha and beta	1.4×10^{10}

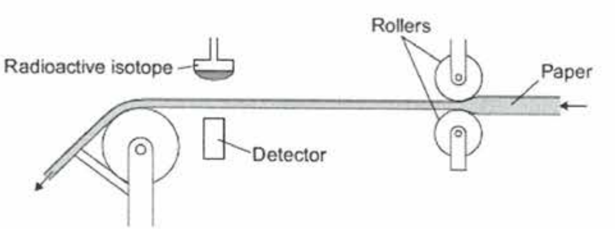
(i) State which radioactive isotope in the table above emits only radiation that is **not** deflected by a magnetic field.

Give a reason for your choice.

(2)

(ii) **Figure 2** shows a radioactive isotope being used to monitor the thickness of paper during production.

Figure 2



State which radioactive isotope in the table should be used to monitor the thickness of the paper.

Explain your choice.

(3)

All the radioactive isotopes in the table have practical uses.

State which source in the table would need replacing most often.

Explain your choice.

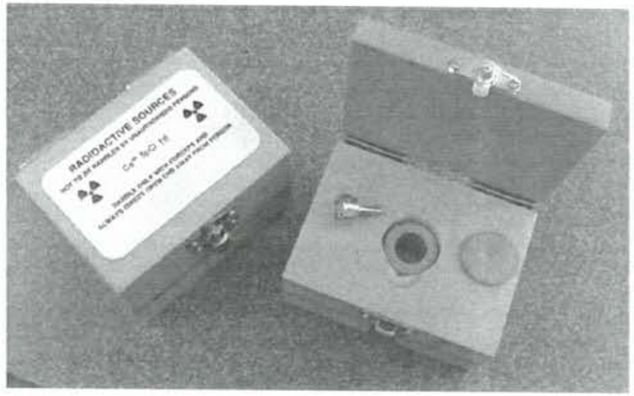
(3)

(iii) When the radioactive isotopes are not in use, they are stored in lead-lined wooden boxes.

The boxes reduce the level of radiation that reaches the surroundings.

Figure 3 shows two of these boxes.

Figure 3



State **one** source from the table which emits radiation that could penetrate the box.

Explain your answer.

(3)
(Total 14 marks)

Q44.

Atoms are different sizes.

One of the heaviest naturally occurring stable elements is lead.

Two of its isotopes are lead-206 ($^{206}_{82}Pb$) and lead-208 ($^{208}_{82}Pb$).

(a) (i) What is meant by 'isotopes'?

___

___

___

___

(2)

(ii) How many protons are in the nucleus of a $^{206}_{82}Pb$ atom?

___

(1)

(iii) How many neutrons are in the nucleus of a $^{206}_{82}Pb$ atom?

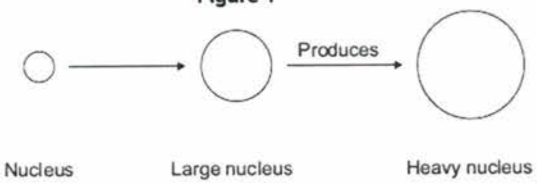
___

(1)

(b) A nucleus can be accelerated in a particle accelerator and directed at a large nucleus. This produces a heavy nucleus that will decay after a short time.

This is shown in **Figure 1**.

Figure 1



(i) In 1984, nuclei of iron (Fe) were directed at nuclei of lead (Pb). This produced nuclei of hassium (Hs).

Complete the equation for this reaction by writing numbers in the empty boxes.

$$^{58}_{\square}Fe + ^{\square}_{\square}Pb = ^{265}_{108}Hs + ^{1}_{0}X$$

(3)

(ii) Use the correct answer from the box to complete the sentence.

an electron	**a proton**	**a neutron**

The particle **X** in part (b)(i) is ___ .

(1)

(iii) After acceleration the iron nuclei travel at a steady speed of one-tenth of the speed of light.

The speed of light is 3.00×10^8 m/s.

Calculate the time taken for the iron nuclei to travel a distance of 12 000 m.

___

___

Time taken = ___ s

(2)

(iv) Linear accelerators, in which particles are accelerated in a straight line, are **not** used for these experiments. Circular particle accelerators are used.

Suggest why.

___

___

___

___

___

___

(3)

(c) Hassium-265 ($^{265}_{108}Hs$) decays by alpha emission with a half-life of 0.002 seconds.

(i) What is meant by 'half-life'?

Tick (✓) **two** boxes.

	Tick (✓)
The average time for the number of nuclei to halve	
The time for count rate to be equal to background count	
The time for background count to halve	
The time for count rate to halve	

(2)

(ii) Complete the equation for the decay of Hs-265 by writing numbers in the empty boxes.

$$^{265}_{108}\text{Hs} = ^{\square}_{\square}\text{Sg} + ^{\square}_{\square}\alpha$$

(2)

(d) The table below shows how the atomic radius of some atoms varies with atomic number.

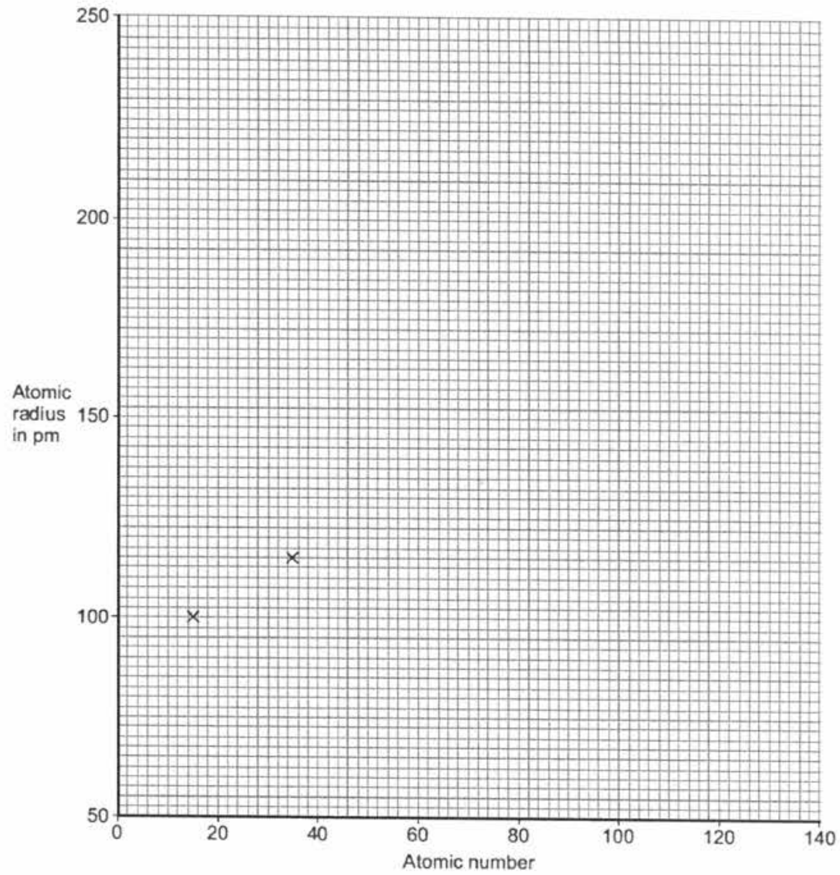
Atomic number	Atomic radius in picometres (pm)
15	100
35	115
50	130
70	150
95	170

1 pm = 10^{-12} m

(i) On **Figure 2**, use the data from the table above to plot a graph of atomic radius against atomic number and draw a line of best fit.

Two points have been plotted for you.

Figure 2



(2)

(ii) Scientists believe that the element with atomic number 126 can be produced and that it will be stable.

Use your graph in **Figure 2** to predict the atomic radius of an atom with atomic number 126.

Atomic radius = ____________________ pm

(1)
(Total 20 marks)

Q45.

(a) Nuclear fuels and the wind are two of the energy sources used to generate electricity in the UK.

Explain the advantages of using energy from nuclear fuels to generate electricity rather than using energy from the wind.

Include in your answer a brief description of the process used to generate electricity from nuclear fuels.

(4)

(b) In the UK, most electricity is generated in power stations that emit carbon dioxide into the atmosphere. The impact of these power stations on the environment could be reduced by the increased use of 'carbon capture' technology.

Describe how 'carbon capture' would prevent the build-up of carbon dioxide in the atmosphere.

(2)
(Total 6 marks)

Q46.

The first commercial nuclear power station in the world was built at Calder Hall in Cumbria.

The atoms produced by the fission of uranium are also radioactive. The used fuel is sent to a reprocessing plant where it can be safely treated.

(i) Calder Hall power station is next to the Sellafield reprocessing plant. Suggest an advantage of having the two plants close together.

(1)

(ii) One of the radioactive products is iodine-138. This has a half-life of 6 seconds. A sample of radioactive material contains 2000 atoms of iodine-138.

How long will it take for the number of iodine-131 atoms to decrease to 125?

Answer = ______________ seconds

(3)
(Total 4 marks)

Q1.

(a) chemical 1

kinetic 1

in this order only

(b) $E_k = 0.5 \times 80 \times 12^2$ 1

$E_k = 5760$ (J) 1

*an answer of 5760 (J) scores **2** marks*

(c) $E = 0.040 \times 480 \times 50$ 1

$E = 960$ (J) 1

*an answer of 960 (J) scores **2** marks*

(d) increased 1

[7]

Q2.

(a) $h = 1.75$ (m) 1

$E_p = 60 \times 9.8 \times 1.75$

allow a correct substitution using an incorrectly / not converted value of h 1

$E_p = 1029$ (J)

allow a correct calculation using an incorrectly / not converted value of h 1

$P = \frac{1029}{1.40}$

allow a correct substitution using their calculated value of E_p 1

$P = 735$ (W)

allow an answer consistent with their value for E_p 1

(b) girl increases her kinetic energy (as well as increasing her gravitational potential energy) 1

some energy is wasted in her muscles

or

some energy transferred as thermal energy (to surroundings)

allow some energy transferred due to air resistance

ignore unqualified references to friction

ignore references to sound 1

(c) the boy's mass was greater than the girl's mass 1

[8]

Q3.

(a) product of mass and velocity 1

(b) (i) 4kg or 4000g 1

(ii) M = 8kgm/s or Ns

for 3 marks

else M = 8

for 2 marks

else M – mv or 4 × 2

for 1 mark 3

(iii) 8 kgm/s (watch e.c.f.) 1

(iv) v = 400

for 3 marks

else v = 8/0.02

for 2 marks

else M – mv, v – M/m or 8 = 0.02v

for 1 mark 3

(v) ke = 8

for 3 marks

else ke = 1/2 (4×2^2)

for 2 marks

else ke = 1/2 (mv^2)

for 1 mark 3

(vi) transferred to heat and sound
or does work against wood/pushing wood aside/deforming bullet 1

[13]

Q4.

(a) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance.

0 marks
No relevant content.

Level 1(1-2 marks)
There is a basic explanation of **one** feature
or
a simple statement relating reduction in energy transfer to **one** feature.

Level 2(3-4 marks)
There is a clear explanation of **one** feature
or
a simple statement relating reduction in energy transfer to **two** features.

Level 3(5-6 marks)
There is a detailed explanation of at least **two** features
or
a simple statement relating reduction in energy transfer to all **four** features.

Examples of the points made in response

extra information

accept throughout:
heat for energy
loss for transfer

plastic cap:

- plastic is a poor conductor
  accept insulator for poor conductor
- stops convection currents forming at the top of the flask so stopping energy transfer by convection
- molecules / particles evaporating from the (hot) liquid cannot move into the (surrounding) air so stops energy transfer by evaporation
- plastic cap reduces / stops energy transfer by conduction / convection / evaporation

glass container:

- glass is a poor conductor so reducing energy transfer by conduction
- glass reduces / stops energy transfer by conduction

vacuum:

- both conduction and convection require a medium / particles
- so stops energy transfer between the two walls by conduction and

convection

- vacuum stops energy transfer by conduction / convection

silvered surfaces:

- silvered surfaces reflect infrared radiation
  accept heat for infrared
- silvered surfaces are poor emitters of infrared radiation
- infrared radiation (partly) reflected back (towards hot liquid)
- silvered surfaces reduce / stop energy transfer by radiation 6

(b) (the ears have a) small <u>surface</u> <u>area</u>
ears are small is insufficient 1

so reducing energy radiated / transferred (from the fox)
accept heat lost for energy radiated
*do **not** accept stops heat loss* 1

[8]

Q5.

(a) independent variable: (type of) insulation / material
do not accept thickness of material 1

dependent variable: time 1

(b) 0.1 (°C) 1

(c) viewing angle affects measurement
or
parallax error
allow judgement needed in reading the position (of the liquid in the thermometer)
allow the level of the liquid may be between lines
allow number of lines may be miscounted
ignore harder to read
ignore lines are close together
ignore human error 1

(d) E = 10 500(J) 1

$$m = \frac{10\,500}{4200 \times (85\text{-}65)}$$

*allow a correct substitution **and** rearrangement using an incorrectly / not converted value of E*

1

$m = 0.125$ (kg)

allow a correct calculation using an incorrectly / not converted value of E

1

(e) (same) temperature decrease in a shorter time means a higher thermal conductivity

allow converse answer

1

(because) the rate of energy transfer is higher

1

[9]

Q6.

(a) other energy resources = 95 (%)

1

hydroelectric = 5 (%)

1

(b) $E_p = 2\,500\,000 \times 9.8 \times 15$

1

$E_p = 367\,500\,000$ (J)
or
$E_p = 3.675 \times 10^8$ (J)

allow 370 000 000 (J)
or
$E_p = 3.7 \times 10^8$ (J)

1

(c) energy = power × time
or
$E = P \times t$

1

(d) $t = 3600$ (s)

1

$E = 3000 \times 3600$

allow a correct substitution using an incorrectly/not converted value for t

1

$E = 10\,800\,000$ (J)
or
$E = 1.08 \times 10^7$ (J)

allow an answer consistent with their incorrectly/not converted value for t

allow a correct answer given to 2 s.f.

1

(e) the level of the water in the river varies
or
the amount of rainfall varies

1

and is lower in the summer months

allow specified months or range of months eg April to September

1

MP2 dependent on scoring MP1

[10]

Q7.

(a) The energy transferred each second to the bulb.

1

(b) power = potential difference × current
or

$P = VI$

1

(c)

*an answer of 0.17 (A) scores **3** marks*

$40 = I \times 230$

1

$I = \dfrac{40}{230}$

1

$I = 0.17$ (A)

*a correct answer that rounds to 0.17 (A) scores **3** marks*

1

(d)

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

1

(e)

*an answer of 2.7 (W) scores **3** marks*

$$0.30 = \frac{\text{useful power output}}{9.0}$$

1

useful power output = 0.30×9.0

1

useful power output = 2.7 (W)

1

(f) bulbs also transfer thermal energy

allow light bulbs emit infrared radiation as well as visible light
ignore so people know how bright the bulb is 1

the efficiency of the light bulb also needs to be considered
allow the cost to power the light bulb depends on the efficiency
allow to see how much energy is wasted 1

[11]

Q8.

(a) $P = \frac{120000}{8.0}$ 1

$P = 15\,000$ (W) 1

*an answer of 15 000 (W) scores **2** marks*

(b) energy is transferred in heating the surroundings 1

friction causes energy to be transferred in non-useful ways 1

(c) the switches are in parallel 1

(so) closing either switch completes the circuit 1

(d) gravitational potential energy = mass × gravitational field strength × height
allow $E_p = m\,g\,h$ 1

(e) $E_p = 280 \times 9.8 \times 14$ 1

$E_p = 38\,416$ (J) 1

$E_p = 38\,000$ (J)
*an answer that rounds to 38 000 scores **2** marks* 1

*an answer of 38 000 scores **3** marks*

[10]

Q9.

(a) fan 1

drill 1

washing machine
*four circled including correct three scores **1** mark*
five circled scores zero 1

(b) Appliances only transfer part of the energy usefully 1

The energy transferred by appliances makes the surroundings warmer 1

[5]

Q10.

(a) geothermal 1

nuclear 1

biofuel 1

(b) gravitational (potential) 1

kinetic 1

sound 1

(c) (i) 90% or 0.9(0)
*an answer of 0.9(0) with a unit gains **1** mark* 2

(ii) 60 (MW)
allow 10% 1

(iii) increased 1

[10]

Q11.

(a) any **three** from:

- no carbon dioxide emitted (to produce electricity)
  no greenhouse gases is insufficient
- doesn't cause global warming
  allow climate change or greenhouse effect for global warming
- nuclear power doesn't cause earthquakes
- more energy released per kg of fuel (compared to shale gas)

3

(b) uranium
or
plutonium

ignore any numbers given 1

(c) a <u>neutron</u> is absorbed by a (large) nucleus

a description in terms of only atoms negates first two marking points 1

the nucleus splits into two (smaller) nuclei 1

releasing energy (and gamma rays) 1

and (two / three) neutrons 1

[8]

Q12.

(a) **Level 3**: The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced. 5–6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced. 3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear. 1–2

No relevant content 0

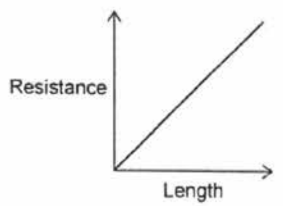
Indicative content

- measure the length of the wire (between the crocodile clips) using the ruler
- length varied by moving crocodile clips
- current measured with ammeter
- potential difference measured with voltmeter
- calculate resistance for each length
- use $V = IR$ to calculate resistance
- record current and pd for different lengths

- repeat readings of current and pd for each length and mean values calculated
- remove any anomalous readings
- ensure values of current are low to minimise heating of wire
- ensure circuit is disconnected between readings

Level 2:
Varying the length of the wire. Measurements / equipment needed for pd and current.

(b)



1

(c) potential difference is (very) low 1

(so) no risk of electric shock
or
(so) no risk of electrocution

allow less risk of electric shock
allow so wire won't melt
allow so wire won't get hot 1

[9]

Q13.

(a) switch 1

(b) current 1

potential difference

allow p.d.
allow voltage

in this order only 1

(c)

Quantity	Decrease	Stay the same	Increase
Current in the circuit	✓		
Potential difference across the lamp	✓		
Total resistance of the circuit			✓

any extra tick in a row negates the mark for that row 3

(d) $\text{current} = \frac{15}{60}$ 1

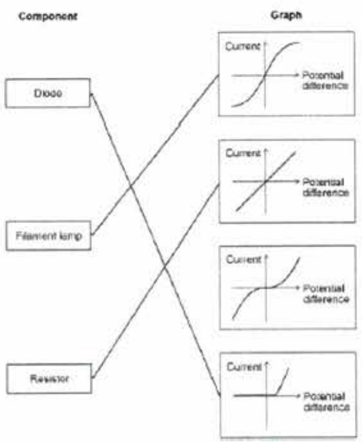
current = 0.25 (A)

1

(e) $R = \frac{6.0}{0.12}$ 1

$R = 50\ (\Omega)$ 1

(f)



2 marks for all 3 correct

1 mark for 1 or 2 correct

additional line from a box on the left negates the mark for that box 2

(g) a zero error 1

[13]

Q14.

(a) (very high p.d. means) very low currents 1

which means less (thermal) energy is transferred to surroundings
allow less power loss in cables 1

which increases the efficiency of power transmission 1

(b) electric field strength is very high 1

causing the air to become ionised
allow the air breaks down

allow the air becomes a conductor
allow the air conducts charge 1

(the kite / string) conducts charge to the person / earth
ignore answers referring to the kite touching the power cables 1

(c) straight line passing through the origin 1

line drawn below existing line for all values 1

(d) the potential difference across the wires/cable is the same 1

(but) the resistance of the steel wire is greater (and so less current in the steel) 1

[10]

Q15.

(a) 0.08 (s) 1

(b) the current goes higher than normal value
allow the current goes (too) high

or
the current goes higher than 1.5 A 1

(c) P = 1.5 × 24 1

P = 36 (W) 1

*an answer of 36 (W) scores **2** marks*

(d) LED lamps waste a smaller proportion of the input energy than filament lamps 1

[5]

Q16.

(a) parallel 1

(b) S_1 1

(c) S_1, S_2 and S_3 1

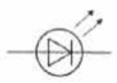
(d) energy transferred = power × time
or
$E = P \times t$

(e) 3600 = 1200 × t 1

$t = \frac{3600}{1200}$ 1

t = 3 (s) 1

(f)



1

[8]

Q17.

(a) increased 1

decreased 1

stayed the same 1

(b) random error 1

(c) A_2 = 0.12 (A) 1

A_5 = 0.36 (A) 1

(d) P = 0.12^2 × 15 1

P = 0.216 (W) 1

[8]

Q18.

(a) potential difference

allow p.d.

allow voltage

1

temperature 1

in this order only

(b) the current increases (when the potential difference increases) 1

(which) causes the temperature of the filament to increase 1

(so) the resistance increases

*do **not** accept resistance increases and then levels off*

1

(c) a higher proportion / percentage of the (total) power / energy input is usefully transferred

wastes less energy is insufficient

or

higher (useful) power / energy output for the same (total) power / energy input

1

(d) potential difference increases 1

current decreases 1

(e) 1000 (Ω)

reason only scores if R = 1000 (Ω)

1

potential difference is shared in proportion to the resistance

allow a justification using a correct calculation

1

(f) 12 = I × 7000 1

$I = \frac{12}{7000}$ 1

I = 1.71 × 10^{-3} (A)

*an answer that rounds to 1.7 × 10^{-3} (A) scores **3** marks*

1

I = 1.7 × 10^{-3} (A)

this answer only

or

I = 0.0017 (A)

*an answer of 2.4 × 10^{-3} (A) scores **2** marks*

*if no other marks scored allow **1** mark for calculation of total resistance (7000 Ω)*

1

*an answer of 1.7 × 10^{-3} (A) scores **4** marks*

[14]

Q19.

(a) polarity of the potential difference doesn't change

allow direction of the potential difference doesn't *change* 1

(b) $E = QV$ 1

(c) $5010 = Q \times 12$ 1

$Q = \frac{5010}{12}$ 1

$Q = 417.5$ (C)

allow 418 (C) 1

(d) $5010 = 0.015 \times L$ 1

$L = \frac{5010}{0.015}$ 1

$L = 334\ 000$ (J/kg) 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

- particles in a solid are in a regular pattern
- particles in a liquid are in a random arrangement

- particles in a solid are vibrating about fixed positions
- particles in a liquid are moving freely

- as the ice changes to water the temperature remains constant
- because as the ice changes to water the potential energy of the particles increases

- as the water warms the particles move faster
- so the kinetic energy of the particles increases

- internal energy is the total kinetic and potential energy of all the particles

ignore any references to density of ice vs liquid water
ignore any references to spacing of particles

[14]

Q20.

(a) changes

allow reverses 1

(b) dependent 1

(c) kettle **C**
or
2.8 kW 1

highest power (output)

allow higher power (output) 1

(d) values for gradient calculation shown on graph or on answer lines 1

power input = 2200 (W)

*accept an answer that rounds to 2200 (W) for **2** marks* 1

(e) charge flow = current × time

allow $Q = It$ 1

(f) $2400 = I \times 250$ 1

$I = \frac{2400}{250}$ 1

$I = 9.6$ (A)

an answer of 9.6 (A) scores 3 marks 1

[10]

Q21.

(a) transformer **X** increases potential difference 1

and decreases current

do not accept if student states that potential difference decreases 1

reducing (thermal) energy transfer to surroundings

do not accept no energy transfer to surroundings
or
reducing (thermal) energy transfer from transmission cables 1

increasing the efficiency (of power transmission) 1

(b) transformer **Y** decreases the potential difference 1

to a safe / safer value
dependent on scoring 1st marking point 1

(c) $3.24 \times 10^{11} = Q \times 230$ 1

$Q = \frac{3.24 \times 10^{11}}{230}$ 1

Q = 1408 695 652 (C) 1

$Q = 1.41 \times 10^{9}$ (C)
or
Q = 1 410 000 000 (C)
allow correct rounding of an incorrect answer using data from the question 1

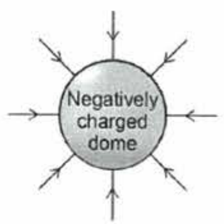
[10]

Q22.

(a) negative 1

(b) repulsion 1

(c)



1

(d) resistance 1

(e) ionised 1

(f) electrons 1

(g) energy transferred = 0.000 002 × 300 000 1

energy transferred = 0.6 (J) 1

[8]

Q23.

(a) electrons 1

electrons 1

(b) a positive charge 1

(c) a force of repulsion 1

the rods have the same charge
or
the rods are both negatively charged
dependent on scoring first marking point 1

(d)

1

(e)

1

[7]

Q24.

(a) non-contact (force)
allow electrostatic (force) 1

attraction (between hair and balloon)
allow repulsion between the hairs on the head 1

(b)

*an answer of 2.0×10^{-6} (C) scores **3** marks*
*an answer of 2×10^{-3} (C) scores **2** marks*

$0.0050 = Q \times 2500$

this mark may be awarded if pd is incorrectly or not converted 1

$Q = \frac{0.0050}{2500}$

this mark may be awarded if pd is incorrectly or not converted 1

$Q = 2.0 \times 10^{-6}$ (C)
or
$Q = 0.0000020$ (C)

these answers only 1

(c)

*an answer of 120 (Ω) scores **5** marks*

$0.16 = I \times 4.0 \times 10^{-3}$
or
$I = \frac{0.16}{4.0 \times 10^{-3}}$

this mark may be awarded if time is incorrectly / not converted 1

$I = 40$ (A)

this value only 1

$4800 = 40 \times R$

allow 4800 = their calculated I × R 1

$R = \frac{4800}{40}$

allow R = 4800 / their calculated I 1

$R = 120$ (Ω)

allow an answer consistent with their calculated I 1

[10]

Q25.

(a) fleece rubs against shirt

it refers to the fleece 1

or

friction (between fleece and shirt)

(causing) <u>electrons</u> to transfer from one to the other

accept a specific direction of transfer
*do **not** accept charge for electrons*
positive electrons negates this mark
movement of protons negates this mark 1

(b) Electrical charges move easily through metals. 1

An electric current is a flow of electrical charge. 1

(c) (i) copper

reason only scores if copper chosen 1

(good electrical) conductor

accept it is a metal
any mention of heat conduction negates this mark 1

(ii) lower than 1

(iii) accept any sensible suggestion,eg:

- too many variables (to control)
- lightning strikes / storms are random / unpredictable
- do not know which building will be struck
- do not know when a building will be struck
- do not know when lightning will happen
- (very) difficult to create same conditions in a laboratory
- lightning storms are not the same

it is not safe is insufficient
*do **not** accept lightning does not strike the same place twice* 1

[8]

Q26.

(a) minimum distance between wind turbines is at least 500 m in all directions

turbines can rotate to face into wind and still maintain the minimum distance 1

(b) density = mass/volume

allow $\rho = m / V$ 1

(c) $1.2 = \frac{51000}{V}$ 1

$V = \frac{51000}{1.2}$ 1

V = 42 500 1

V = 43 000 1

m^3

*an answer of 43 000 scores **4** marks*
*an answer of 42 500 scores **3** marks* 1

(d) $2.4 \times 10^9 / 1.6 \times 10^6$ 1

1500

*an answer of 1500 scores **2** marks* 1

(e) wind power is unreliable 1

(very) large numbers of wind turbines would need to be constructed

allow calculation of this (15 625) 1

[11]

Q27.

(a) (black) is a good absorber of (infrared) radiation 1

(b) (i) amount of energy required to change (the state of a substance) from solid to liquid (with no change in temperature)

melt is insufficient 1

unit mass / 1kg 1

(ii) 5.1×10^6 (J)

accept 5×10^6

*allow **1** mark for correct substitution ie $E = 15 \times 3.4 \times 10^5$* 2

(c) (i) mass of <u>ice</u>

allow volume / weight / amount / quantity of <u>ice</u> 1

(ii) to distribute the salt throughout the ice 1

to keep all the ice at the same temperature 1

(iii) melting point decreases as the mass of salt is increased

allow concentration for mass

accept negative correlation

*do **not** accept inversely proportional* 1

(d) 60 000 (J)

accept 60 KJ

*allow **2** marks for correct substitution ie $E = 500 \times 2.0 \times 60$*

*allow **2** marks for an answer of 1000 **or** 60*

*allow **1** mark for correct substitution ie*

*$E = 500 \times 2.0$ **or** $0.50 \times 2.0 \times 60$*

*allow **1** mark for an answer of 1* 3

(e) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
There is *an attempt at a description of some advantages or disadvantages.*

Level 2 (3–4 marks)
There is a basic description of *some advantages **and / or** disadvantages for some of the methods*

Level 3 (5–6 marks)
There is a clear description of the advantages and disadvantages of all the methods.

examples of the points made in the response

extra information

energy storage

advantages:

- no fuel costs
- no environmental effects

disadvantages:

- expensive to set up and maintain
- need to dig deep under road
- dependent on (summer) weather

- digging up earth and disrupting habitats

salt spreading

advantages:

- easily available
- cheap

disadvantages:

- can damage trees / plants / drinking water / cars
- needs to be cleaned away

undersoil heating

advantages:

- not dependent on weather
- can be switched on and off

disadvantages:

- costly
- bad for environment

6

[18]

Q28.

(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]

Q29.

(a) the gradient for ice is steeper than the gradient for water (liquid)

allow the temperature of the ice increased faster than the temperature of the water

1

which means that less energy is needed to increase the temperature by a fixed amount

1

(b) water took more time to vaporise than the ice took to melt

1

which means that less energy is needed to change the state from solid to liquid (than from liquid to vapour)

1

(c) any **two** from:

- ice/water would take more time to increase in temperature
  allow gradients would be less steep
- ice/water would take more time to change state
- the change in temperature with time would not be linear
  allow horizontal lines would be longer

2

(d) $E = 69\,000$ (J)

1

$69\,000 = 0.030 \times L$

allow a correct substitution of an incorrectly/not converted value of E

1

$$L = \frac{69\,000}{0.030}$$

allow a correct rearrangement using an incorrectly/not converted value of E

1

$L = 2\,300\,000$
or
$L = 2.3 \times 10^6$

allow a correct calculation using an incorrectly/not converted value of E

1

J/kg

allow a unit consistent with their numerical answer

eg 2300 kJ/kg

1

[11]

Q30.

(a) loft insulation 1

energy saved in 10 years £600 1

net saving (600 – 110) £490 1

OR

hot water jacket 1

energy saved in 10 years £140 1

This is the highest percentage saving on cost 1

(b) transferred to environment / surroundings 1

as heat / thermal energy 1

[5]

Q31.

(a) greater than 1

less than 1

in this order only

(b) <u>boiling</u>

ignore evaporation 1

temperature is constant

allow temperature remains the same 1

(c)

*a correct answer that rounds to 140 000 (J) scores **2** marks*

E = 0.063 × 2 260 000 1

E = 140 000 (J)

allow 142 380 (J) 1

(d)

*an answer of 0.6 scores **2** marks*

$\text{density} = \frac{0.063}{0.105}$ 1

density = 0.6 1

kg / m³ 1

[9]

Q32.

(a) The particles move in random directions. 1

The particles move with a range of speeds. 1

(b) 100 000 × 0.030 = 3000 1

p × 0.025 = 3000

allow a correct substitution using an incorrectly calculated value using pV = constant 1

$p = \frac{3000}{0.025}$

allow a correct rearrangement using an incorrect value of the constant 1

p = 120 000 (Pa)

allow a correct calculation using an incorrect value of the constant

allow correct substitution into $p_1V_1 = p_2V_2$ for first 2 marking points 1

(c) particles would have a higher (mean) kinetic energy

allow particles would have a higher (mean) speed

do not accept particles vibrate more 1

(so) increased number of collisions with the walls of the balloon per second

allow greater frequency of collisions with the walls of the balloon 1

greater forces exerted in collisions (between particles and balloon walls)

allow greater rate of change of momentum (of particles) 1

greater force exerted on same area

allow description using p=F/A 1

[10]

Q33.

(a) 1 (cm³)

1

(b) pressure is inversely proportional to volume 1

data to prove inversely proportional relationship

eg 8 × 200 = 1600

and 10 × 160 = 1600

*if no other marks score allow for **1** mark: as volume decreases pressure increases* 2

(c) (as the gas is compressed) the volume of gas decreases 1

(so there are) more frequent collisions of gas particles with container walls 1

(and) each particle collision with the wall causes a force 1

(so there is a) greater force on walls 1

[8]

Q34.

(a) protons

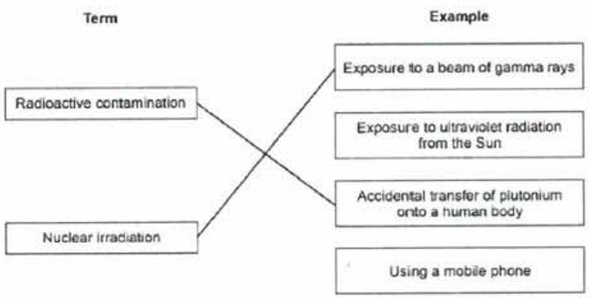
this order only 1

neutrons 1

(b) the time taken for half the nuclei in a sample to decay 1

(c) carbon-18 1

(d)



1 mark for each correct line

additional line from a box on the left negates the mark for that box

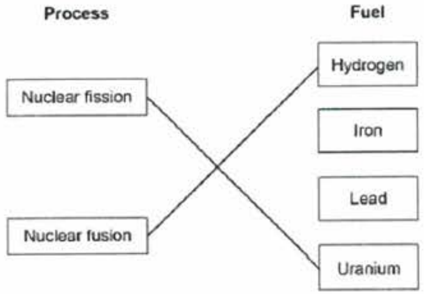
2

(e) to remove radioactive dust from their shoes 1

(f) number of days = $\frac{0.072}{0.00050}$ 1

number of days = 144 1

(g)



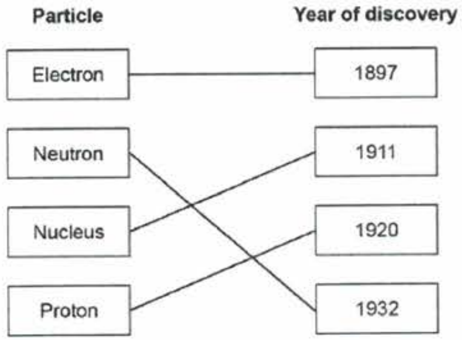
1 mark for each correct line

additional line from a box on the left negates the mark for that box 2

[11]

Q35.

(a)



4 correct for 2 marks

2 or 3 correct for 1 mark

additional line from a box on the left negates the mark for that box 2

(b) both the alpha particles and the (gold) nucleus have positive / same charge

*'it' is alpha particle **A***

allow alpha particles and protons have positive / same charge

1

so the alpha particle and the gold nucleus repel each other

allow like charges repel

ignore deflection (this refers to the path taken not the force)

1

(c) particle **B** passes closer to the nucleus

*'it' is particle **B***

1

so experiences a stronger (repulsive) force
or
so experiences a stronger electric field

*any mention of particle **B** colliding with the nucleus scores zero*

1

(d) the atom is mostly empty space

1

(e) in the Bohr model the electrons orbit (the nucleus) at specific distances (whereas in the nuclear model the electrons can orbit at a continuous range of distances)

allow energy levels or shells for specific distances

1

(f) to move to a higher energy level an electron absorbs energy from electromagnetic radiation

allow absorbs energy by collision with another electron allow EM radiation for electromagnetic radiation

1

to move to a lower energy level an electron emits energy in the form of electromagnetic radiation

1

if no other mark scored allow 1 mark for an electron changes energy level by emitting or absorbing electromagnetic radiation

[10]

Q36.

(a) Similarities:

- same number of protons

or
same atomic number

allow both atoms / nuclei contain 6 protons

1

- same number of electrons

1

Difference:

- different number of neutrons

or
different mass number

*allow carbon-12 has 6 neutrons **and** carbon-14 has 8 neutrons*

1

(b) the time it takes for the number of nuclei (in a radioactive sample) to halve (is 5700 years)

allow atoms for nuclei

or
the time it takes for the activity (of a radioactive sample) to halve (is 5700 years)

ignore radioactivity

or
the time it takes for the radiation emitted (by a radioactive sample) to halve (is 5700 years)
or
the time it takes for the count rate (of a radioactive sample) to halve (is 5700 years)
or
the time it takes for the mass of carbon-14 (in a sample) to halve (is 5700 years)

1

(c) 2 half-lives

1

128.74 (s)

allow 129 (s)

1

(d) nitrogen-18

1

greatest activity

MP2 and MP3 dependent on scoring MP1

allow emits most radiation per second

allow emits most radiation in a given time period

ignore shortest half-life

1

(so) greatest dose of radiation absorbed (per second)

1

(e) irradiation is the exposure of an object / person to radiation

allow 'absorption of radiation' for 'exposure'

allow specific examples of ionising radiation

1

(while) contamination is the (unwanted) presence of radioactive material / atoms on an object / person *allow 'inside a person' for 'on an object / person'* 1

(f) any **one** from:

- cancer / tumours
- DNA / genetic mutation
  ignore mutates cells
- damages / kills cells
- radiation poisoning / sickness / burns
  ignore death

1

(g) some radioactive materials emit alpha radiation 1

which has a (very) short range (in air)
MP2 dependent on scoring MP1 allow weakly penetrating for short range (in air) 1

(h) pilot's dose in 24 hours = 0.072 (mSv) 1

number of days = $\frac{0.072}{0.00050}$ 1

number of days = 144

OR

nuclear power worker hourly dose = 0.0000208... (mSv) (1)

number of days = $\frac{0.0030}{0.0000208}$ (1)

number of days = 144 (1)

OR

$\frac{\text{hourly dose}}{\text{daily dose}} = \frac{0.0030}{0.00050} = 6$ (1)

number of days = 6 × 24 (1)

number of days = 144 (1)

1

[17]

Q37.

(a) (an equal amount of) positive charge
*do **not** accept charge on the atom / nucleus is positive* 1

(b) (i) a (significant) number of alpha particles were scattered by more than 4°
or

alpha particles deflected backwards
accept (some) measurements / results were unexpected 1

measurements / results could not be explained by 'plum pudding' model
or
measurements / results did not support predictions
can be explained by the nuclear model is insufficient
accept measurements / results did not support hypothesis 1

(ii) many / (over)100 000 measurements / results taken
accept Rutherford(and Marsden) were respected scientists
or
scientists were respected
accept measurements / results taken over several months
the experiment was repeated many times is insufficient 1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a 'best-fit' approach to the marking.

0 marks
no relevant content

Level 1 (1–2 marks)
A brief description is given with some particles correctly named

Level 2 (3–4 marks)
A description is given with all three particles named
plus either
the polarity of charge associated with the three particles
or
the relative mass of the three particles
or
the relative mass for one particle and the relative charge for one particle given

Level 3 (5–6 marks)
A more detailed description is given, naming the particles and polarity of charge
and either
the relative mass is given for at least two particles
or
the relative charge is given for at least two particles

Examples of the points made in the response

brief description

contains protons, neutrons and electrons

protons are positive
electrons are negative

neutrons are uncharged

has a nucleus

relative charge

proton +1
electron − 1
neutron 0

relative mass

proton 1
neutron 1
electron (about) 1 / 2000

accept protons and neutrons have the same mass

accept electrons have tiny / negligible mass
zero mass is neutral

more detailed description

protons and neutrons make up the nucleus
electrons orbit the nucleus
electrons are in shells
most of the atom is empty space
nucleus occupies a very small fraction of the volume of the atom
electrons orbit at a relatively large distance from the nucleus
most of the mass of the atom is contained in the nucleus
the nucleus as a whole is positively charged total number of protons in the nucleus equals the total number of electrons orbiting it in an atom

6

[10]

Q38.

(a) (i) (total) number of protons plus neutrons

accept number of nucleons

accept amount for number

do not accept number of particles in the nucleus

1

(ii) number of neutrons decreases by one

1

number of protons increases by one

accept for both marks a neutron changes into a proton

1

(b) (i) $^{208}_{81}\text{Th}$

1

correct order only

1

(ii) the number of protons determines the element

accept atomic number for number of protons

1

alpha and beta decay produce different changes to the number of protons

there must be a comparison between alpha and beta which is more than a description of alpha and beta decay alone

or

alpha and beta decay produce different atomic numbers

ignore correct reference to mass number

1

[7]

Q39.

(a) radiation (from source **A**) travels (approximately) 3 cm (in air)

1

(after which) count rate decreases to background radiation

1

(because) alpha radiation has a short range (in air)

allow alpha radiation has (very) low penetrating ability

allow beta <u>and</u> gamma radiation have a (much) longer range in air

1

(b) use an aluminium sheet

allow other materials that beta would be stopped by e.g. brick, sheets of iron / lead, etc.

ignore sheet(s) of metal foil unless thickness is given

1

(which) beta radiation will not penetrate but gamma will
or
(which) only gamma will penetrate

MP2 dependent on scoring MP1

1

(c) any **one** from:

- increase distance between source and teacher
- limit exposure time
- use tongs / forceps
- wear a lead apron
- keep source in box unless in use
- stand behind safety screen
- point source away from teacher

allow any reasonable precaution that increases distance between the source and the teacher, or limits exposure time

ignore wear PPE unqualified ignore examples of additional clothing

1

(d) wear gloves / apron
or
wear a lab coat
or
handle source with tongs / forceps

allow no eating / drinking (while radioactive source is in the lab)
allow do not touch the source (with bare hands)
ignore wear a mask
ignore wear safety glasses
ignore protective clothing unqualified
ignore wear a hazmat suit
ignore wear PPE unqualified
1

(e) tangent drawn on line at 300 s
do not allow a line drawn that crosses the graph line
1

attempt to calculate gradient of the tangent
allow missing power for Δy
1

activity = 7.1×10^{20}
allow a value between 6.5 and 7.6×10^{20}
1

becquerel / Bq
ignore decays/second
1
[11]

Q40.

(a) Any **one** from:
- (medical) x-rays
  allow CT scans
- radiotherapy
- nuclear weapons (testing)
  allow nuclear fallout
- named nuclear disaster e.g. Chernobyl / Fukushima / Three Mile Island.
  ignore radioactive / nuclear waste

1

(b) uranium / plutonium
ignore any number given
allow thorium
1

(c) neutron absorbed by a uranium nucleus
1

nucleus splits into two parts
allow an atom splits into two parts if 1st marking point doesn't score
1

and (2/3) neutrons (are released)
1

and gamma rays (are emitted)

1

(d) lighter nuclei join to form heavier nuclei
allow specific examples
1

some of the mass (of the nuclei) is converted to energy (of radiation)
1

(e) activity decreases quickly
allow nuclei / waste will decay at a greater rate
ignore waste is radioactive for less time
1

risk of harm decreases quickly
allow burial site doesn't need to be monitored for as long
or
doesn't need to be buried underground for as long
or
may not need to be buried underground
1
[10]

Q41.

(a) (i) nuclear reactor
1

star
1

(ii) nuclei are joined (not split)
accept converse in reference to nuclear fission
*do **not** accept atoms are joined*
1

(b) (i) any **four** from:
- neutron
- (neutron) absorbed by U (nucleus)
  ignore atom
  *do **not** accept reacts*
  *do **not** accept added to*
- forms a larger nucleus
- (this larger nucleus is) unstable
- (larger nucleus) splits into two (smaller) nuclei / into Ba and Kr
- releasing three neutrons and energy
  accept fast-moving for energy

4

(ii) 56 (Ba)
1

57 (La)
*if proton number of Ba is incorrect allow **1** mark if that of La is 1 greater*
1

$^{0}_{-1}\beta$

accept e for β

$^{139}_{56}Ba \longrightarrow ^{139}_{57}La + ^{0}_{-1}\beta$

*scores **3** marks*

1

[10]

Q42.

(a) 7

1

(b) 3

1

number of <u>protons</u>

reason only scores if 3 chosen

1

(c) levels

1

(d) $^{4}_{2}He$

correct order only

1

1

$^{0}_{-1}e$

1

(e) shorter half-life (than the other sources)

1

exposure time to radiation is shorter

1

[9]

Q43.

(a) (average) time taken for the amount / number of nuclei / atoms (of the isotope in a sample) to halve

or

time taken for the count rate (from a sample containing the isotope) to fall to half

accept (radio)activity for count rate

1

(b) *60 ±3* (days)

1

indication on graph how value was obtained

1

(c) (i) cobalt(-60)

1

gamma not deflected by a magnetic field

or

gamma have no charge

dependent on first marking point

accept (only) emits gamma

gamma has no mass is insufficient

*do **not** accept any reference to half-life*

1

(ii) strontium(-90)

1

any **two** from:

- <u>only</u> has beta
- alpha would be absorbed
- gamma unaffected
- *beta penetration / absorption depends on thickness of paper*

*if thorium(-232) or radium(-226) given, max **2** marks can be awarded*

2

(iii) cobalt(-60)

1

shortest half-life

accept half-life is 5 years

dependent on first marking point

1

so activity / count rate will decrease quickest

1

(iv) *americium(-241) / cobalt(-60) / radium(-226)*

1

gamma emitter

1

(only gamma) can penetrate lead *(of this box)*

do not allow lead fully absorbs gamma

1

[14]

Q44.

(a) (i) (atoms with the) same number of protons

allow same atomic number

***or** same proton number*

1

(atoms with) different number of neutrons

allow different mass number

1

(ii) 82

1

(iii) 124 1

(b) (i) $^{58}_{\boxed{26}}Fe + ^{\boxed{208}}_{\boxed{82}}Pb$

1 mark for each correct box 3

(ii) (a) neutron 1

(iii) 4.0×10^{-4} (s)
or
0.0004
$3.00 \times 10^{8} \times 0.1 = 12\,000 / t$
*gains **1** mark* 2

(iv) particles need to travel a large distance 1

equipment would have to be very long 1

with circular paths long distances can be accommodated in a smaller space 1

(c) (i) the average time for the number of nuclei to halve 1

the time for count rate to halve 1

(ii) $^{\boxed{261}}_{\boxed{106}}Sg + ^{\boxed{4}}_{\boxed{2}}\alpha$

***1** mark if top boxes total = 265*
***and** bottom boxes total = 108*
***1** mark for 4 and 2 for alpha* 2

(d) (i) 3 plotted points
± ½ small square 1

best line through points 1

(ii) 190–205 (pm)
or correct from student's line 1

[20]

Q45.

(a) *answers must be in terms of nuclear fuels*

concentrated source of energy
idea of a small mass of fuel able to generate a lot of electricity 1

that is able to generate continuously
accept it is reliable
***or** can control / increase / decrease electricity generation*
idea of available all of the time / not dependent on the weather
ignore reference to pollutant gases 1

the energy from (nuclear) <u>fission</u> 1

is used to heat water to steam to turn turbine linked to a generator 1

(b) <u>carbon dioxide</u> is not released (into the atmosphere) 1

but is (caught and) stored (in huge natural containers) 1

[6]

Q46.

(i) sensible answers e.g. risk of radioactive leak during transport eliminated cheaper transport 1

(ii) 4 half-lives 4 × 6 = 24 seconds 3

[4]