Development of Scientific Thinking

Name: __________

Class: __________

Date: __________

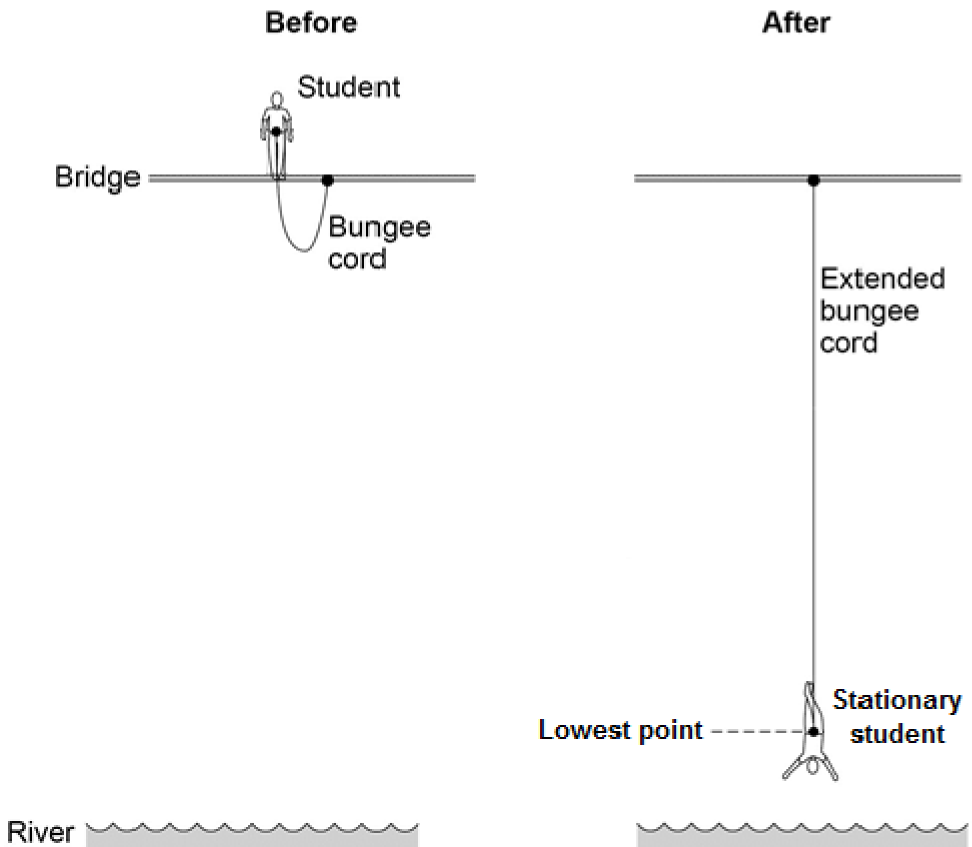
Time: **453 minutes**

Marks: **451 marks**

Comments:

1 The image below shows a student before and after a bungee jump.

The bungee cord has an unstretched length of 20 m.



(a) For safety reasons, it is important that the bungee cord used is appropriate for the student's weight.

Give **two** reasons why.

1 ....

....

2 ....

....

(2)

(b) The student jumps off the bridge.

Complete the sentences to describe the energy transfers.

Use answers from the box.

elastic potential	**gravitational potential**	**kinetic**	**sound**	**thermal**

Before the student jumps from the bridge he has a store of

.... energy.

When he is falling, the student's store of ....
energy increases.

When the bungee cord is stretched, the cord stores energy as

.... energy.

(3)

(c) At the lowest point in the jump when the student is stationary, the extension of the bungee cord is 35 metres.

The bungee cord behaves like a spring with a spring constant of 40 N / m.

Calculate the energy stored in the stretched bungee cord.

Use the correct equation from the Physics Equations Sheet.

....

....

....

Energy = ... J

(2)
(Total 7 marks)

2 Alpha, beta and gamma are types of nuclear radiation.

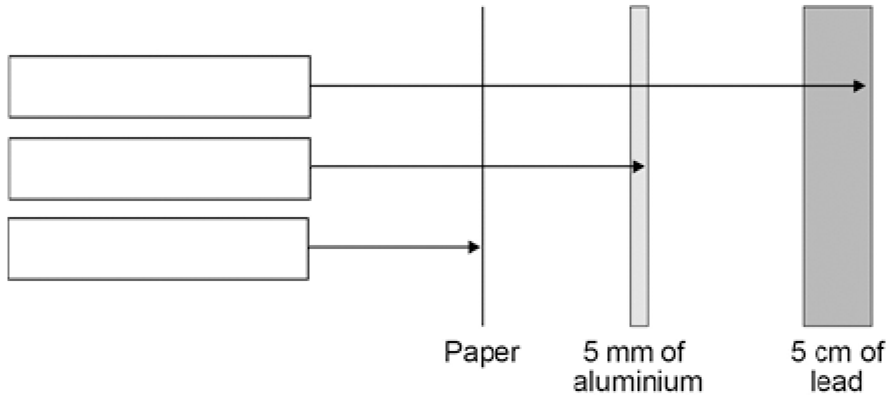
(a) Draw **one** line from each type of radiation to what the radiation consists of.

Type of radiation	**What radiation consists of**
	Electron from the nucleus
Alpha	
	Two protons and two neutrons
Beta	
	Electromagnetic radiation
Gamma	
	Neutron from the nucleus

(3)

(b) A teacher demonstrates the penetration of alpha, beta and gamma radiation through different materials.

The demonstration is shown in the figure below.



Complete the figure above by writing the name of the correct radiation in each box.

(2)

(c) Give **two** safety precautions the teacher should have taken in the demonstration.

1 ....

....

2 ....

....

(2)

(d) The table below shows how the count rate from a radioactive source changes with time.

Time in seconds	0	40	80	120	160
Count rate in counts / second	400	283	200	141	100

Use the table to calculate the count rate after 200 seconds.

....

....

(2)

(e) The half-life of the radioactive source used was very short.

Give **one** reason why this radioactive source would be much less hazardous after 800 seconds.

....

....

(1)
(Total 10 marks)

3 Scientists sometimes replace one scientific model with a different model.

For example, in the early 20th Century the plum pudding model of the atom was replaced by the nuclear model of the atom.

Explain what led to the plum pudding model of the atom being replaced by the nuclear model of the atom.

....

....

....

....

....

....

....

....

....

....

(Total 6 marks)

4 A student models the random nature of radioactive decay using 100 dice.

He rolls the dice and removes any that land with the number 6 facing upwards.

He rolls the remaining dice again.

The student repeats this process a number of times.

The table below shows his results.

Roll number	Number of dice remaining
0	100
1	84
2	70
3	59
4	46
5	40
6	32
7	27
8	23

(a) Give **two** reasons why this is a good model for the random nature of radioactive decay.

1 ....

....

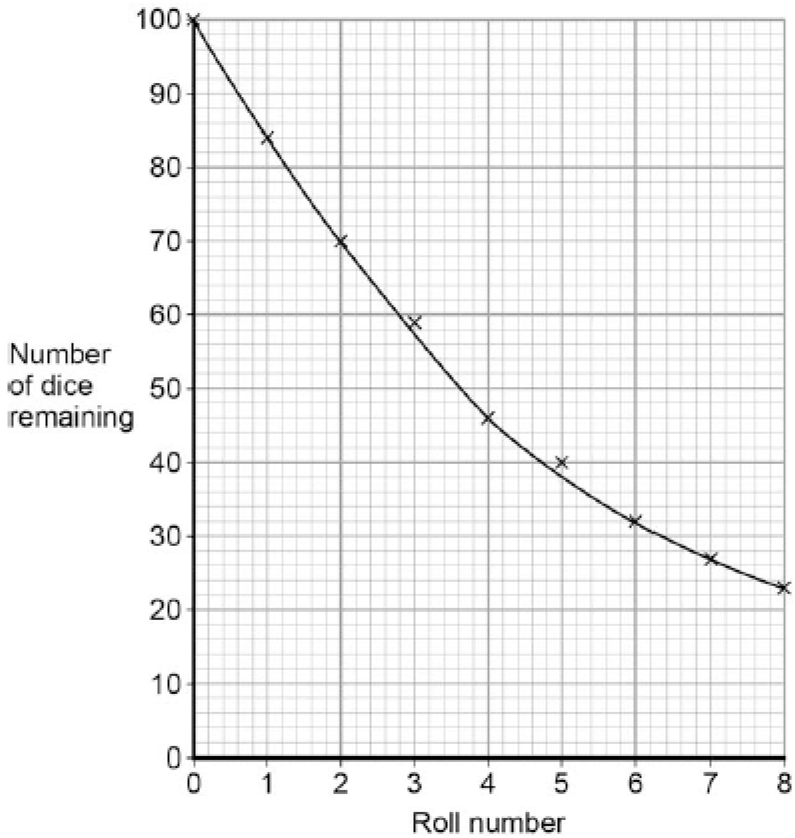
2 ....

....

(2)

(b) The student's results are shown in **Figure 1**.

Figure 1



Use **Figure 1** to determine the half-life for these dice using this model.

Show on **Figure 1** how you work out your answer.

Half-life = ... rolls

(2)

(c) A teacher uses a protactinium (Pa) generator to produce a sample of radioactive material that has a half-life of 70 seconds.

In the first stage in the protactinium generator, uranium (U) decays into thorium (Th) and alpha (α) radiation is emitted.

The decay can be represented by the equation shown in **Figure 2**.

Figure 2

$$^{238}_{92}U \longrightarrow {}^{234}_{\square}Th + \alpha$$

Determine the atomic number of thorium (Th) 234.

Atomic number = ...

(1)

(d) When protactinium decays, a new element is formed and radiation is emitted.

The decay can be represented by the equation shown in **Figure 3**.

Figure 3

$$^{234}_{91}Pa \rightarrow ^{234}_{92}X + radiation$$

When protactinium decays, a new element, **X**, is formed.

Use information from **Figure 2** and **Figure 3** to determine the name of element **X**.

....

(1)

(e) Determine the type of radiation emitted as protactinium decays into a new element.

Give a reason for your answer.

....

....

....

....

(2)

(f) The teacher wears polythene gloves as a safety precaution when handling radioactive materials.

The polythene gloves do **not** stop the teacher's hands from being irradiated.

Explain why the teacher wears polythene gloves.

....

....

....

....

(2)
(Total 10 marks)

5 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.

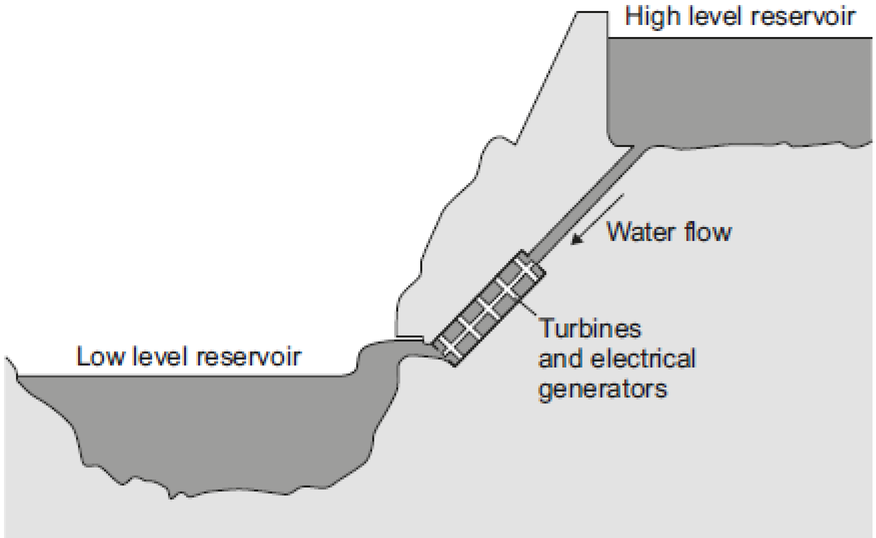
biofuel	**coal**	**geothermal**	**nuclear**	**waves**

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)

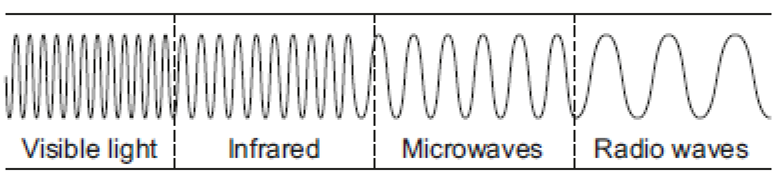
(iii) How is the temperature of the surroundings affected by the energy wasted by the pumped storage power station?

....

(1)
(Total 10 marks)

6 Infrared and microwaves are two types of electromagnetic radiation.

The diagram below shows the positions of the two types of radiation within part of the electromagnetic spectrum.



(a) Name **one** type of electromagnetic radiation which has more energy than infrared.

....

(1)

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

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

greater than	**less than**	**the same as**

The wavelength of infrared is .... the wavelength of microwaves.

The frequency of microwaves is .... the frequency of infrared.

The speed of microwaves in a vacuum is .... the speed of infrared in a vacuum.

(3)
(Total 4 marks)

7 A small community of people live in an area in the mountains.
The houses are not connected to the National Grid.

The people plan to buy an electricity generating system that uses either the wind or the flowing water in a nearby river.

Figure 1 shows where these people live.

Figure 1

(a) It would not be economical to connect the houses to the National Grid.
Give **one** reason why.

....

....

....

....

(1)

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

Information about the two electricity generation systems is given in **Figure 2**.

Figure 2

The wind turbine costs £50 000 to buy and install.
The hydroelectric generator costs £20 000 to buy and install.
The average power output from the wind turbine is 10 kW.
The hydroelectric generator will produce a constant power output of 8 kW.

Compare the advantages and disadvantages of the two methods of generating electricity.

Use your knowledge of energy sources as well as information from **Figure 2**.

(6)
(Total 7 marks)

8 Infrared and microwaves are two types of electromagnetic radiation.

(a) State **one** example of the use of each type of radiation for communication.

Infrared: ....

Microwaves: ....

(2)

(b) Some of the properties of infrared and microwaves are the same.

State **two** of these properties.

1 ....

....

2 ....

....

(2)
(Total 4 marks)

9 All European Union countries are expected to generate 20% of their electricity using renewable energy sources by 2020.

The estimated cost of generating electricity in the year 2020 using different energy sources is shown in **Table 1**.

Table 1

Energy source	Estimated cost (in the year 2020) in pence per kWh
Nuclear	7.8
Solar	25.3
Tidal	18.8
Wind	10.0

France generated 542 billion kWh of electricity using nuclear power stations in 2011.
France used 478 billion kWh of electricity and sold the rest of the electricity to other countries in 2011.

(a) France may continue generating large amounts of electricity using nuclear power stations instead of using renewable energy resources.

Suggest **two** reasons why.

1. ....

....

2. ....

....

(2)

(b) Give **two** disadvantages of generating electricity using nuclear power stations.

1. ....

....

2. ....

....

(2)

(c) A panel of solar cells has an efficiency of 0.15.

The total power input to the panel of solar cells is 3.2 kW.

Calculate the useful power output of this panel of solar cells in kW.

....

....

....

....

Useful power output = ... kW

(2)

(d) **Table 2** shows the manufacturing cost and efficiency of different types of panels of solar cells.

Table 2

Type of Solar Panel	Cost to manufacture a 1 m^2 solar panel in £	Efficiency in %
A	40.00	20
B	22.50	15
C	5.00	10

Some scientists think that having a low manufacturing cost is more important than improving the efficiency of solar cells.

Use information from **Table 2** to suggest why.

....

....

....

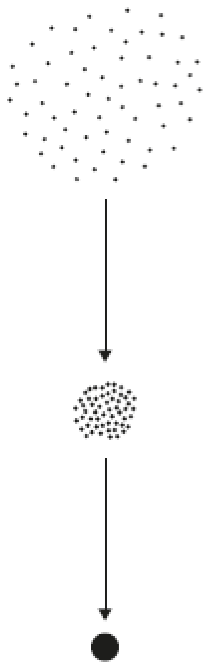
....

....

....

(2)
(Total 8 marks)

10 (a) The figure below shows how a star is formed.
Use **one** answer from each box to complete the sentences.



gas	rock	water

A star starts as a huge cloud of dust and ___________________ particles in space.

friction	fusion	gravity

The force of ___________________ pulls the particles in the cloud closer together.

protostar	red giant	white dwarf

The compressed mass of particles

forms a ___________________ .

(3)

(b) Elements heavier than iron are formed in a supernova.
What is a supernova?

Tick (✓) **one** box.

the explosion of a massive star ☐

a very bright, hot young star ☐

a very cool super giant star ☐

(1)

(c) Brown dwarf stars are small stars too cool to give out visible light. They were first discovered in 1995. Scientists think that there are millions of these stars spread throughout the Universe.

Which **one** of the following is the most likely reason why brown dwarf stars were not discovered before 1995?

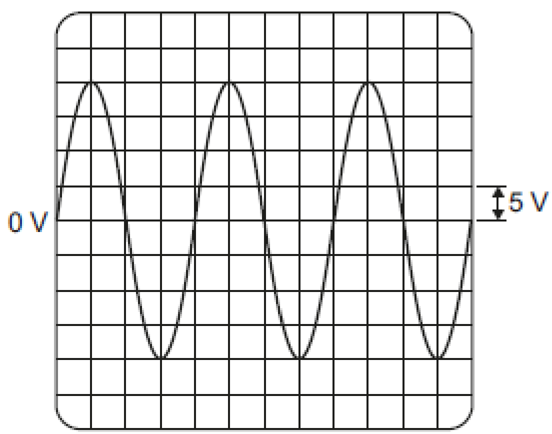
Tick (✓) **one** box.

Brown dwarf stars did not exist before 1995.	☐
Scientists were looking in the wrong part of the Universe.	☐
The telescopes and measuring instruments were not sensitive enough.	☐

(1)
(Total 5 marks)

11 (a) **Figure 1** shows the oscilloscope trace an alternating current (a.c.) electricity supply produces.

Figure 1



One vertical division on the oscilloscope screen represents 5 volts.

Calculate the peak potential difference of the electricity supply.

....

Peak potential difference = ... V

(1)

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

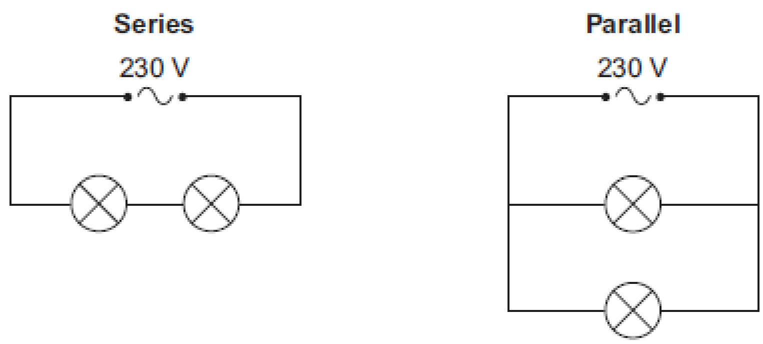
40	**50**	**60**

In the UK, the frequency of the a.c. mains electricity supply is .... hertz.

(1)

(c) **Figure 2** shows how two lamps may be connected in series or in parallel to the 230 volt mains electricity supply.

Figure 2



(i) Calculate the potential difference across each lamp when the lamps are connected in **series**.

The lamps are identical.

....

Potential difference when in series = ... V

(1)

(ii) What is the potential difference across each lamp when the lamps are connected in **parallel**?

Tick (✓) **one** box.

115 V ☐ 230 V ☐ 460 V ☐

(1)

(iii) Give **one** advantage of connecting the lamps in parallel instead of in series.

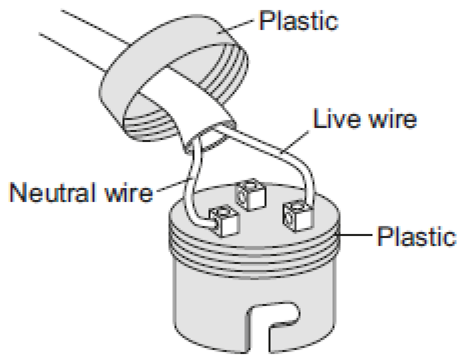
....

....

(1)

(d) **Figure 3** shows the light fitting used to connect a filament light bulb to the mains electricity supply.

Figure 3



The light fitting does **not** have an earth wire connected.

Explain why the light fitting is safe to use.

....

....

....

....

(2)

(e) A fuse can be used to protect an electrical circuit.

Name a different device that can also be used to protect an electrical circuit.

....

(1)
(Total 8 marks)

12 (a) Uranium has two natural isotopes, uranium-235 and uranium-238.

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

electrons	**neutrons**	**protons**

The nucleus of a uranium-238 atom has three more .... than the nucleus of a uranium-235 atom.

(1)

(b) Uranium-235 is used as a fuel inside a nuclear reactor.
Energy is released from nuclear fuels by the process of nuclear fission.

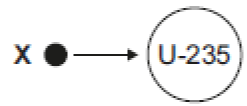
What is the energy released from nuclear fuels inside a nuclear reactor used for?

....

(1)

(c) **Figure 1** shows the nucleus of an atom of uranium-235 (U-235) about to undergo nuclear fission.

Figure 1



(i) Before nuclear fission can happen the nucleus of a uranium atom has to absorb the particle labelled **X**.

What is particle **X**?

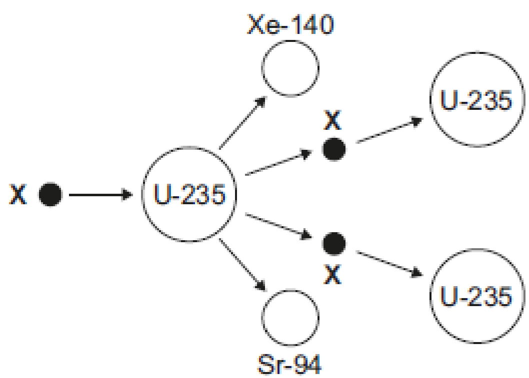
Tick (✓) **one** box.

an electron ☐ a neutron ☐ a proton ☐

(1)

(ii) The process of nuclear fission, shown in **Figure 2**, causes the nucleus of the uranium-235 (U-235) atom to split apart and release two of the particles X.

Figure 2



Complete **Figure 2** to show how the particles **X start** a chain reaction.

(2)
(Total 5 marks)

13 Alpha particles, beta particles and gamma rays are types of nuclear radiation.

(a) Describe the structure of an alpha particle.

....

....

(1)

(b) Nuclear radiation can change atoms into ions by the process of ionisation.

(i) Which type of nuclear radiation is the least ionising?

Tick (✓) **one** box.

alpha particles	☐
beta particles	☐
gamma rays	☐

(1)

(ii) What happens to the structure of an atom when the atom is ionised?

....

....

(1)

(c) People working with sources of nuclear radiation risk damaging their health.

State **one** precaution these people should take to reduce the risk to their health.

....

....

(1)

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

The type of radiation emitted from a radioactive source can be identified by comparing the properties of the radiation to the properties of alpha, beta and gamma radiation.

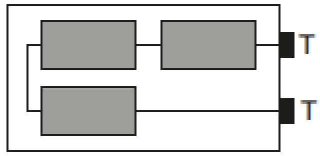
Describe the properties of alpha, beta and gamma radiation in terms of their:

- penetration through materials
- range in air
- deflection in a magnetic field.

(6)
(Total 10 marks)

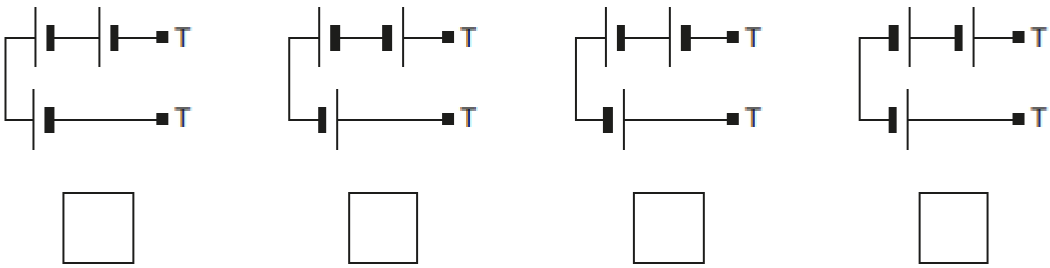
14 (a) **Figure 1** shows the inside of a battery pack designed to hold three identical 1.5 V cells.

Figure 1



Which **one** of the arrangements shown in **Figure 2** would give a 4.5 V output across the battery pack terminals **T**?

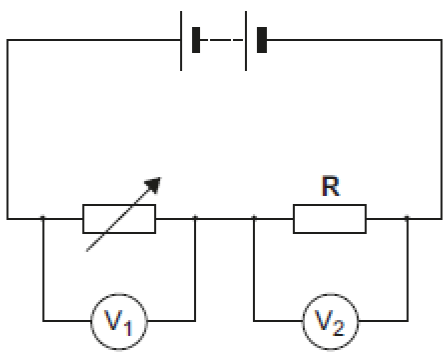
Figure 2



(1)

(b) **Figure 3** shows a variable resistor and a fixed value resistor connected in series in a circuit.

Figure 3



Complete **Figure 3** to show how an ammeter would be connected to measure the current through the circuit.

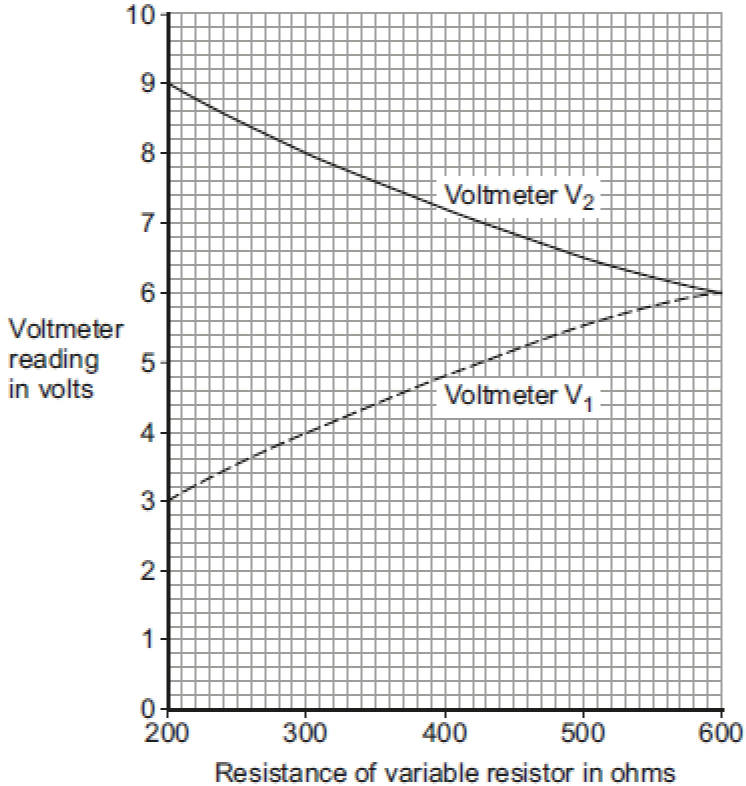
Use the correct circuit symbol for an ammeter.

(1)

(c) The variable resistor can be adjusted to have any value from 200 ohms to 600 ohms.

Figure 4 shows how the reading on voltmeter $\mathbf{V_1}$ and the reading on voltmeter $\mathbf{V_2}$ change as the resistance of the variable resistor changes.

Figure 4



(i) How could the potential difference of the battery be calculated from **Figure 4**?

Tick (✓) **one** box.

9 + 3 = 12 V	☐
9 – 3 = 6 V	☐
9 ÷ 3 = 3 V	☐

Give the reason for your answer.

....

....

(2)

(ii) Use **Figure 4** to determine the resistance of the fixed resistor, **R**.

Resistance of R = ... Ω

Give the reason for your answer.

....

....

(2)

(iii) Calculate the current through the circuit when the resistance of the variable resistor equals 200 Ω.

....

....

....

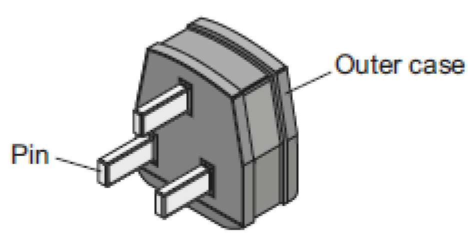
Current = ... A

(3)
(Total 9 marks)

15 (a) A washing machine is connected to the mains electricity supply using a cable and three-pin plug.

Figure 1 shows a three-pin plug.

Figure 1



Name the materials used in the structure of a plug. Give the reason why each material is used.

Pin ....

....

Outer case ....

....

(1)

(b) The three-pin plug contains a fuse. The fuse is connected to one of the wires inside the cable.

(i) Which **one** of the wires inside the cable is the fuse connected to?

....

(1)

(ii) The fuse is a thin wire inside a closed glass tube. The wire acts as a resistor.

What effect does a current through a wire have on the wire?

....

(1)

(iii) The power of the washing machine varies between 0.7 kW and 2 kW depending on which part of the wash cycle is operating.

Calculate the maximum current drawn from the mains electricity supply by the washing machine.

The mains electricity supply is at a potential difference of 230 V.

....

....

....

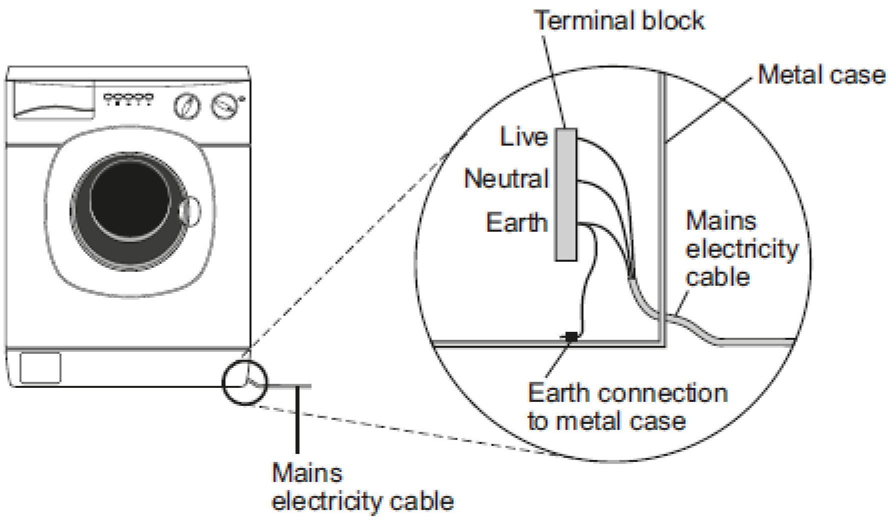
Current = ... A

(2)

(c) **Figure 2** shows how the mains electricity cable is connected to the washing machine.

The earth wire is connected to the metal case of the washing machine.

Figure 2



If a fault makes the metal case live, the earth wire and fuse inside the plug prevent the mains cable from overheating and causing a fire.

Explain how.

....

....

....

....

(2)

(d) New research has shown that many people underestimate the hazards of using mains electricity.

It is important that people do understand the hazards of using mains electricity.

Suggest why.

....

....

....

(1)
(Total 9 marks)

16 (a) Brown dwarf stars are thought to have been formed in the same way as other stars. They are too small for nuclear fusion reactions to take place in them. Brown dwarf stars emit infrared radiation but are not hot enough to emit visible light.

(i) Describe how a star is formed.

....

....

....

....

(2)

(ii) Describe the process of nuclear fusion.

....

....

....

(1)

(iii) Scientists predicted that brown dwarf stars existed before the first one was discovered in 1995.

Suggest **one** reason why scientists are now able to observe and identify brown dwarf stars.

....

....

....

(1)

(b) In the 18th century some scientists suggested a theory about how the planets formed in the Solar System. The theory was that after the Sun formed, there were cool discs of matter rotating around the Sun. These cool discs of matter formed the planets. The scientists thought this must have happened around other stars too.

(i) Thinking about this theory, what would the scientists have predicted to have been formed in other parts of the Universe?

....

....

(1)

(ii) Since the 1980s scientists studying young stars have shown the stars to be surrounded by cool discs of rotating matter.

What was the importance of these observations to the theory the scientists suggested in the 18th century?

....

....

(1)

(c) The Earth contains elements heavier than iron.

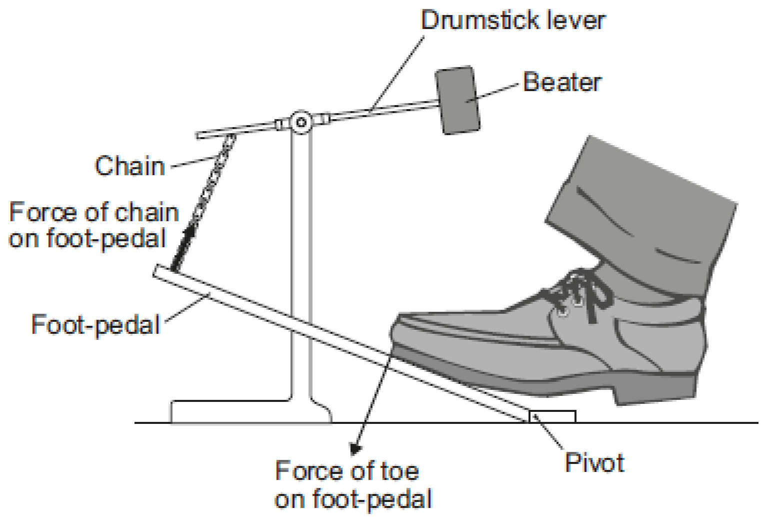
Why is the presence of elements heavier than iron in the Earth evidence that the Solar System was formed from material produced after a massive star exploded?

....

....

(1)
(Total 7 marks)

17 A drum is hit by a beater attached to a drumstick lever. The drumstick lever is attached to a foot-pedal by a chain, as shown below.



(a) State how the size of the force of the chain on the foot-pedal compares with the size of the force of the toe on the foot-pedal.

....

....

(1)

(b) The foot-pedal is pushed halfway down and held stationary.

The force of the toe and the force of the chain each create a moment which acts on the foot-pedal.

Compare the size and direction of the moments of the toe and the chain.

Tick (✓) **one** box.

Size	**Direction**	**Tick (✓)**
The moments are equal	same	
The moments are equal	opposite	
The moment of the force of the toe is greater	same	

(1)

(c) How can the drummer create a greater moment about the pivot without increasing the force he applies?

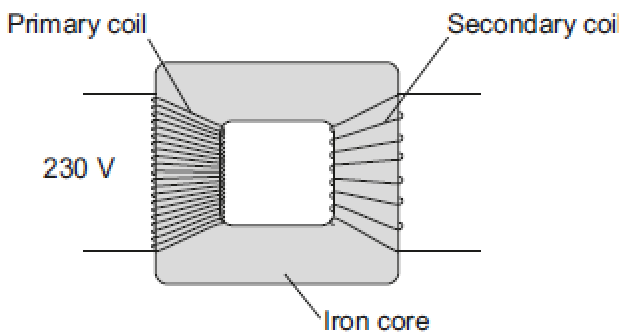
....

....

(1)
(Total 3 marks)

18 **Figure 1** shows the structure of a traditional transformer.

Figure 1



(a) There is an alternating current in the primary coil of the transformer.

State what is produced in the iron core.

....

....

(2)

(b) A transformer has only **one** turn of wire on the secondary coil.
The potential difference across the secondary coil is 11.5 V
The potential difference across the primary coil is 230 V

Calculate the number of turns on the primary coil.

....

....

....

....

Number of turns on the primary coil = ...

(2)

(c) In most transformers, the power output is less than the power input.

State why.

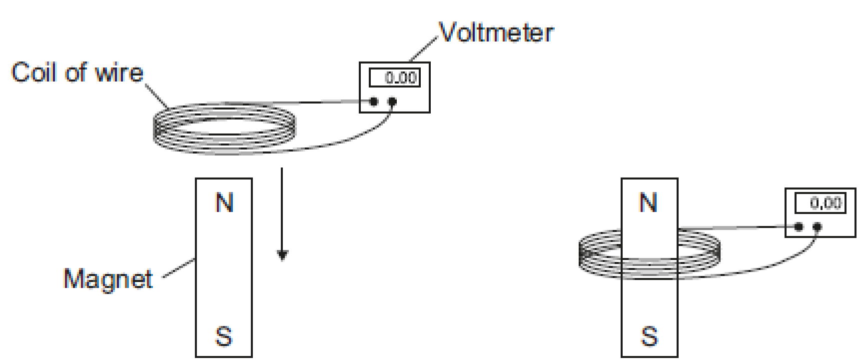
....

....

(1)

(d) Two students investigated how magnets can be used to produce a potential difference.
The students held a coil of wire above a magnet. The students quickly lowered the coil so that the magnet was inside the coil, as shown in **Figure 2**.

Figure 2



The students recorded the maximum potential difference for coils with different numbers of turns of wire. The results are shown in the table.

Number of turns of wire in the coil	**Maximum potential difference in volts**	
	Results from student 1	**Results from student 2**
5	0.09	0.08
10	0.20	0.15
15	0.31	0.25
20	0.39	0.33
25	0.51	0.39

(i) State the resolution of the voltmeter.

Give **one** reason why the resolution of the voltmeter is suitable for this investigation.

Resolution ....

Reason ....

....

(2)

(ii) The two students used exactly the same equipment to carry out their investigations. Both students recorded their results correctly.

Give the reason why student 2 got different results from student 1.

....

....

(1)

(iii) The students decided that even though the results were different, there was no need to repeat the investigation.

How do the results show that the investigation is reproducible?

....

....

(1)

(iv) State the name of the process which causes the potential difference to be produced in this investigation.

....

(1)

(e) A transformer has been developed that can be used with many different devices.

Suggest **one** advantage of having a transformer that can be used with many different devices.

....

....

(1)
(Total 11 marks)

19 X-rays and ultrasound can both be used for scanning internal organs.

(a) Ultrasound is used to scan unborn babies but X-rays are **not** used to scan unborn babies.

Explain why.

....

....

....

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....

....

(3)

(b) The behaviour of ultrasound waves when they meet a boundary between two different materials is used to produce an image.

Describe how.

....

....

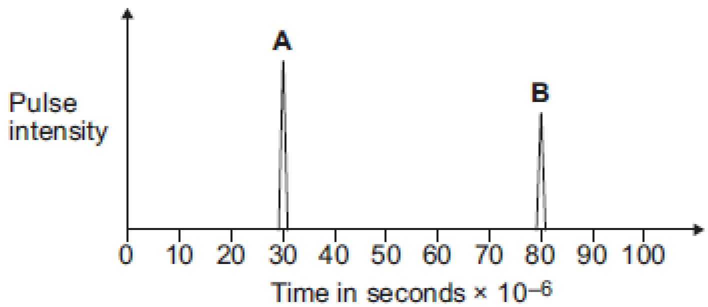
....

....

(2)

(c) **Figure 1** shows two pulses from a scan of an unborn baby. The emitted pulse is labelled **A**. The returning pulse picked up by the receiver is labelled **B**.

Figure 1



The closest distance between the unborn baby and the mother's skin is 4.0 cm.
Use information from **Figure 1** to calculate the average speed of the pulse.

....

....

....

....

....

....

Average speed = ... m/s

(3)

(d) **Figure 2** shows an X-ray of an arm with a broken bone.

Figure 2

© emmy-images/iStock

(i) Describe how X-rays are able to produce an image of bones.

....

....

....

....

....

....

(3)

(ii) Complete the following sentence.

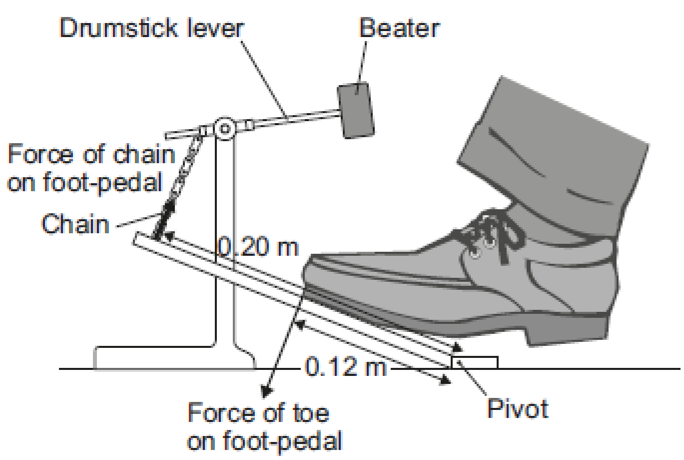
X-rays are able to produce detailed images because their wavelength

is very ....

(1)
(Total 12 marks)

20 A drum is hit by a beater attached to a drumstick lever. The drumstick lever is attached to a foot-pedal by a chain, as shown in the **Figure 1**.

Figure 1



(a) When the toe is pushed down the force creates a moment on the foot-pedal.

(i) State what is meant by the moment of a force.

....

....

(1)

(ii) The foot-pedal is pushed halfway down and held stationary. The toe and the chain both exert a force on the foot-pedal.

Compare the sizes and directions of the moments caused by the force of the toe and the force of the chain on the foot-pedal.

....

....

(1)

(iii) The drummer's toe pushes with a 1.5 N force on the foot-pedal.
The perpendicular distance from the pivot to the force is 0.12 m.
The perpendicular distance from the pivot to the chain is 0.20 m.

Calculate the force of the chain acting on the foot-pedal.

....

....

....

....

....

....

Force = ... N

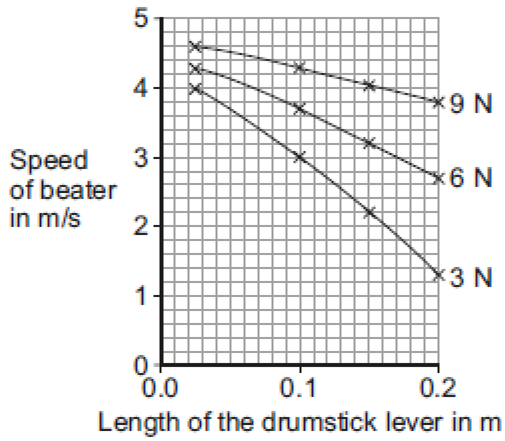
(3)

(b) The foot-pedal is pushed with different forces to make the beater move at different speeds.

The higher the speed at which the beater hits the drum, the louder the sound the drum makes.

Figure 2 shows how the length of the drumstick lever affects the speed of the beater for three different forces.

Figure 2



The drummer needs to be able to sometimes play the drum quietly and sometimes loudly.

How does the **length** of the drumstick lever affect the variation in loudness of the sound from the drum when applying:

a force of 3 N? ....

....

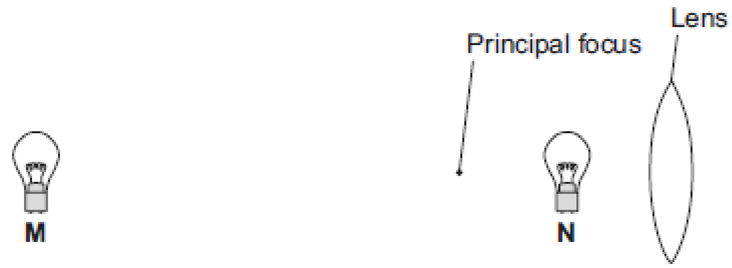
a range of forces from 3 N to 9 N? ....

....

(2)
(Total 7 marks)

21 (a) A light bulb is placed between a convex lens and the principle focus of this lens, at position **N** shown in **Figure 1**. The light bulb is then moved to position **M**, a large distance from the lens.

Figure 1



Describe how the nature of the image formed changes as the light bulb is moved from position **N** to position **M**.

....

....

....

....

....

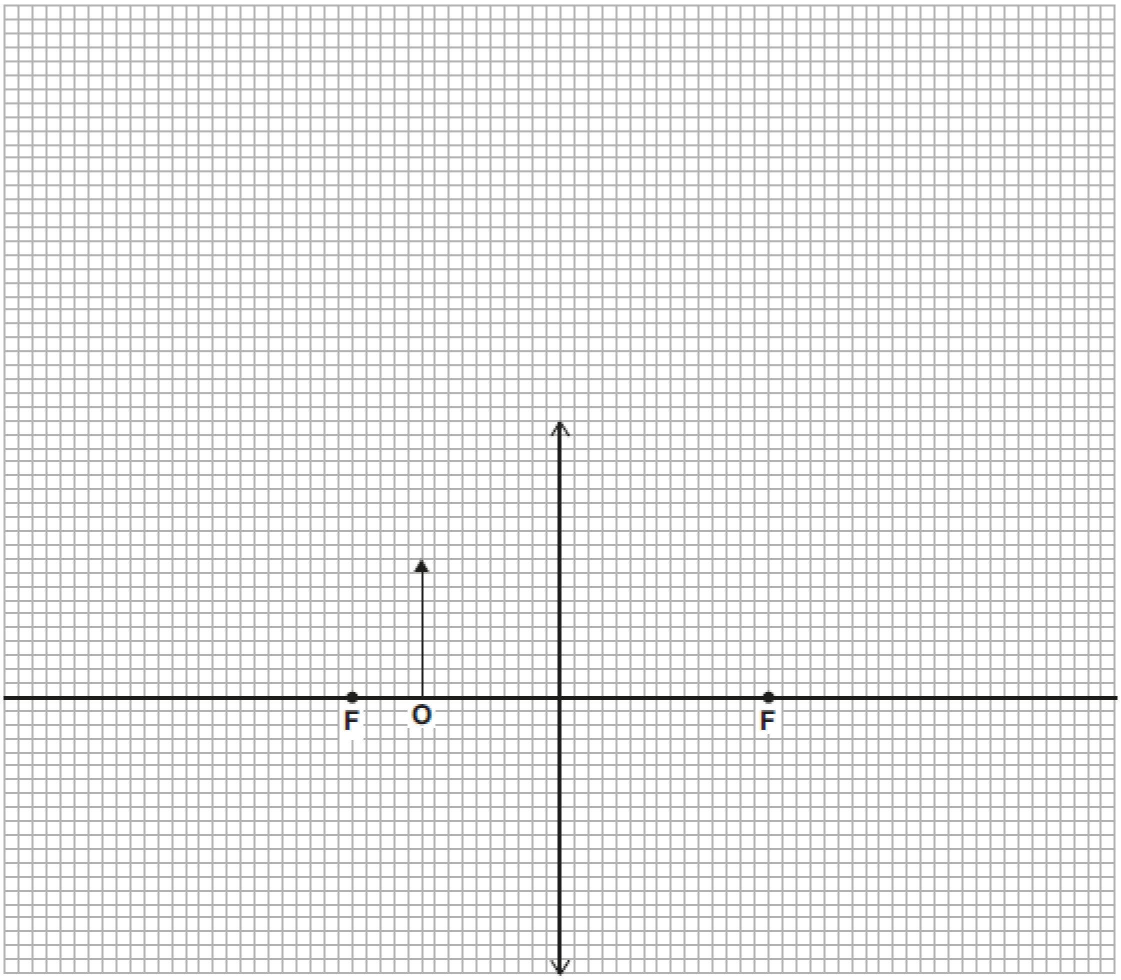
....

(3)

(b) An object, **O**, is very near to a convex lens, as shown in **Figure 2**.

Complete **Figure 2** to show how rays of light from the object form an image.

Figure 2

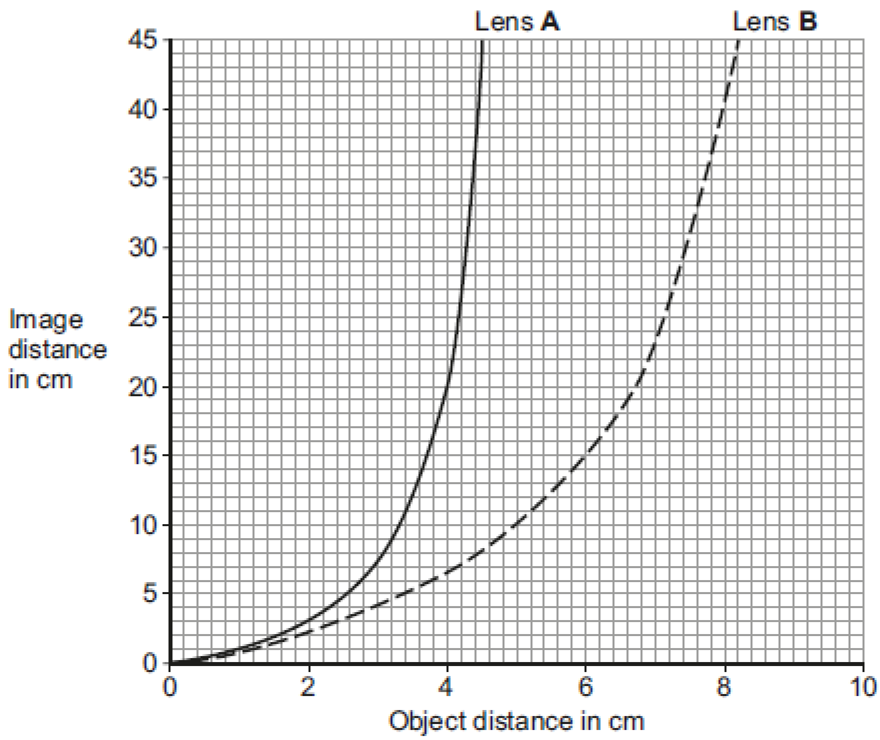


(3)

(c) The object distance is the distance from an object to the lens. The image distance is the distance from the lens to the image.

Figure 3 shows how the image distance changes with the object distance, for two identically shaped convex lenses, **A** and **B**. Each lens is made from a different type of glass.

Figure 3



(i) When the object distance is 4 cm, the image distance for lens **A** is longer than for lens **B**.

State why.

....

....

(1)

(ii) When the object is moved between lens **B** and the principal focus, the image size changes. The table shows the magnification produced by lens **B** for different object distances.

Object distance in cm	**Magnification**
0.0	1
5.0	2
6.7	3
7.5	4
8.0	5

Using information from **Figure 3** and the table, describe the relationship between the **image** distance and the magnification produced by lens **B**.

....

....

....

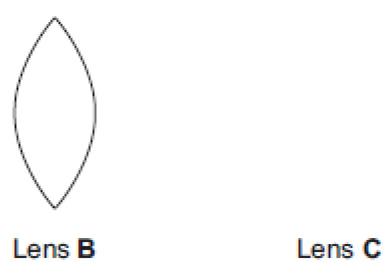
(2)

(iii) A third convex lens, lens **C**, is made from the same type of glass as lens **B**, but has a shorter focal length than lens **B**.

Lens **B** is shown in **Figure 4**.

Complete **Figure 4** to show how lens **C** is different from lens **B**.

Figure 4



(1)
(Total 10 marks)

22 (a) Radioactive sources that emit alpha, beta or gamma radiation can be dangerous.

What is a possible risk to health caused by using a radioactive source?

....

....

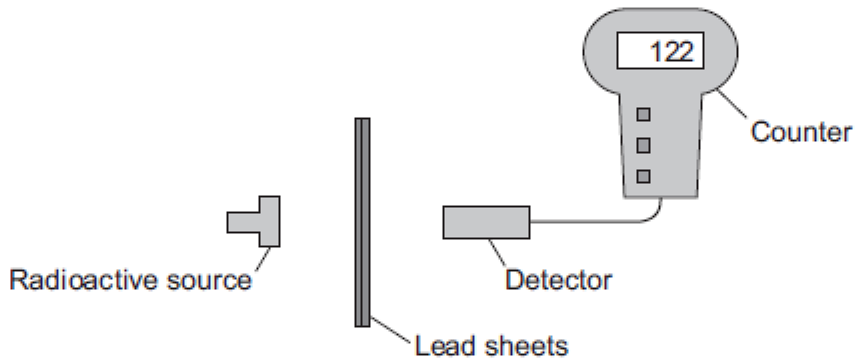
(1)

(b) In an experiment, a teacher put a 2 mm thick lead sheet in front of a radioactive source. She used a detector and counter to measure the radiation passing through the lead sheet in one minute.

She then put different numbers of lead sheets, each 2 mm thick, in front of the radioactive source and measured the radiation passing through in one minute.

The apparatus the teacher used is shown in **Figure 1**.

Figure 1



(i) When using a radioactive source in an experiment, how could the teacher reduce the risk to her health?

Suggest **one** way.

....

....

(1)

(ii) The number recorded on the counter is actually higher than the amount of radiation detected from the source.

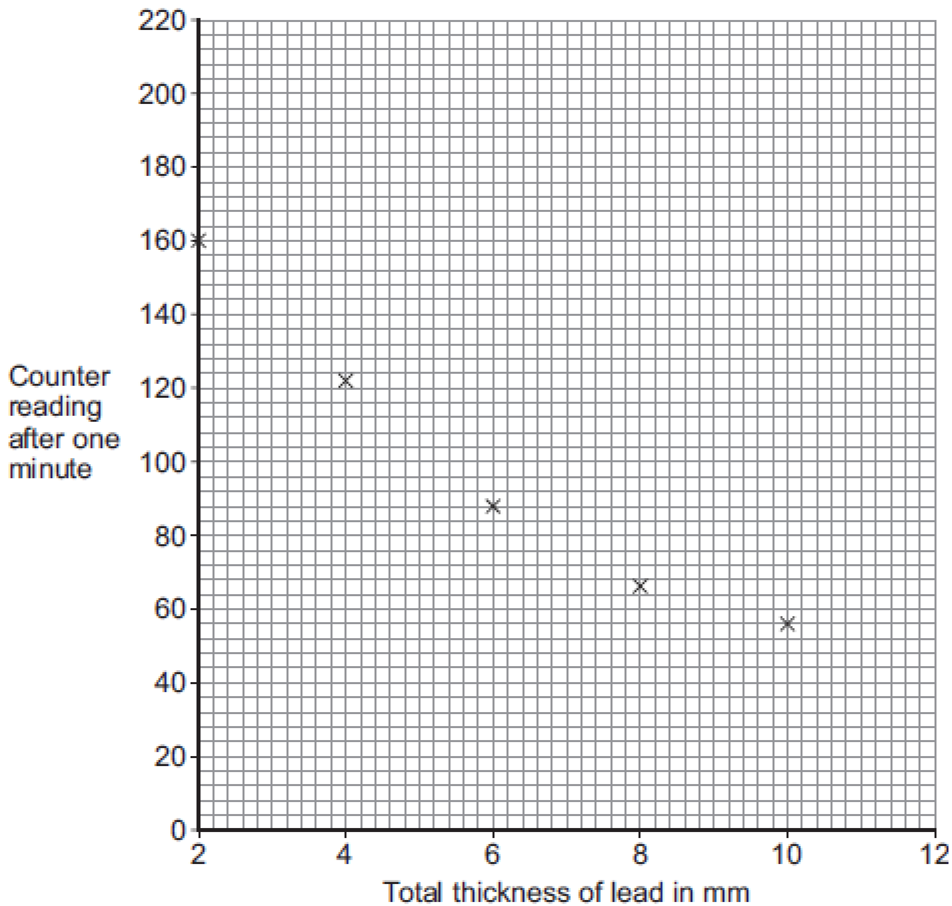
Complete the following word equation.

The number recorded on the counter	=	The amount of radiation detected from the source	+	.... radiation

(1)

(c) The readings taken by the teacher are plotted in **Figure 2**.

Figure 2



(i) Draw a line of best fit to complete **Figure 2**.

(1)

(ii) How does the amount of radiation **absorbed** by the lead change as the total thickness of the lead is increased?

....

....

(1)

(iii) Use **Figure 2** to estimate the reading on the counter when the total thickness of the lead is increased to 12 mm.

Estimated counter reading = ...

(1)

(d) What type of radiation was emitted from the radioactive source?

Draw a ring around the correct answer.

alpha **beta** **gamma**

Give a reason for your answer.

....

....

(2)
(Total 8 marks)

23 Many countries use nuclear power stations to generate electricity.
Nuclear power stations use the process of nuclear fission to release energy.

(a) (i) What is nuclear fission?

....

....

(1)

(ii) Plutonium-239 is one substance used as a fuel in a nuclear reactor. For nuclear fission to happen, the nucleus must absorb a particle.

What type of particle must be absorbed?

....

(1)

(b) Nuclear **fusion** also releases energy.
Nuclear fusion happens at very high temperatures. A high temperature is needed to overcome the repulsion force between the nuclei.

(i) Why is there a repulsion force between the nuclei of atoms?

....

....

(1)

(ii) Where does nuclear fusion happen naturally?

....

(1)

(c) In 1991, scientists produced the first controlled release of energy from an experimental nuclear **fusion** reactor. This was achieved by fusing the hydrogen isotopes, deuterium and tritium.

Deuterium is naturally occurring and can easily be extracted from seawater. Tritium can be produced from lithium. Lithium is also found in seawater.

The table gives the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Type of fuel	**Energy released from 1 kg of fuel in joules**
Fusion fuel	3.4×10^{14}
Fission fuel	8.8×10^{13}

(i) Suggest **two** advantages of the fuel used in a fusion reactor compared with plutonium and the other substances used as fuel in a fission reactor.

1...

....

....

2...

....

....

(2)

(ii) Some scientists think that by the year 2050 a nuclear fusion power station capable of generating electricity on a large scale will have been developed.

Suggest **one** important consequence of developing nuclear fusion power stations to generate electricity.

....

....

....

(1)

(d) Tritium is radioactive.

After 36 years, only 10 g of tritium remains from an original sample of 80 g.

Calculate the half-life of tritium.

Show clearly how you work out your answer.

....

....

Half-life = ... years

(2)
(Total 9 marks)

24 (a) Complete the following sentences.

Ultrasound waves have a minimum frequency

of .... hertz.

The wavelength of an X-ray is about the same as

the diameter of ....

(2)

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

The images show one medical use of ultrasound and one medical use of X-rays.

©monkeybusinessimages/iStock/Thinkstock

© targovecom/iStock/Thinkstock

Compare the medical uses of ultrasound and X-rays.

Your answer should include the risks, if any, and precautions, if any, associated with the use of ultrasound and X-rays.

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(6)
(Total 8 marks)

25 When two objects interact, they exert forces on each other.

(a) Which statement about the forces is correct?

Tick (✓) **one** box.

	Tick (✓)
The forces are equal in size and act in the same direction.	
The forces are unequal in size and act in the same direction.	
The forces are equal in size and act in opposite directions.	
The forces are unequal in size and act in opposite directions.	

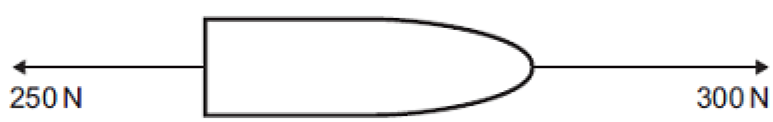
(1)

(b) A fisherman pulls a boat towards land.

The forces acting on the boat are shown in **Diagram 1**.

The fisherman exerts a force of 300 N on the boat.
The sea exerts a resistive force of 250 N on the boat.

Diagram 1



(i) Describe the motion of the boat.

....

....

....

....

(2)

(ii) When the boat reaches land, the resistive force increases to 300 N.
The fisherman continues to exert a force of 300 N.

Describe the motion of the boat.

Tick (✓) **one** box.

Accelerating to the right ☐

Constant velocity to the right ☐

Stationary ☐

(1)

(iii) Explain your answer to part **(b)(ii)**.

....

....

....

....

(2)

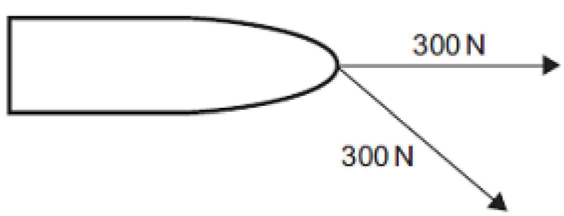
(iv) Another fisherman comes to help pull the boat. Each fisherman pulls with a force of 300 N, as shown in **Diagram 2**.

Diagram 2 is drawn to scale.

Add to **Diagram 2** to show the single force that has the same effect as the two 300 N forces.

Determine the value of this resultant force.

Diagram 2



Resultant force = ... N

(4)
(Total 10 marks)

26 Atoms contain three types of particle.

(a) Draw a ring around the correct answer to complete the sentence.

The particles in the nucleus of the atom are	electrons and neutrons. electrons and protons. neutrons and protons.

(1)

(b) Complete the table to show the relative charges of the atomic particles.

Particle	**Relative charge**
Electron	–1
Neutron	
Proton	

(2)

(c) (i) A neutral atom has no overall charge.

Explain this in terms of its particles.

....

....

....

....

(2)

(ii) Complete the sentence.

An atom that loses an electron is called an ....

and has an overall .... charge.

(2)

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

Some substances are radioactive. They may emit alpha or beta particles.

Describe the characteristics of alpha particles and beta particles in terms of their:

- structure
- penetration through air and other materials
- deflection in an electric field.

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(6)
(Total 13 marks)

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

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

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

....

Wasted energy = ... J

(1)

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

....

....

(1)

(iii) Calculate the efficiency of this light bulb.

....

....

Efficiency = ...

(2)

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

....

....

Time = ... s

(2)

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

The table shows some of this information.

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

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

....

(1)

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

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

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

Use the information given in the table.

....

....

....

....

(2)

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

....

....

(1)
(Total 10 marks)

28 On 14 October 2012, a skydiver set a world record for the highest free fall from an aircraft.

After falling from the aircraft, he reached a maximum steady velocity of 373 m / s after 632 seconds.

(a) Draw a ring around the correct answer to complete the sentence.

This maximum steady velocity is called the [frictional / initial / terminal] velocity.

(1)

(b) The skydiver wore a chest pack containing monitoring and tracking equipment.
The weight of the chest pack was 54 N.

The gravitational field strength is 10 N / kg.

Calculate the mass of the chest pack.

....

....

Mass of chest pack = ... kg

(2)

(c) During his fall, the skydiver's acceleration was not uniform.

Immediately after leaving the aircraft, the skydiver's acceleration was 10 m / s ^{2}.

(i) Without any calculation, estimate his acceleration a few seconds after leaving the aircraft.

Explain your value of acceleration in terms of forces.

Estimate ....

Explanation ....

....

....

....

....

....

(3)

(ii) Without any calculation, estimate his acceleration 632 seconds after leaving the aircraft.

Explain your value of acceleration in terms of forces.

Estimate ....

Explanation ....

....

....

....

....

....

(3)
(Total 9 marks)

29 (a) **Diagram 1** shows a magnetic closure box when open and shut. It is a box that stays shut, when it is closed, due to the force between two small magnets.

These boxes are often used for jewellery.

Diagram 1

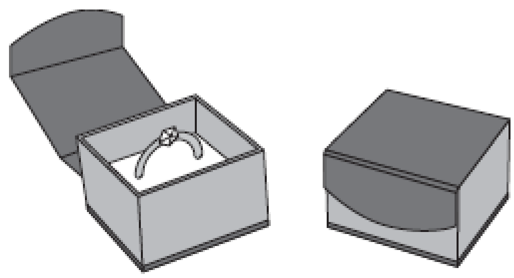
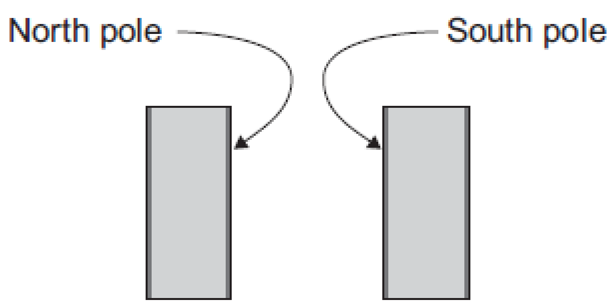


Diagram 2 shows the two magnets. The poles of the magnets are on the longer faces.

Diagram 2



(i) Draw, on **Diagram 2**, the magnetic field pattern between the two facing poles.

(2)

(ii) The magnets in the magnetic closure box must **not** have two North poles facing each other.

Explain why.

....

....

....

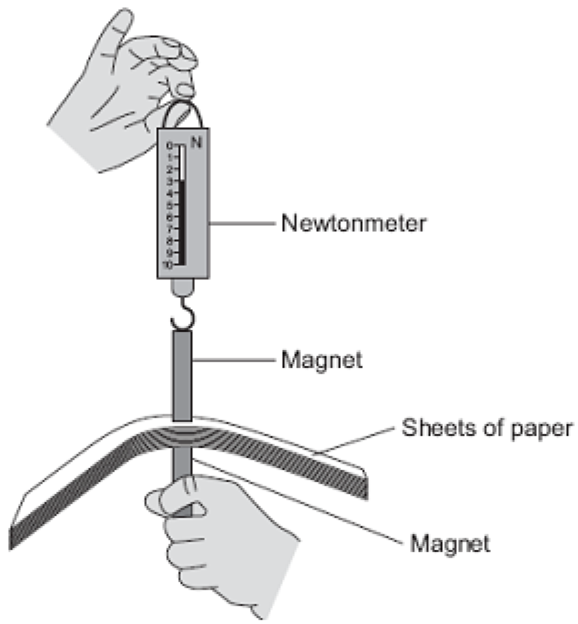
....

(2)

(b) A student is investigating how the force of attraction between two bar magnets depends on their separation.

She uses the apparatus shown in **Diagram 3**.

Diagram 3



She uses the following procedure:

- ensures that the newtonmeter does not have a zero error
- holds one of the magnets
- puts sheets of paper on top of the magnet
- places the other magnet, with the newtonmeter magnetically attached, close to the first magnet
- pulls the magnets apart
- notes the reading on the newtonmeter as the magnets separate
- repeats with different numbers of sheets of paper between the magnets.

The results are shown in the table.

Number of sheets of paper between the magnets	10	20	30	40	50	60	70	80	120
Newtonmeter reading as the magnets separate	3.1	2.6	2.1	1.5	1.1	1.1	1.1	1.1	1.1

(i) Describe the pattern of her results.

....

....

....

....

(2)

(ii) No matter how many sheets of paper the student puts between the magnets, the force shown on the newtonmeter never reaches zero.

Why?

....

....

(1)

(iii) The student is unable to experiment with fewer than 10 sheets of paper without glueing the magnet to the newtonmeter.

Suggest why.

....

....

....

....

(2)

(iv) Suggest **three** improvements to the procedure that would allow the student to gain more accurate results.

....

....

....

....

....

....

....

....

(3)

(v) The thickness of one sheet of paper is 0.1 mm.

What is the separation of the magnets when the force required to separate them is 2.1 N?

....

....

....

Separation of magnets = ... mm

(3)
(Total 15 marks)

30 All objects emit and absorb infrared radiation.

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

dark matt	**dark shiny**	**light matt**	**light shiny**

The best emitters of infrared radiation have

.... surfaces.

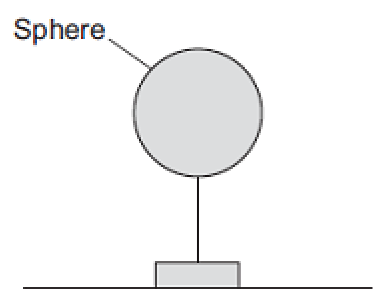
The worst emitters of infrared radiation have

.... surfaces.

(2)

(b) **Diagram 1** shows a sphere which is at a much higher temperature than its surroundings.

Diagram 1



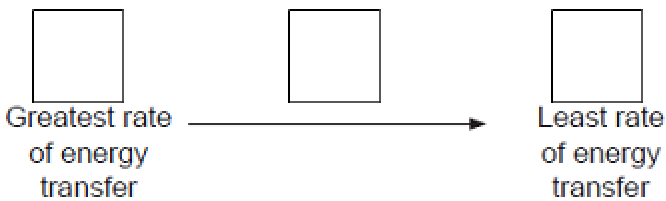
Energy is transferred from the sphere to the surroundings.

The table shows readings for the sphere in three different conditions, **A**, **B** and **C**.

Condition	Temperature of sphere in °C	Temperature of surroundings in °C
A	70	5
B	80	0
C	90	30

In each of the conditions, **A**, **B** and **C**, the sphere transfers energy to the surroundings at a different rate.

Put conditions **A**, **B** and **C** in the correct order.



Give a reason for your answer.

....

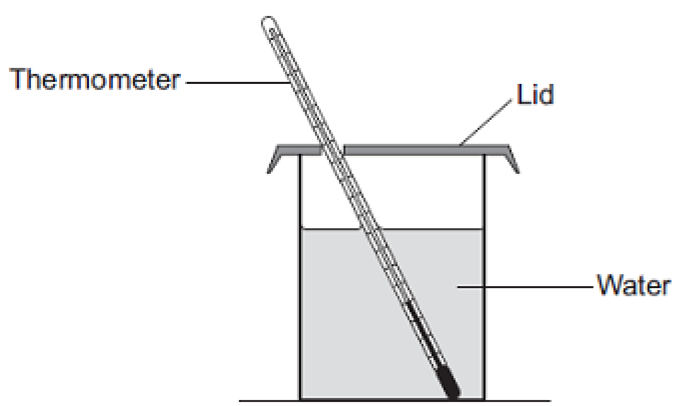
....

(2)

(c) **Diagram 2** shows a can containing water.

A student investigates how quickly a can of water heats up when it is cooler than room temperature.

Diagram 2



The student has four cans, each made of the same material, with the following outer surfaces.

dark matt **dark shiny** **light matt** **light shiny**

The student times how long it takes the water in each can to reach room temperature.

Each can contains the same mass of water at the same starting temperature.

(i) Which can of water will reach room temperature the quickest?

Give a reason for your answer.

....

....

....

....

(2)

(ii) Apart from material of the can, mass of water and starting temperature, suggest **three** control variables for the student's investigation.

1 ....

....

2 ....

....

3 ....

....

(3)

(d) The photographs show two different foxes.

Fox A

Fox B

Which fox is better adapted to survive cold conditions?

Give reasons for your answer.

....

....

....

....

....

....

....

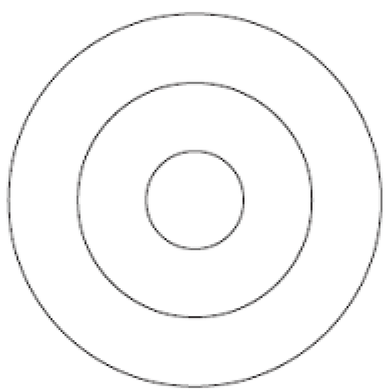
....

(3)
(Total 12 marks)

31 A teacher demonstrates the production of circular waves in a ripple tank.

Diagram 1 shows the waves at an instant in time.

Diagram 1



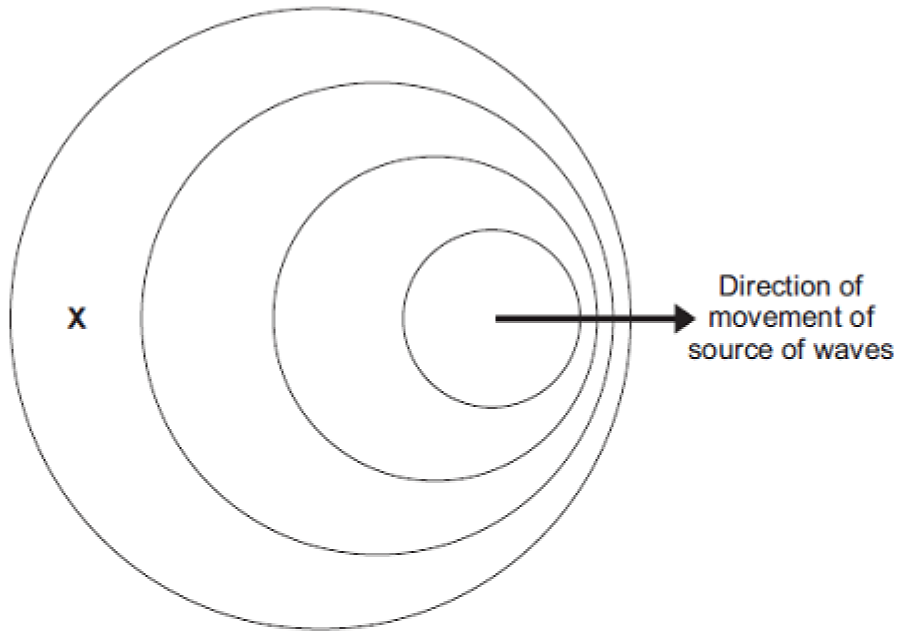
(a) Show on **Diagram 1** the wavelength of the waves.

(1)

(b) The teacher moves the source of the waves across the ripple tank.

Diagram 2 shows the waves at an instant in time.

Diagram 2
(Actual size)



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

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

In **Diagram 2**, the observed wavelength of the waves at **X**

has ....

In **Diagram 2**, the frequency of the waves at **X**

has ....

(2)

(ii) Take measurements from **Diagram 2** to determine the wavelength of the waves received at **X**.

Give the unit.

....

....

Wavelength = ...

(3)

(c) The teacher uses the waves in the ripple tank to model the changes in the wavelengths of light observed from distant galaxies.

When observed from the Earth, there is an increase in the wavelength of light from distant galaxies.

(i) State the name of this effect.

....

(1)

(ii) What does this increase in wavelength tell us about the movement of most galaxies?

....

....

(1)

(iii) Explain how this observation supports the Big Bang theory of the formation of the Universe.

....

....

....

....

....

....

....

....

....

....

....

....

(4)

(iv) State **one** other piece of evidence that supports the Big Bang theory of the formation of the Universe.

....

....

(1)

(Total 13 marks)

32 (a) Radio waves, microwaves and visible light are all electromagnetic waves that are used for communication.

(i) Name another electromagnetic wave that is used for communication.

....

(1)

(ii) Name an electromagnetic wave which is **not** used for communication.

State a use for this electromagnetic wave.

Electromagnetic wave ....

Use ....

....

(2)

(b) The table below shows the wavelengths for some electromagnetic waves, **A**, **B**, **C** and **D**.

Wave	**Wavelength**
A	1000 m
B	100 m
C	10 m
D	3 cm

A teacher is going to demonstrate diffraction of waves through a gap. She will carry out the demonstration in a classroom.

The teacher is able to generate waves **A**, **B**, **C** and **D**.

Which wave, **A**, **B**, **C** or **D**, would she use? ☐

Explain your answer.

....

....

....

....

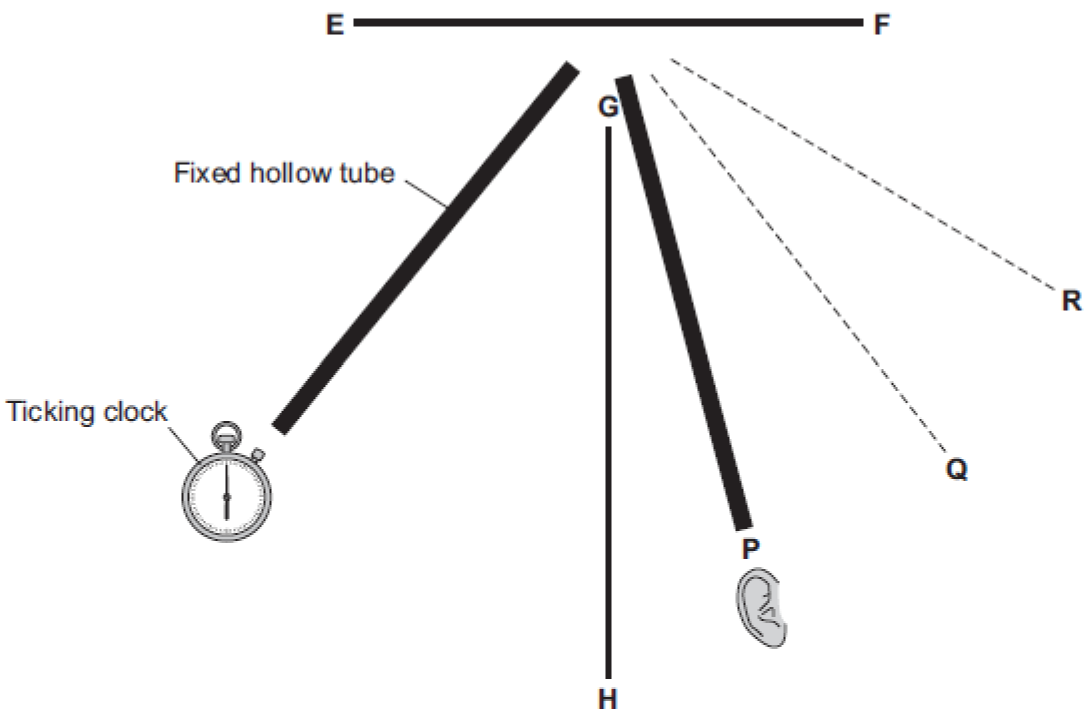
....

....

(3)

(c) In another demonstration, a teacher used a loud ticking clock as a source of sound, two hollow tubes and two smooth surfaces, **EF** and **GH**.

The figure below shows one of the hollow tubes fixed in position with a ticking clock at one end.



A student placed his ear at one end of the other hollow tube in position **P**. He moved this hollow tube, in turn, to positions **Q** and **R**.

(i) At which position, **P**, **Q** or **R**, did he hear the loudest sound? ☐

(1)

(ii) Explain your answer to part **(i)**.

....

....

....

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....

....

(3)

(iii) Suggest why smooth surface **GH** in the figure above was needed.

....

....

(1)

(iv) The frequency of a sound wave is 15 Hz.

The speed of sound is 330 m / s.

Calculate the wavelength of the sound wave.

....

....

Wavelength = ... m

(2)

(v) Give a reason why it would **not** be possible to do the demonstration in the figure above using sound waves with a frequency of 15 Hz.

....

....

(1)
(Total 14 marks)

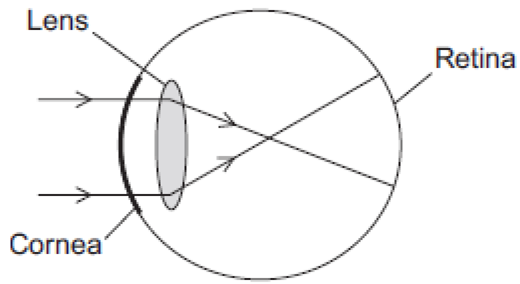
33 Lenses can be used to correct visual defects.

Figure 1 shows a child wearing glasses.
Wearing glasses allows a lens to correct a visual defect.

Figure 1

(a) **Figure 2** shows rays of light entering a child's eye and being focused at a point. This point is not on the retina so the child sees a blurred image.

Figure 2



(i) What is the visual defect of this eye?

....

....

(1)

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

converging	**convex**	**diverging**

The type of lens used to correct this visual defect is a .... lens.

(1)

(b) Visual defects may be corrected with eye surgery. A laser may be used in eye surgery.

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

light	**sound**	**X-rays**

A laser is a concentrated source of ....

(1)

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

Lasers can be used to correct a visual defect by changing the shape of the cornea.

A knife is used to cut a flap in the cornea. The laser vaporises a portion of the cornea and permanently changes its shape. The flap is then replaced.

Most patients are back at work within a week. Driving may be unsafe for one to two weeks. Tinted glasses with ultraviolet protection are needed when out in the sun for the first three months.

Many people in their mid-40s need reading glasses. This is because the eye lens becomes less flexible with age. Laser surgery cannot cure this.

Laser surgery for both eyes costs £1000. A pair of glasses costs £250.

Describe the advantages and disadvantages of:

- having laser surgery to correct visual defects
- wearing glasses to correct visual defects.

....

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Extra space ....

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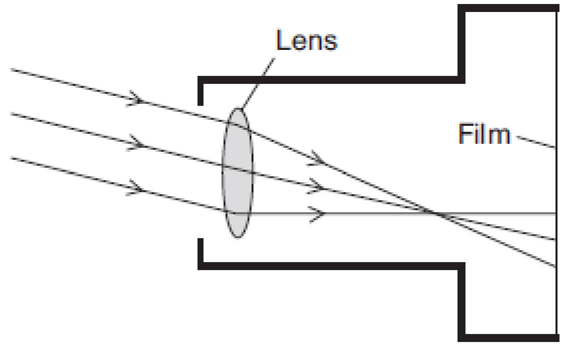
(6)

(d) **Figure 3** shows parallel rays of light, from a point on a distant object, entering a camera.

Figure 3



Describe the adjustment that has to be made to focus the image on the film.

....

....

....

....

(2)
(Total 11 marks)

34 The current in a circuit depends on the potential difference (p.d.) provided by the cells and the total resistance of the circuit.

(a) Using the correct circuit symbols, draw a diagram to show how you would connect 1.5 V cells together to give a p.d. of 6 V.

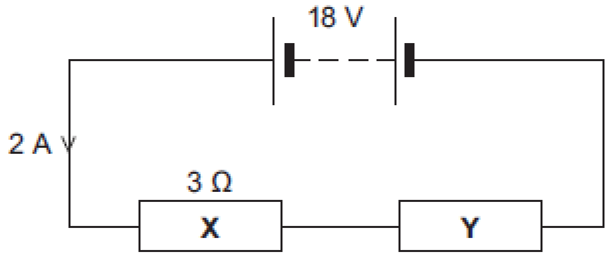
(2)

(b) **Figure 1** shows a circuit containing an 18 V battery.

Two resistors, **X** and **Y**, are connected in series.

- **X** has a resistance of 3 Ω.
- There is a current of 2 A in **X**.

Figure 1



(i) Calculate the p.d. across **X**.

....

....

P.d. across **X** = ... V

(2)

(ii) Calculate the p.d. across **Y**.

....

....

....

P.d. across **Y** = ... V

(2)

(iii) Calculate the total resistance of **X** and **Y**.

....

....

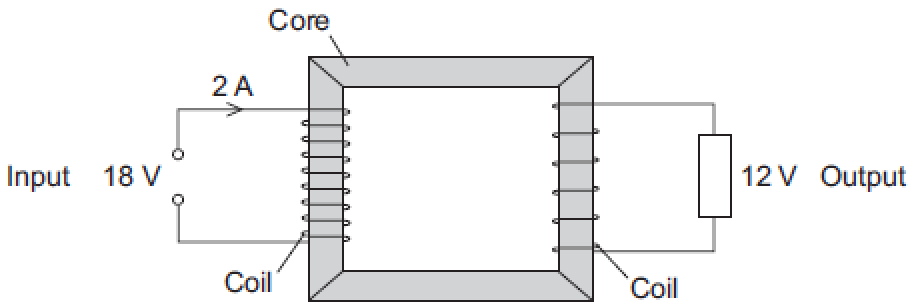
....

Total resistance of **X** and **Y** = ... Ω

(2)

(c) **Figure 2** shows a transformer.

Figure 2



(i) An 18 V battery could **not** be used as the input of a transformer.

Explain why.

....

....

....

....

(2)

(ii) The transformer is 100% efficient.

Calculate the output current for the transformer shown in **Figure 2**.

....

....

....

Output current = ... A

(2)
(Total 12 marks)

35 Different radioactive isotopes have different values of half-life.

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

....

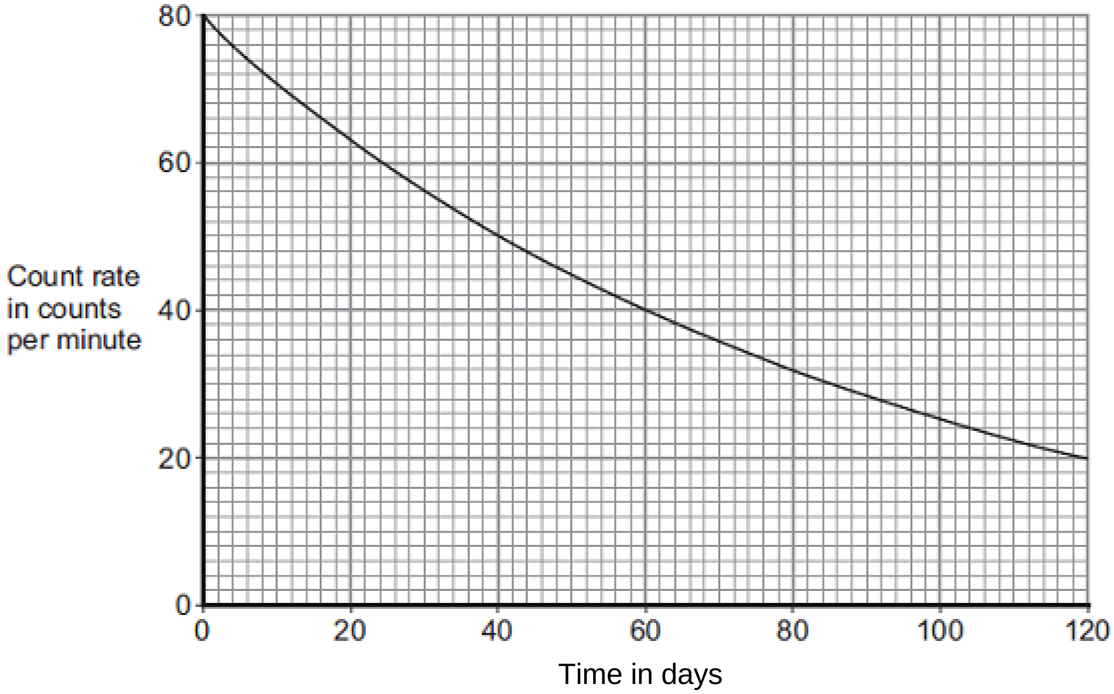
....

....

(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 gamma	1600
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.

....

....

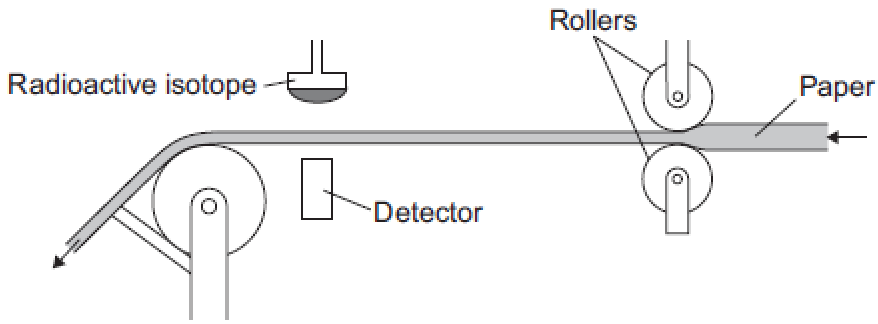
....

....

(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.

....

....

....

....

....

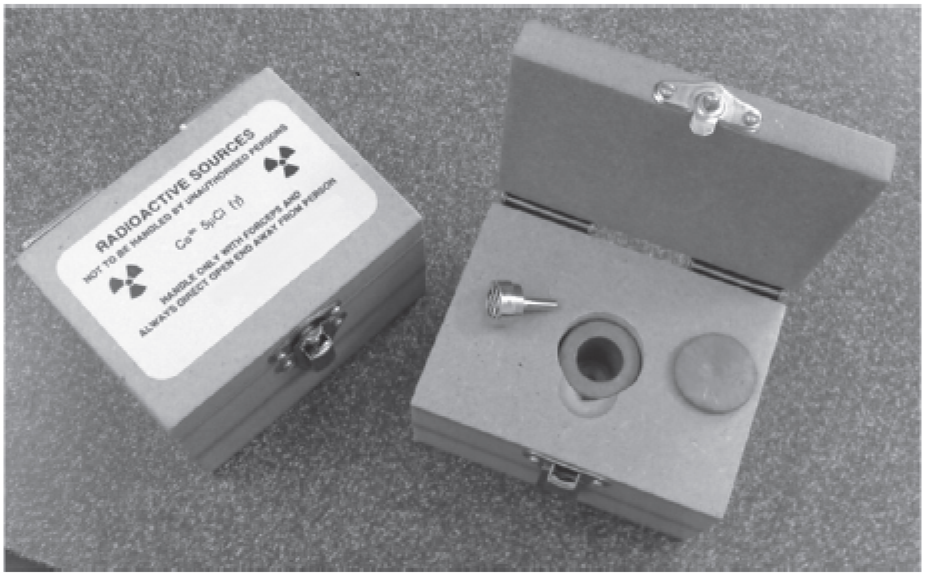
(3)

(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)

36 (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.

....

....

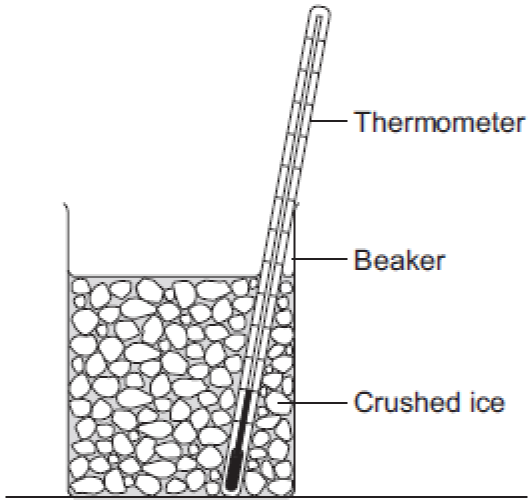
Energy = ... J

(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.

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Extra space ....

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(6)
(Total 18 marks)

37 Electricity can be generated using various energy sources.

(a) Give **one** advantage and **one** disadvantage of using nuclear power stations rather than gas-fired power stations to generate electricity.

Advantage ....

....

Disadvantage ....

....

(2)

(b) (i) A single wind turbine has a maximum power output of 2 000 000 W.

The wind turbine operated continuously at maximum power for 6 hours.

Calculate the energy output in kilowatt-hours of the wind turbine.

....

....

....

Energy output = ... kWh

(2)

(ii) Why, on average, do wind turbines operate at maximum power output for only 30% of the time?

....

....

(1)

(c) An on-shore wind farm is made up of many individual wind turbines.

They are connected to the National Grid using underground power cables.

Give **one** advantage of using underground power cables rather than overhead power cables.

....

....

(1)
(Total 6 marks)

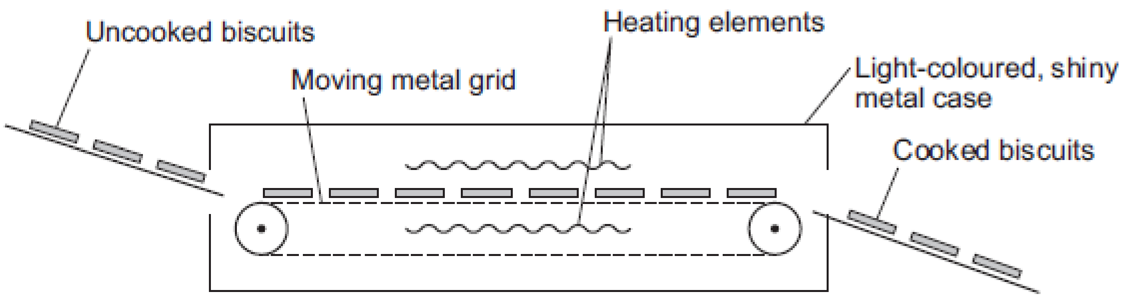
38 **Figure 1** shows one way that biscuit manufacturers cook large quantities of biscuits.

The uncooked biscuits are placed on a moving metal grid.

The biscuits pass between two hot electrical heating elements inside an oven.

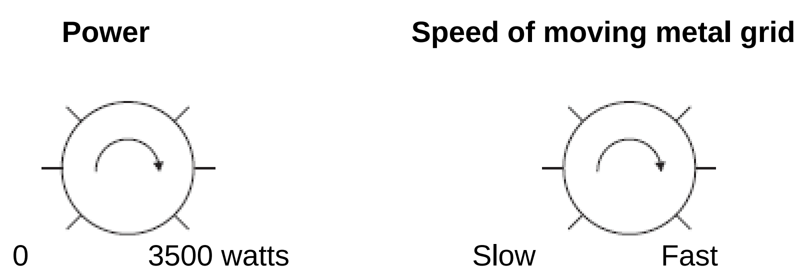
The biscuits turn brown as they cook.

Figure 1



The oven has two control knobs, as shown in **Figure 2**.

Figure 2



(a) Which type of electromagnetic radiation makes the biscuits turn brown?

....

(1)

(b) Suggest **two** ways of cooking the biscuits in this oven, to make them turn browner.

1 ....

....

2 ....

....

(2)

(c) The inside and outside surfaces of the oven are light-coloured and shiny.

Explain why.

....

....

....

....

....

....

(3)
(Total 6 marks)

39 (a) Iceland is a country that generates nearly all of its electricity from renewable sources.

In 2013, about 80% of Iceland's electricity was generated using hydroelectric power stations (HEP).

Describe how electricity is generated in a hydroelectric power station. Include the useful energy transfers taking place.

....

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(4)

(b) The UK produces most of its electricity from fossil fuels.

Many people in the UK leave their televisions in 'stand by' mode when not in use, instead of switching them off.

It is better for the environment if people switch off their televisions, instead of leaving them in 'stand by' mode.

Explain why.

....

....

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....

....

(3)

(c) A scientist wrote in a newspaper:

'Appliances that do not automatically switch off when they are not being used should be banned.'

Suggest why scientists alone cannot make the decision to ban these appliances.

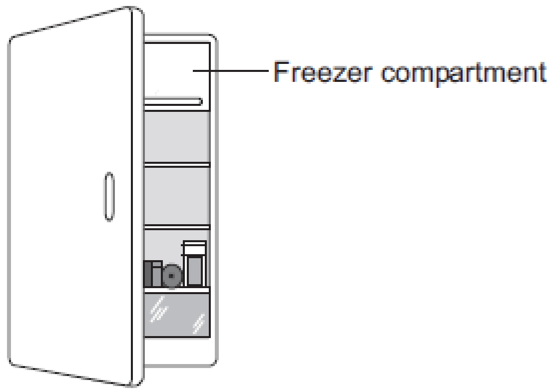
....

....

(1)
(Total 8 marks)

40 (a) The figure below shows a fridge with a freezer compartment.

The temperature of the air inside the freezer compartment is –5 °C.



The air inside the fridge forms a convection current when the fridge door is closed.

Explain why.

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(4)

(b) The table below shows information about four fridges.

Fridge	Volume in litres	Energy used in one year in kWh
A	250	300
B	375	480
C	500	630
D	750	750

A householder concludes that the energy used in one year is directly proportional to the volume of the fridge.

Explain why her conclusion is **not** correct.

Use data from the table in your answer.

....

....

....

....

(2)

(c) New fridges are more efficient than fridges made twenty years ago.

Give **one** advantage and **one** disadvantage of replacing an old fridge with a new fridge.

Ignore the cost of buying a new fridge.

Advantage ....

....

Disadvantage ....

....

(2)
(Total 8 marks)

41 **Table 1** shows information about different light bulbs.

The bulbs all have the same brightness.

Table 1

Type of bulb	**Input power in watts**	**Efficiency**
Halogen	40	0.15
Compact fluorescent (CFL)	14	0.42
LED	7	0.85

(a) (i) Calculate the useful power output of the CFL bulb.

....

....

....

Useful power output = ... watts

(2)

(ii) Use your answer to part **(i)** to calculate the waste energy produced each second by a CFL bulb.

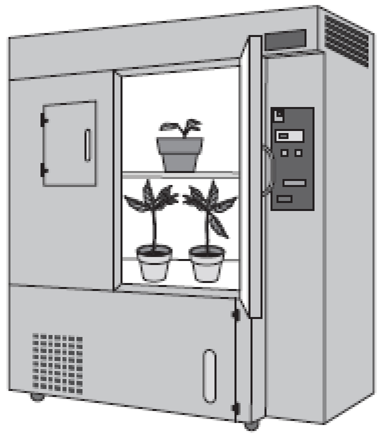
....

Waste energy per second = ... joules

(1)

(b) (i) A growth cabinet is used to investigate the effect of light on the rate of growth of plants.

The figure below shows a growth cabinet.



In the cabinet the factors that affect growth can be controlled.

A cooler unit is used to keep the temperature in the cabinet constant. The cooler unit is programmed to operate when the temperature rises above 20 °C.

The growth cabinet is lit using 50 halogen bulbs.

Changing from using halogen bulbs to LED bulbs would reduce the cost of running the growth cabinet.

Explain why.

....

....

....

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....

....

(4)

(ii) A scientist measured the rate of growth of plants for different intensities of light.

What type of graph should be drawn to present the results?

....

Give a reason for your answer.

....

....

(1)

(c) **Table 2** gives further information about both a halogen bulb and a LED bulb.

Table 2

Type of bulb	**Cost to buy**	**Lifetime in hours**	**Operating cost over the lifetime of one bulb**
Halogen	£1.50	2 000	£16.00
LED	£30.00	48 000	£67.20

A householder needs to replace a broken halogen light bulb.

Compare the cost efficiency of buying and using halogen bulbs rather than a LED bulb over a time span of 48 000 hours of use.

Your comparison must include calculations.

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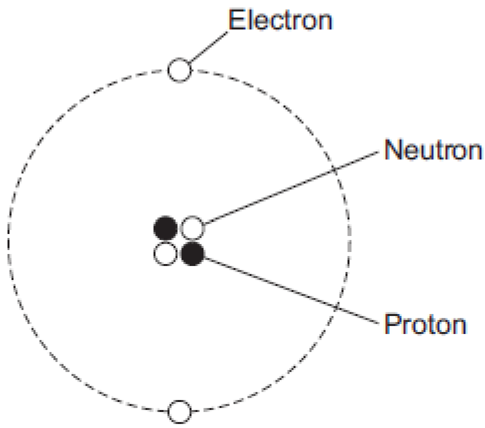
(4)
(Total 12 marks)

42

(a) The figure below shows a helium atom.



(i) Which **one** of the particles in the atom is **not** charged?

Draw a ring around the correct answer.

electron **neutron** **proton**

(1)

(ii) Which **two** types of particle in the atom have the same mass?

.... and ....

(1)

(iii) What is the atomic number of a helium atom?

Draw a ring around the correct answer.

2 **4** **6**

Give a reason for your answer.

....

....

(2)

(b) Alpha particles are one type of nuclear radiation.

(i) Name **one** other type of nuclear radiation.

....

(1)

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

electrons	**neutrons**	**protons**

The difference between an alpha particle and a helium atom is that the alpha particle does **not** have any ....

(1)

(iii) Which **one** of the following is a property of alpha particles?

Tick (✓) **one** box.

Have a long range in air ☐

Are highly ionising ☐

Will pass through metals ☐

(1)

(c) Doctors may use nuclear radiation to treat certain types of illness.

Treating an illness with radiation may also harm a patient.

(i) Complete the following sentence.

The risk from treating a patient with radiation is that the radiation may

.... healthy body cells.

(1)

(ii) Draw a ring around the correct answer to complete the sentence.

Radiation may be used to treat a patient if the risk from the

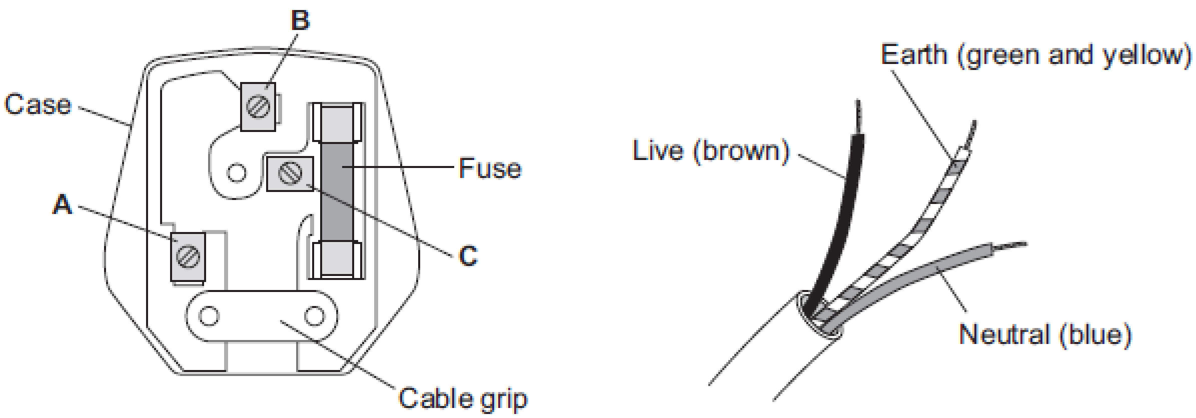
radiation is [much bigger than / about the same as / much smaller than] the possible benefit of having the treatment.

(1)
(Total 9 marks)

43 (a) **Figure 1** shows the inside of a three-pin plug and a length of three-core cable.

The cable is to be connected to the plug.

Figure 1



(i) Complete **Table 1** to show which plug terminal, **A**, **B** or **C**, connects to each of the wires inside the cable.

Table 1

Wire	**Plug terminal**
Live	
Neutral	
Earth	

(2)

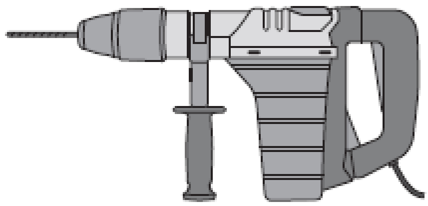
(ii) Name a material that could be used to make the case of the plug.

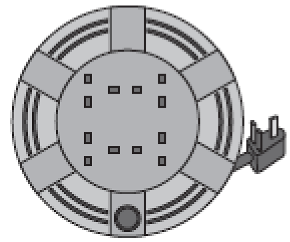
....

(1)

(b) **Figure 2** shows an electric drill and an extension lead. The drill is used with the extension lead.

Figure 2





Electric drill Extension lead

(i) The drill is used for 50 seconds.

In this time, 30 000 joules of energy are transferred from the mains electricity supply to the drill.

Calculate the power of the drill.

....

....

....

Power = ... W

(2)

(ii) A second drill is used with the extension lead. The power of this drill is 1200 W.

The instructions for using the extension lead include the following information.

When in use the lead may get hot:
DO NOT go over the maximum power
• lead wound inside the case: 820 watts
• lead fully unwound outside the case: 3100 watts

It would **not** be safe to use this drill with the extension lead if the lead was left wound inside the plastic case.

Explain why.

....

....

....

....

....

....

(3)

(c) **Table 2** gives information about three different electric drills.

Table 2

Drill	**Power input in watts**	**Power output in watts**
X	640	500
Y	710	500
Z	800	500

A person is going to buy **one** of the drills, **X**, **Y** or **Z**. The drills cost the same to buy.

Use only the information in the table to decide which **one** of the drills, **X**, **Y** or **Z**, the person should buy.

Write your answer in the box. ☐

Give a reason for your answer.

....

....

....

(1)
(Total 9 marks)

44 Stars go through a life cycle.

Some stars will finish their life cycle as a black dwarf and other stars as a black hole.

(a) The table below gives the mass, relative to the Sun, of three stars, **J**, **K** and **L**.

Star	**Mass of the star relative to the Sun**
J	0.5
K	14.5
L	20.0

Which **one** of the stars, **J**, **K** or **L**, will become a black dwarf? ....

Give a reason for your answer.

....

....

(2)

(b) Scientists can take the measurements needed to calculate the mass of many stars.

Scientists cannot calculate the mass of the star Betelgeuse.

They estimate that the star has a mass between 8 and 20 times the mass of the Sun.

(i) Betelgeuse is in the red super giant stage of its life cycle.

What will happen to Betelgeuse at the end of the red super giant stage?

....

....

(1)

(ii) Suggest **one** reason why scientists can only estimate and **not** calculate the mass of Betelgeuse.

....

....

....

(1)

(iii) In the future, it may become possible for scientists to calculate the mass of Betelgeuse.

Suggest **one** reason why.

....

....

....

(1)

(c) Describe what happens to a star, after the main sequence period, for the star to eventually become a **black dwarf**.

....

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(5)
(Total 10 marks)

45 (a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

....

(1)

(b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

(i) What happens during the process of nuclear fission?

....

....

(1)

(ii) Inside which part of a nuclear power station would molybdenum be produced?

....

(1)

(c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}\text{Mo} \longrightarrow {}^{99}_{43}\text{Tc} + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

....

Give a reason for your answer.

....

....

(2)

(d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term ‘half-life’?

....

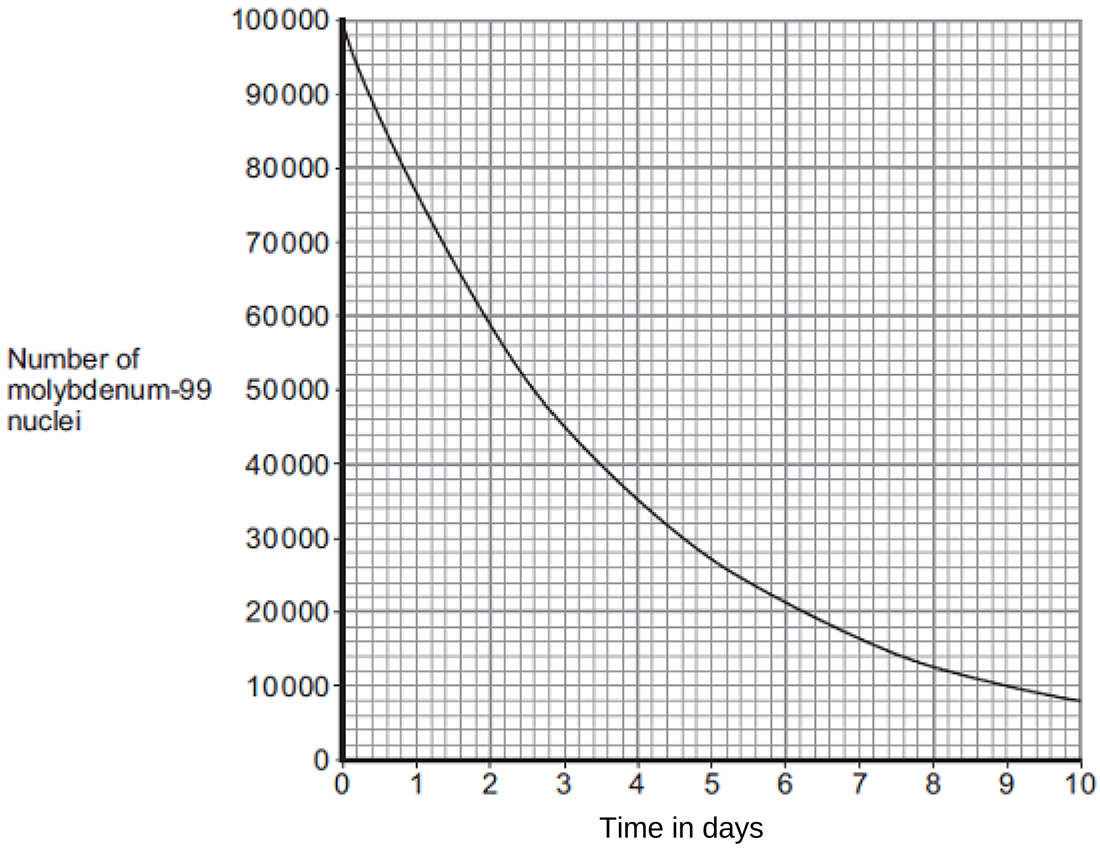
....

....

(1)

(e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

(i) The figure below shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.



A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

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

....

....

....

Number of days = ...

(2)

(ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

....

....

....

....

(2)

(iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

....

....

(1)

(Total 11 marks)

46 (a) Some humans are short-sighted.

Complete the following sentence.

Short sight can be caused by the eyeball being too ....

(1)

(b) Spectacles can be worn to correct short sight.

The table below gives information about three different lenses that can be used in spectacles.

	Lens feature		
	Material	**Mass in grams**	**Type**
Lens A	Plastic	5.0	Concave (diverging)
Lens B	Glass	6.0	Convex (converging)
Lens C	Glass	5.5	Convex (converging)

Which lens from **Table 2** would be used to correct short sight?

Draw a ring around the correct answer.

Lens A **Lens B** **Lens C**

Give the reason for your answer.

....

....

(2)

(c) Every lens has a focal length.

Which factor affects the focal length of a lens?

Tick (✓) **one** box.

The colour of the lens ☐

The refractive index of the lens material ☐

The size of the object being viewed ☐

(1)

(d) A lens has a focal length of 0.25 metres.

Calculate the power of the lens.

....

....

....

Power of lens = ... dioptres

(2)

(e) Laser eye surgery can correct some types of eye defect.

Which of the following is another medical use for a laser?

Tick (✓) **one** box.

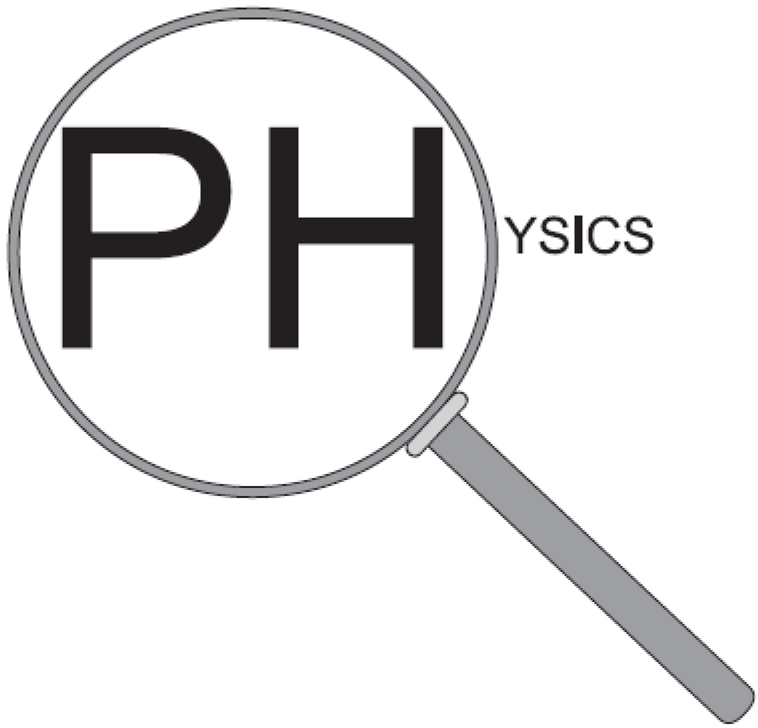
Cauterising open blood vessels ☐

Detecting broken bones ☐

Imaging the lungs ☐

(1)

(f) The figure shows a convex lens being used as a magnifying glass.



Not to scale

An object of height 14 mm is viewed through a magnifying glass.

The image height is 70 mm.

Calculate the magnification produced by the lens in the magnifying glass.

....

....

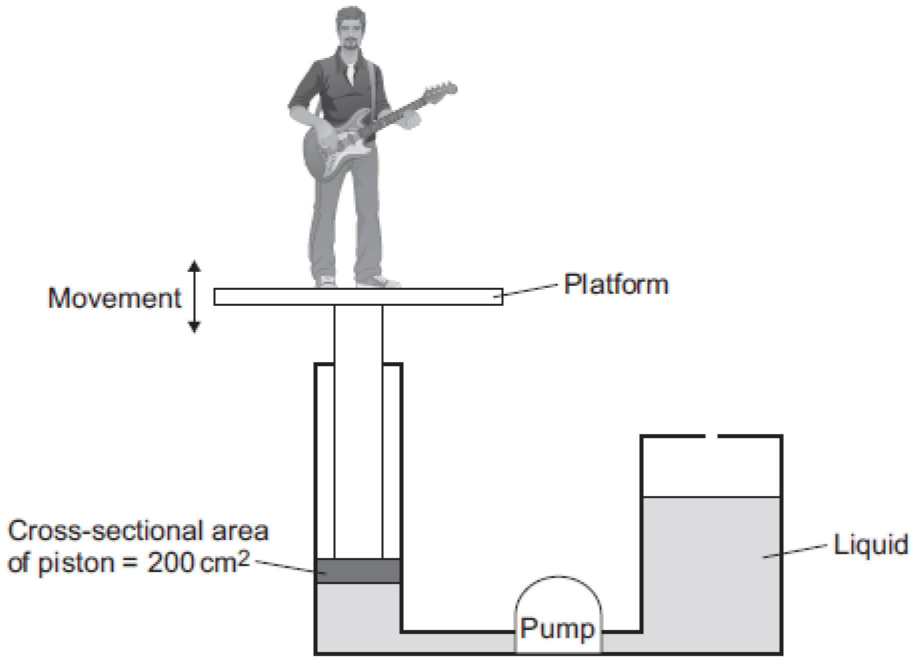
....

Magnification = ...

(2)
(Total 9 marks)

47 Musicians sometimes perform on a moving platform.

The figure below shows the parts of the lifting machine used to move the platform up and down.



(a) What name is given to a system that uses liquids to transmit forces?

Draw a ring around the correct answer.

electromagnetic **hydraulic** **ionising**

(1)

(b) To move the platform upwards, the liquid must cause a force of 1800 N to act on the piston.

The cross-sectional area of the piston is 200 cm^2.

Calculate the pressure in the liquid, in N / cm^2, when the platform moves.

....

....

....

Pressure = ... N / cm^2

(2)

(c) A new development is to use oil from plants as the liquid in the machine.

Growing plants and extracting the oil requires **less energy** than producing the liquid usually used in the machine.

Draw a ring around the correct answer to complete the sentence.

Using the oil from the plants gives	an environmental an ethical a social	advantage over the liquid

usually used.

(1)
(Total 4 marks)

48 (a) What is ultrasound?

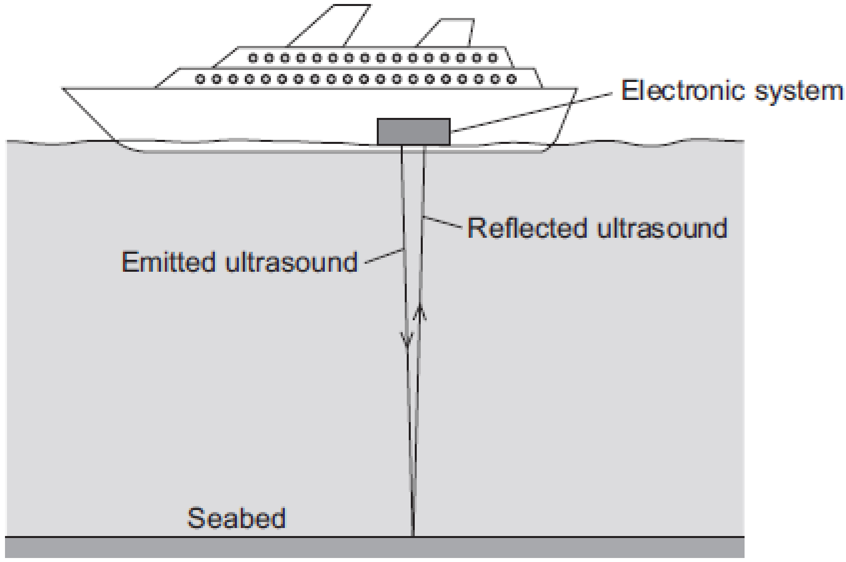
....

....

(1)

(b) **Figure 1** shows how ultrasound is used to measure the depth of water below a ship.

Figure 1



A pulse of ultrasound is sent out from an electronic system on-board the ship.

It takes 0.80 seconds for the emitted ultrasound to be received back at the ship.

Calculate the depth of the water.

Speed of ultrasound in water = 1600 m / s

....

....

....

....

Depth of water = ... metres

(3)

(c) Ultrasound can be used in medicine for scanning.

State **one** medical use of ultrasound scanning.

....

(1)

(d) Images of the inside of the human body can be made using a Computerised Tomography (CT) scanner. The CT scanner in **Figure 2** uses X-rays to produce these images.

Figure 2

monkeybusinessimages/iStock/Thinkstock

State **one** advantage and **one** disadvantage of using a CT scanner, compared with ultrasound scanning, for forming images of the inside of the human body.

Advantage of CT scanning ....

....

....

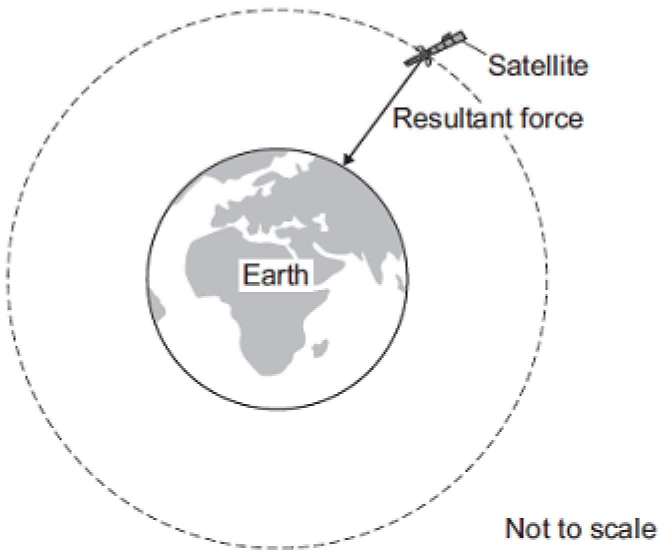
Disadvantage of CT scanning ....

....

....

(2)
(Total 7 marks)

49 Man-made satellites can orbit the Earth, as shown in the figure below.



The satellite experiences a resultant force directed towards the centre of the orbit.

The resultant force is called the centripetal force

(a) What provides the centripetal force on the satellite?

....

(1)

(b) State **two** factors that determine the size of the centripetal force on the satellite.

1 ....

2 ....

(2)

(c) The table below gives data for five different satellites orbiting the Earth.

Satellite	Average height above Earth's surface in kilometres	Time taken to orbit Earth once in minutes	Mass of satellite in kilograms
A	370	93	419 000
B	697	99	280
C	827	103	630
D	5 900	228	400
E	35 800	1440	2 030

(i) State the relationship, if any, between the height of the satellite above the Earth's surface and the time taken for the satellite to orbit the Earth once.

....

....

(1)

(ii) State the relationship, if any, between the time taken for the satellite to orbit the Earth once and the satellite's mass.

....

....

(1)

(d) Over 300 years ago, the famous scientist Isaac Newton proposed, with a 'thought experiment', the idea of satellites.

Newton suggested that if an object was fired at the right speed from the top of a high mountain, it would circle the Earth.

Why did many people accept Isaac Newton's idea as being possible?

Tick (✓) **one** box.

Isaac Newton was a respected scientist who had made new discoveries before. ☐

Isaac Newton went to university. ☐

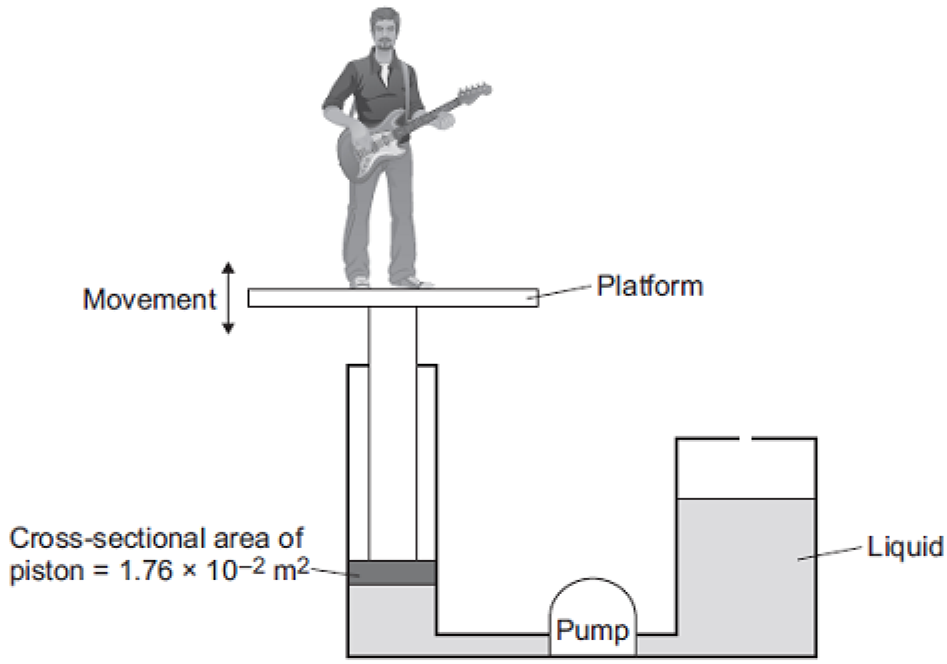
It was a new idea that nobody else had thought of before. ☐

(1)
(Total 6 marks)

50 Musicians sometimes perform on a moving platform.

Figure 1 shows the parts of the lifting machine used to move the platform up and down.

Figure 1



(a) What type of system uses a liquid to transmit a force?

....

(1)

(b) The pump creates a pressure in the liquid of 8.75×10^4 Pa to move the platform upwards.

Calculate the force that the liquid applies to the piston.

....

....

....

Force = ... N

(2)

(c) The liquid usually used in the machine is made by processing oil from underground wells. A new development is to use plant oil as the liquid.

Extracting plant oil requires less energy than extracting oil from underground wells.

Suggest an environmental advantage of using plant oil.

....

....

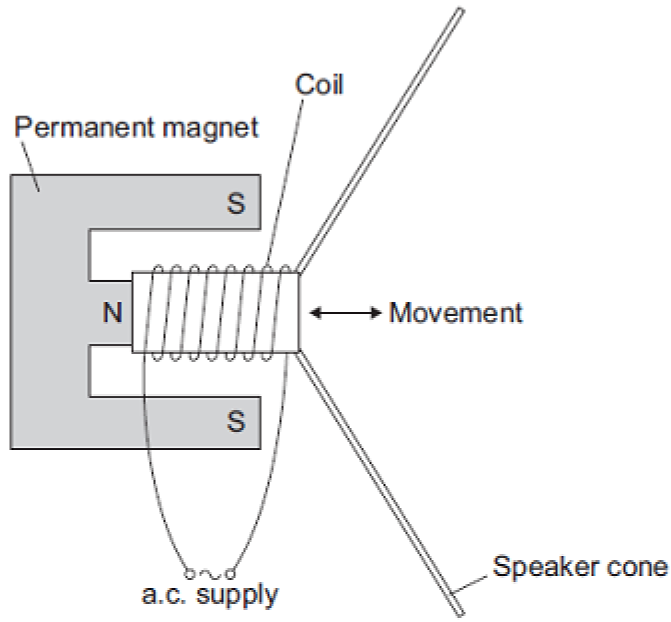
....

(1)

(d) Musicians often use loudspeakers.

Figure 2 shows how a loudspeaker is constructed.

Figure 2



The loudspeaker cone vibrates when an alternating current flows through the coil.

Explain why.

....

....

....

....

....

....

....

....

....

....

(4)
(Total 8 marks)

1 (a) any **two** from:

- bungee rope may snap
- rope may extend too much
- student may land in the river

2

(b) gravitational potential

correct order only

1

kinetic

1

elastic potential

1

(c) $\frac{1}{2} \times 40 \times 35^2$

1

24 500 (J)

accept 25 000 (J) (2 significant figures)

1

*allow 24 500 (J) with no working shown for **2** marks*

[7]

2 (a) Alpha – two protons and two neutrons

1

Beta – electron from the nucleus

1

Gamma – electromagnetic radiation

1

(b) Gamma

Beta

Alpha

*allow **1** mark for 1 or 2 correct*

2

(c) any **two** from:

- (radioactive) source not pointed at students
- (radioactive) source outside the box for minimum time necessary
- safety glasses **or** eye protection **or** do not look at source
- gloves
- (radioactive) source held away from body
- (radioactive) source held with tongs / forceps

accept any other sensible and practical suggestion

2

(d) half-life = 80 s

1

counts / s after 200 s = 71

accept an answer of 70

1

(e) very small amount of radiation emitted

accept similar / same level as background radiation

1

[10]

3

Level 3 (5–6 marks):
A detailed and coherent explanation is provided. The student gives examples that argue a strong case and demonstrate deep knowledge. The student makes logical links between clearly identified, relevant points.

Level 2 (3–4 marks):
An attempt to link the description of the experiment and the results with differences between the two models. The student gives examples of where the plum pudding model does not explain observations. The logic used may not be clear.

Level 1 (1–2 marks):
Simple statements are made that the nuclear model is a better model. The response may fail to make logical links between the points raised.

0 marks:
No relevant content.

Indicative content

- alpha particle scattering experiment
- alpha particles directed at gold foil
- most alpha particles pass straight through
- (so) most of atom is empty space
- a few alpha particles deflected through large angles
- (so) mass is concentrated at centre of atom
- (and) nucleus is (positively) charged
- plum pudding model has mass spread throughout atom
- plum pudding model has charge spread throughout atom

[6]

4

(a) cannot predict which dice / atom will 'decay'

accept answers given in terms of 'roll a 6'

1

cannot predict when a dice / atom will 'decay'

1

(b) 3.6 to 3.7 (rolls)

*allow **1** mark for attempt to read graph when number of dice = 50*

2

(c) 90

1

(d) uranium 1

(e) beta 1

proton number has gone up (as neutron decays to proton and e^-) 1

(f) prevents contamination

or

prevents transfer of radioactive material to teacher's hands 1

which would cause damage / irradiation over a longer time period. 1

[10]

5 (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]

6 (a) any **one** from:

- (visible) light
- UV / ultra violet
- X-ray
- gamma / γ-ray

1

(b) less than

1

less than

1

the same as

1

[4]

7 (a) any **one** from:

- high cost of installing overhead power lines or underground cables or pylons
- high cost as (very) long cables needed
- amount of electricity required is too low

allow not enough (surplus) electricity would be generated

1

(b) 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 apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
clear comparison of advantages **and** disadvantages of **each** method

Level 2 (3 – 4 marks):
at least **one** advantage **and one** disadvantage is stated for **one** method **and** a different advantage **or** disadvantage is stated for the other method

Level 1 (1 – 2 marks):
at least **one** advantage **or one** disadvantage of either method

Level 0 (0 marks):
No relevant information

examples of physics points made in the response

Advantages of both methods:

- both renewable sources of energy
- both have no fuel (cost)
- both have very small (allow 'no') running costs
- no carbon dioxide produced

accept carbon neutral

accept no greenhouse gases

accept doesn't contribute to global warming

Advantages of wind:

- higher average power output

produces more energy is insufficient

Advantages of hydroelectric:

- constant / reliable power (output)
- lower (installation) cost

Disadvantages of wind:

- higher (installation) cost
- variable / unreliable power output
- (may) kill birds / bats

Disadvantages of hydroelectric:

- lower power output
- (may) kill fish or (may) damage habitats
- more difficult to set up (within river)

Disadvantages of both methods:

- (may be) noisy
- visual pollution

ignore payback time unless no other relevant points made

ignore time to build for both

6

[7]

8 (a) **use of infrared:**
remote controls
fibre optic (communications)

1

use of microwaves:
mobile/cell phones

accept mobiles

accept phone signals

satellite (communications/TV)
wi-fi
Bluetooth

1

(b) any **two** from

- same speed
  or
  travel at the speed of light (in a vacuum)
- transverse
  accept a full description of a transverse wave
- transfer energy (from one place to another)
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed / transmitted
- can travel through a vacuum/space
- can be polarised
  travels in straight lines is insufficient

2

[4]

9 (a) any **two** from:

- cost per kWh is lower (than all other energy resources)
  allow it is cheaper
  ignore fuel cost
  ignore energy released per kg of nuclear fuel

- infrastructure for nuclear power already exists
  accept cost of setting up renewable energy resources is high
  accept many renewable power stations would be needed to replace one nuclear power station
  accept (France in 2011 already had a) surplus of nuclear energy, so less need to develop more renewable capacity for increased demand in the future
  accept France benefits economically from selling electricity

- more reliable (than renewable energy resources)
  accept (nuclear) fuel is readily available
  ignore destruction of habitats for renewables

2

(b) any **two** from:

- non-renewable
  allow nuclear fuel is running out
- high decommissioning costs
  accept high commissioning costs
- produces radioactive / nuclear waste
  allow waste has a long half-life
- long start-up time
- nuclear accidents have widespread implications
  allow for nuclear accident a named nuclear accident
  eg Fukushima, Chernobyl
  ignore visual pollution

2

(c) 0.48 (kW)

*allow **1** mark for correct substitution*
ie 0.15 = P / 3.2
*an answer of 480 W gains **2** marks*
*an answer of 48 or 480 scores **1** mark*

2

(d) the higher the efficiency, the higher the cost (per m^2 to manufacture)

accept a specific numerical example

1

more electricity could be generated for the same (manufacturing) cost using lower efficiency solar panels
or
(reducing the cost) allows more solar panels to be bought

accept a specific numerical example

1

[8]

10 (a) gas

correct order only

1

gravity

1

protostar

accept correct word circled in box provided no answer given in answer space

1

(b) the explosion of a massive star

1

(c) The telescopes and measuring instruments were not sensitive enough.

1

[5]

11 (a) 20

1

(b) 50

1

(c) (i) 115

1

(ii) 230

1

(iii) if one goes out the other still works

or

brighter

accept power (output) is greater

can be switched on/off independently is insufficient

1

(d) the outside/casing is plastic

there is plastic around the wires is insufficient

it is plastic is insufficient

1

and plastic is an insulator

an answer the light fitting is double insulated gains both marks

1

(e) (residual current) circuit breaker

accept RCCB

accept RCBO

accept RCCD

accept RCB

accept miniature circuit breaker / MCB

trip switch is insufficient

breaker is insufficient

do not accept earth wire

1

[8]

12 (a) neutrons

1

(b) generate electricity

accept produce electricity

accept heat water

accept produce steam

turns turbines is insufficient

1

(c) (i) a neutron

1

(ii) two particles **X** released from the uranium-235

1

uranium-235 shown splitting into two fragments
or
each particle **X** shown colliding with a uranium-235 and producing 2 further particles **X**

one uranium-235 shown splitting is sufficient, provided no contradiction shown

1

[5]

13 (a) 2 protons and 2 neutrons

accept 2p and 2n

accept (the same as a) helium nucleus

symbol is insufficient

do not accept 2 protons and neutrons

1

(b) (i) gamma rays

1

(ii) loses/gains (one or more) electron(s)

1

(c) any **one** from:

- wear protective clothing
- work behind lead/concrete/glass shielding
- limit time of exposure
- use remote handling

accept wear mask/gloves

wear goggles is insufficient

wear protective equipment/gear is insufficient

accept wear a film badge

accept handle with (long) tongs

accept maintain a safe distance

accept avoid direct contact

1

(d) 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 apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
There is a description of all three types of radiation in terms of at least two of their properties
or
a full description of two types of radiation in terms of all three properties.

Level 2 (3 – 4 marks):
There is a description of at least two types of radiation in terms of some properties
or
a full description of one type of radiation in terms of all three properties
or
the same property is described for all three radiations

Level 1 (1 – 2 marks):
There is a description of at least one type of radiation in terms of one or more properties.

Level 0 (0 marks):
No relevant information

examples of physics points made in the response

alpha particles

- are least penetrating
- are stopped by paper / card

- have the shortest range
- can travel (about) 5cm in air

- are (slightly) deflected by a magnetic field
- alpha particles are deflected in the opposite direction to beta particles by a magnetic field

beta particles

- (some are) stopped by (about) 2mm (or more) of aluminium/metal
- can travel (about) 1 metre in air
- are deflected by a magnetic field
- beta particles are deflected in the opposite direction to alpha particles by a magnetic field

accept (some are) stopped by aluminium foil

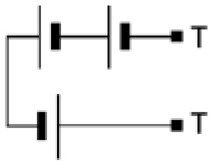
gamma rays

- are the most penetrating
- are stopped by (about) 10cm of lead
- have the longest range
- can travel at least 1 km in air
- are not deflected by a magnetic field

6

[10]

14 (a) 3rd box from the left ticked



1

(b) correct symbol drawn in series with other components

symbol must have upper case A

1

(c) (i) 9 + 3 = 12V

reason only scores if this mark scored

1

pd of battery is shared between the variable resistor and fixed resistor

accept $V_1 + V_2$ = pd of the battery

accept p.d. is shared in a series circuit

accept voltage for p.d.

1

(ii) 600

reason only scores if this mark scored

1

p.d. of supply shared equally when resistors have the same value

or

ratio of the p.d. is the same as the ratio of the resistance

1

(iii) 0.015

or

their (c)(i) ÷ (their (c)(ii) + 200) correctly calculated

*allow **2** marks for correct substitution ie 12 = I × 800*

or

their (c)(i) = I × (their (c)(ii) + 200)

*allow **1** mark for total resistance = 800 (Ω) or their (c)(ii) + 200*

or

*allow **1** mark for a substitution of 12 = I × 200*

or

their (c)(i) = I × 200

or

alternative method using the graph

V = 3 V (1)

3 = I × 200 (1)

3

[9]

15 (a) pin

made from brass because it is (hard and) a (good electrical) conductor

accept copper for brass

metal is insufficient

heat conductor on its own negates

1

outer case

plastic/rubber because it is a (good electrical) insulator

heat insulator on its own negates

1

(b) (i) live

1

(ii) makes it hot/warm

melts is insufficient

1

(iii) 8.7

accept an answer that rounds to 8.7

*allow **1** mark for correct substitution ie 2000 = 230 × I*

*an answer of 0.0087 **or** 0.009 **or** 3.0(4) **or** 5.65 **or** 5.7 gains **1** mark*

2

(c) a (large) current goes from the live wire to the earth wire

accept metal case for live wire

accept a current goes from live to earth

do not accept electricity for current

1

(which causes) the fuse to (overheat and) melt

accept blow for melt

break is insufficient

do not accept snap / blow up for melt

1

(d) reduce chance of an electric shock

accept to reduce the risk of an accident

accept prevent electric shock

accept prevent electrocution

accept prevent or reduce the risk of an (electrical) fire

accept an electric shock can kill you

accept it can kill you

accept so you can use it safely

1

[9]

16 (a) (i) (enough) dust and gas (from space) is pulled together

accept nebula for dust and gas

accept hydrogen for gas

accept gas on its own

dust on its own is insufficient

mention of air negates this mark

1

by:
gravitational attraction
or
gravitational forces
or
gravitaty

ignore any (correct) stages beyond this

1

(ii) joining of two (atomic) nuclei (to form a larger one)

do not accept atoms for nuclei

1

(iii) more sensitive astronomical instruments / telescopes
or
infrared telescopes developed

accept better technology

more knowledge is insufficient

1

(b) (i) (other) planets / solar systems

do not accept galaxy

moons is insufficient

1

(ii) provided evidence to support theory

accept proves the theory

1

(c) elements heavier than iron are formed only when a (massive) star explodes

accept materials for elements

accept supernova for star explodes

accept stars can only fuse elements up to (and including) iron

1

[7]

17 (a) (force on the chain is) smaller (than the force of the toe)

1

(b) Tick in middle box

The moments are equal and opposite

1

(c) move the toe (up the pedal) away from the pivot

1

[3]

18 (a) a magnetic field

accept electromagnetic field

heat is insufficient

1

that is alternating / changing

1

(b) 20

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

$$\frac{230}{11.5}$$

provided no subsequent step

2

(c) (most) transformers are not 100% efficient

allow energy / power is lost to the surroundings

allow energy / power is lost as heat / sound

power is lost is insufficient

1

(d) (i) 0.01 (V)

1

because there is a change in p.d. each time (the number of turns changes)

allow because all the results (to 2 decimal places) are different

accept if results were to 1 decimal place, there might not be a difference

1

(ii) student 2 moved the coil more slowly (than student 1)

accept student 2 moved the coil at a different speed to student 1

do not accept student 2 moved the coil faster (than student 1)

1

(iii) both sets of results show the same pattern

accept trend for pattern

results are similar is insufficient

results follow a pattern is insufficient

1

(iv) (electromagnetic) induction

accept it is induced

do not accept electric / magnetic induction

1

(e) any **one** from:

- more economical / cheaper for the consumer
  allow more convenient
- easier/cheaper to replace if broken/lost
  allow in case one gets lost
- since fewer transformers need to be made less resources are used
  allow fewer plug sockets are needed
  allow fewer transformers are needed
  environmentally friendly is insufficient

1

[11]

19 (a) ultrasound is not ionising
allow ultrasound does not harm the (unborn) baby

1

but X-rays are ionising

1

so X-rays increase the health risk to the (unborn) baby
accept specific examples of health risks, eg cancer, stunted growth, impaired brain function etc
X-rays are dangerous is insufficient

1

(b) ultrasound/waves are partially <u>reflected</u>

(when they meet a boundary) (between two different media / substances / tissues)
must be clear that not all of the wave is reflected

1

the time taken is measured (and is used to determine distances)

1

(c) 1600 (m/s)

*800 (m/s) gains **2** marks*

*160 000 (m/s) gains **2** marks*

*0.0016 (m/s) gains **2** marks*

*allow **2** marks for*

$$\frac{0.04}{25 \times 10^{-6}}$$

or

$$\frac{0.08}{50 \times 10^{-6}}$$

*80 000 (m/s) gains **1** mark*

*0.0008 (m/s) gains **1** mark*

*allow **1** mark for*

$$\frac{0.04}{25}$$

or

$$\frac{0.08}{50}$$

*allow **1** mark for evidence of doubling the distance or halving the time*

3

(d) (i) they are absorbed by bone

allow stopped for absorbed

X-rays are reflected negates this mark

1

they are transmitted by soft tissue

allow pass through for transmitted

allow flesh / muscle / fat

accept less (optically) dense material for soft tissue

1

(the transmitted) X-rays are detected

1

(ii) short

accept small

1

[12]

20 (a) (i) turning effect

accept force multiplied by perpendicular distance from the line of action of the force to the pivot

1

(ii) moments are equal (in size) and opposite (in direction)

both parts are required

allow clockwise moment = anticlockwise moment

1

(iii) 0.9 (N)

*allow **2** marks for F = 0.18 ÷ 0.2 provided no subsequent steps*

*allow **1** mark for (anticlockwise moment) = 0.18 (Nm)*

*allow **1** mark for correct substitution i.e. 1.5 × 0.12 = F × 0.20*

3

(b) a longer drumstick lever gives a quieter sound
a longer drumstick lever allows
a greater range of volumes

a greater force gives a louder sound is insufficient

1

[7]

21 (a) the image would decrease in size

1

the image would change (from virtual) to real

accept that the image (of bulb M) can be projected on to a screen

1

the image would change (from non-inverted) to inverted

1

(b) a ray through the centre of the lens

rays should be drawn with a ruler

ignore arrows

1

a ray parallel to the principal axis and passing through the principal focus to the right of lens

accept solid or dashed lines

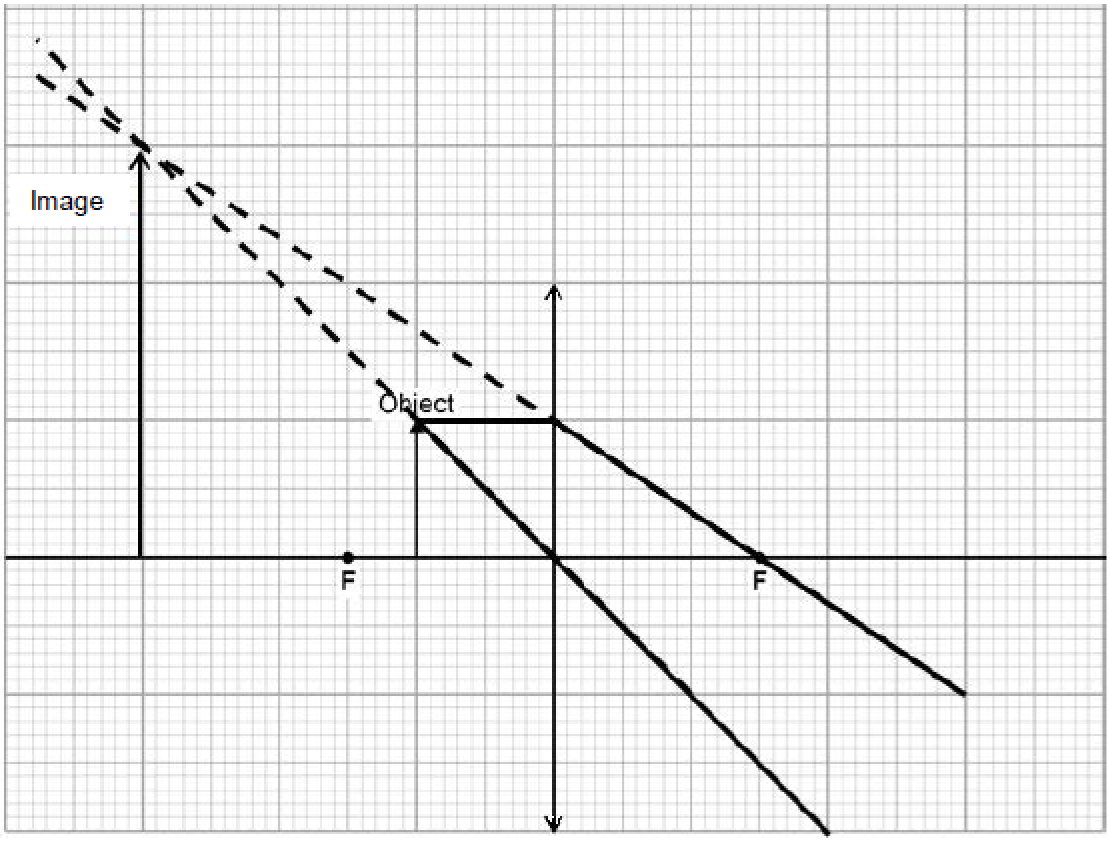
accept a ray drawn as if from the principal focus to the left of the lens, emerging parallel to the principal axis

1

image drawn where rays cross

image should be to left of the lens

1



(c) (i) (because the glass in) lens A has a greater refractive index

accept lens A is more powerful

accept lens A has a shorter focal length

1

(ii) when the magnification increases by 1, the image distance increases by 10 cm

*accept for **1** mark it is a linear pattern*

or

as the image distance increases, the magnification increases

*do **not** accept directly proportional*

2

(iii) diagram showing the surfaces of a convex lens C having greater curvature than lens B

the size of the lens drawn is not important

1

[10]

22 (a) cell damage or cancer

accept kills / mutates cells

radiation poisoning is insufficient
ionising is insufficient

1

(b) (i) any **one** from:

- use tongs to pick up source
- wear gloves
- use (lead) shielding
- minimise time (of exposure)
- maximise distance (between source and teacher).

accept any other sensible and practical suggestion

ignore reference to increasing / decreasing the number / thickness of lead sheets

1

(ii) background

1

(c) (i) curve drawn *from point 2,160*

*do **not** accept straight lines drawn from dot to dot*

1

(ii) (also) increases

less radiation passes through is insufficient

1

(iii) 50

accept any value from 40 to 56 inclusive

1

(d) gamma

1

only gamma (radiation) can pass through lead

*accept alpha **and** beta cannot pass through lead*
a general property of gamma radiation is insufficient

1

[8]

23 (a) (i) splitting of a(n atomic) nucleus

do not accept splitting an atom

1

(ii) Neutron

1

(b) (i) nuclei have the same charge
or
nuclei are positive

accept protons have the same charge

1

(ii) (main sequence) star

accept Sun or any correctly named star

accept red (super) giant

1

(c) (i) any **two** from:

- easy to obtain / extract
- available in (very) large amounts
- releases more energy (per kg)

  *do **not** accept figures only*
- produces little / no radioactive waste.

  naturally occurring is insufficient

  seawater is renewable is insufficient

  less cost is insufficient

2

(ii) any **one** from:

- makes another source of energy available
- increases supply of electricity
- able to meet global demand
- less environmental damage
- reduces amount of other fuels used.

  accept any sensible suggestion

  accept a specific example

  accept a specific example

1

(d) 12

*allow **1** mark for obtaining 3 half-lives*

2

[9]

24 (a) 20,000

accept 20 kilo

or

20 k

***or** 20 001*

1

an atom

1

(b) 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 in the Marking Guidance and apply a ‘best-fit’ approach to the marking.

0 marks
no relevant content

Level 1 (1−2 marks)
At least one relevant statement is given for either type of wave

Level 2 (3−4 marks)
either
a use, risk and precaution is given for one type of wave
or
A medical use is given for both types of wave
plus
a risk or precaution for one type of wave

Level 3 (5−6 marks)
At least one medical use is given for both types of wave linked to the risks and any precautions necessary

Examples of the points made in the response

Medical use of X-rays

Any one from:

- Detecting bone fractures
- Detecting dental problems
- Killing cancer cells
- CT scanning.

Ignore details about how X-rays / ultrasound work

accept any specific use of X-rays, eg

- *detecting heart / lung disorders (with chest X-rays)*
- *mammograms / breast cancer detection*
- *detecting stones / bowel disease (with abdominal X-rays)*

Risks with X-rays

X-rays pose a risk / danger / hazard

accept are harmful

X-rays cause ionisation / damage to cells

or

mutate cells / cause mutations / increase chances of mutations

or

turn cells cancerous / produce abnormal growths / produce rapidly growing cells

or

kill cells

accept a description of what ionising is

instead of cell, any of these words can be used: DNA / genes / chromosomes / nucleus

accept (may) cause cancer

Operator precautions with X-rays

The X-ray operator should go behind a (metal / glass) screen / leave the room when making an X-ray / wear a lead lined apron

accept appropriate precautions for the patient e.g. limit the total exposure / dose (in one year)

wear a radiation badge is insufficient

Medical use of ultrasound

Any one from:

- Pre-natal scanning
- Imaging (a named body part).
- removal / destruction of kidney / gall stones
- removing plaque from teeth

  cleaning teeth is insufficient

- accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation.

  accept physiotherapy

  *accept curing prostate cancer **or** killing prostate cancer cells*

Risks with ultrasound
Ultrasound poses no risk / danger / hazard (to the user / patient)

accept ultrasound is safer than using X-rays

Ultrasound is not ionising
or
Ultrasound does not damage (human) cells

Precautions with ultrasound
The operator needs to take no precautions when making an ultrasound scan

this can be assumed if it is stated that ultrasound is harmless or it is safer than using x-rays or it is non-ionising

6

[8]

25 (a) the forces are equal in size and act in opposite directions

1

(b) (i) forwards / to the right / in the direction of the 300 N force

answers in either order

1

accelerating

1

(ii) constant velocity to the right

1

(iii) resultant force is zero

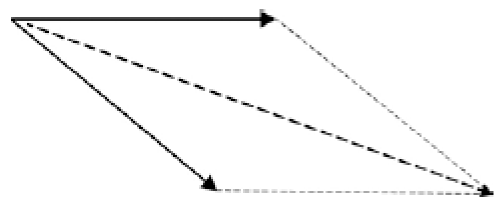
accept forces are equal / balanced

1

so boat continues in the same direction at the same speed

1

(iv) parallelogram or triangle is correctly drawn with resultant



3

value of resultant in the range 545 N – 595 N

parallelogram drawn without resultant gains ***1*** *mark*

If no triangle or parallelogram drawn:

drawn resultant line is ***between*** *the two 300 N forces gains* ***1*** *mark*

drawn resultant line is between and longer than the two 300 N forces gains ***2*** *marks*

1

[10]

26 (a) neutrons and protons

1

(b) 0

1

(+)1

1

(c) (i) total positive charge = total negative charge

accept protons and electrons have an equal opposite charge

1

(because) no of protons = no of electrons

1

(ii) ion

1

positive

1

(d) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a best-fit approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
There is a basic description of at least **one** of the particles in terms of its characteristics.

Level 2 (3 – 4 marks)
There is a clear description of the characteristics of **both** particles
or
a full description of either alpha **or** beta particles in terms of their characteristics.

Level 3 (5 – 6 marks)
There is a clear and detailed description of **both** alpha and beta particles in terms of their characteristics.

examples of the physics points made in the response:

structure

- alpha particle consists of a helium nucleus
- alpha particle consists of 2 protons and 2 neutrons
- a beta particle is an electron
- a beta particle comes from the nucleus

penetration

- alpha particles are very poorly penetrating
- alpha particles can penetrate a few cm in air
- alpha particles are absorbed by skin
- alpha particles are absorbed by thin paper
- beta particles can penetrate several metres of air
- beta particles can pass through thin metal plate / foil
- beta particles can travel further than alpha particles in air
- beta particles can travel further than alpha particles in materials eg metals

deflection

- alpha particles and beta particles are deflected in opposite directions in an electric field
- beta particles are deflected more than alpha particles
- alpha particles have a greater charge than beta particles but beta particles have much less mass
  or
  beta particles have a greater specific charge than alpha particles

6
[13]

27 (a) (i) 150

1

(ii) transferred to the surroundings by heating

reference to sound negates mark

1

(iii) 0.75

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

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

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

2

(iv) 20 (s)

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

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

2

(b) (i) to avoid bias

1

(ii) use less power and last longer

1

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

or

filament costs (5 times) more in energy consumption

1

(iii) any **one** from:

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

1

[10]

28 (a) terminal

1

(b) 5.4 (kg)

*correct substitution of 54 = m × 10 gains **1** mark*

2

(c) (i) 0< a <10

1

some upward force

accept some drag / air resistance

1

reduced resultant force

1

(ii) 0

1

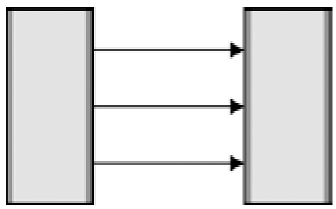
upward force = weight (gravity) 1

resultant force zero 1

[9]

29 (a) (i) field pattern shows:
some straight lines in the gap 1

direction N to S



1

(ii) north poles repel 1

(so) box will not close 1

(b) (i) as paper increases (rapid) decrease in force needed 1

force levels off (after 50 sheets) 1

(ii) the newtonmeter will show the weight of the top magnet 1

(iii) (top) magnet and newtonmeter separate before magnets separate
accept reverse argument 1

(because) force between magnets is greater than force between magnet and hook of newtonmeter 1

(iv) any **three** from:

- means of reading value of force at instant the magnets are pulled apart
- increase the pulling force gently
  or
  use a mechanical device to apply the pulling force
- clamp the bottom magnet
- use smaller sheets of paper
- fewer sheets of papers between readings (smaller intervals)
- ensure magnets remain vertical
- ensure ends of magnet completely overlap
- repeat the procedure several times for each number of sheets and take a mean
- make sure all sheets of paper are the same thickness

3

(v) 3 (mm)

*30 × 0.1 ecf gains **2** marks*

*2.1 N corresponds to 30 sheets gains **1** mark*

3

[15]

30 (a) dark matt

1

light shiny

1

(b) B A C

1

biggest temperature difference (80 °C)

dependent on first mark

1

(c) (i) (the can that is) dark matt

1

best absorber (of infrared radiation)

1

(ii) any **three** from:

- same area / shape of can
- surrounding temperature is the same for all cans
- same surface underneath cans
- same position in the room

3

(d) fox A

smaller ears

1

thicker fur

1

these minimise energy transfer

dependent on first 2 marks

1

[12]

31 (a) wavelength correctly shown

1

(b) (i) increased

1

decreased

1

(ii) 17-18 inclusive

1

evidence of measurement divided by 3 or mean of 3 separate measurements

1

mm

accept cm if consistent with answer

1

(c) (i) red shift

1

(ii) moving away

1

(iii) the furthest galaxies show the biggest red shift

1

(meaning that) the furthest galaxies are moving fastest

1

(so the) Universe is expanding

1

(extrapolating backwards this suggests that) the Universe started from an initial point

1

(iv) cosmic microwave background radiation

allow CMBR

1

[13]

32 (a) (i) infrared / *IR*

1

(ii) *UV / X-rays / gamma rays*

1

appropriate use corresponding with given wave:

dependent on first marking point

- UV: security marking ***or*** *tanning*
- X-rays: medical imaging ***or*** *checking baggage*
- gamma rays: sterilising surgical instruments ***or*** killing harmful bacteria in food

accept any sensible alternative uses

1

(b) D

1

gap must be comparable to wavelength

accept converse

1

can create gap of that size in classroom

dependent on first marking point

1

(c) (i) Q

1

(ii) sound waves reflected

accept 'it' for sound waves

ignore bounce

1

at EF

1

angle of incidence equal to angle of reflection

1

(iii) stop sound going direct from clock to ear

1

(iv) 22 (m)

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

*330 = 15 × λ scores **1** mark*

2

(v) outside audible range

1

[14]

33 (a) (i) short sight

accept myopia

1

(ii) diverging

1

(b) light

1

(c) Marks awarded for this answer will be determined by the quality of communication 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 a basic description of one advantage ***or*** disadvantage of using **either** of the methods

Level 2 (3–4 marks)
There is a *description* of some advantages **and / or** disadvantages of using **both** methods
or
a full, detailed description of the advantages and disadvantages of using **either** of the methods.

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

examples of the points made in the response

extra information

laser surgery

advantages:

- *appearance*
- *permanent effect*
- no glasses which need changing

disadvantages:

- risks associated with surgery
- large cost
- not able to drive etc straightaway
- (still) might need glasses for reading

wearing glasses

advantages:

- able to function straightaway
- any problems easy to sort out

disadvantages:

- *easily broken*
- *easily lost*
- need changing
- overall cost might be greater if several changes in vision
- might eventually need two pairs of glasses

6

(d) move lens 1

closer to film 1

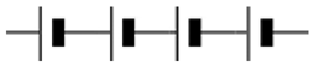
[11]

34 (a) *attempt to draw four cells in series* 1

correct circuit symbols

circuit symbol should show a long line and a short line, correctly joined together

example of correct circuit symbol:



1

(b) (i) 6 (V)

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

*V = 3 × 2 scores **1** mark*

provided no subsequent step

2

(ii) 12 (V)

ecf from part (b)(i)

18 – 6

or

*18 – their part (b)(i) scores **1** mark*

2

(iii) 9 (Ω)

ecf from part (b)(ii) correctly calculated

3 + their part (b)(ii) / 2

or

*18 / 2 scores **1** mark*

provided no subsequent step

2

(c) (i) need a.c. 1

battery is d.c. 1

(ii) 3 (A)

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

*18 × 2 = 12 × I_s scores **1** mark*

2

[12]

35 (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]

36 (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]

37 (a) advantage

any **one** from:

- produce no / little greenhouse gases / carbon dioxide

  allow produces no / little polluting gases

  allow doesn't contribute to global warming / climate change

  allow produce no acid rain / sulphur dioxide

  reference to atmospheric pollution is insufficient

  produce no harmful gases is insufficient
- high(er) energy density in fuel

  accept one nuclear power station produces as much power as several gas power stations

  nuclear power stations can supply a lot of or more energy is insufficient
- long(er) operating life

  allow saves using reserves of fossil fuels or gas

1

disadvantage

any **one** from:

- produce (long term) radioactive waste

  accept waste is toxic

  accept nuclear for radioactive
- accidents at nuclear power stations may have far reaching or long term consequences
- high(er) decommissioning costs

  accept high(er) building costs
- long(er) start up time

1

(b) (i) 12 000 (kWh)

*allow **1** mark for correct substitution eg*

2000 × 6

or

2 000 000 × 6

or

$$\frac{12\ 000\ 000}{1000}$$

*an answer of 12 000 000 scores **1** mark*

2

(ii) any idea of unreliability, eg

- wind is unreliable

  reference to weather alone is insufficient
- shut down if wind too strong / weak
- wind is variable

1

(c) any **one** from:

- cannot be seen
- no hazard to (low flying) aircraft / helicopters
- unlikely to be or not damaged / affected by (severe) weather

  unlikely to be damaged is insufficient
- (normally) no / reduced shock hazard

  safer is insufficient

  less maintenance is insufficient

  installed in urban areas is insufficient

1

[6]

38 (a) infrared / IR

correct answer only

1

(b) any **two** from:

- increase the power / watts

  allow increase the temperature of the oven or make the oven hotter
- decrease the speed

  allow leave the biscuits in for longer
- put biscuits through again

  increase radiation is insufficient

  ignore changes to the design of the oven

2

(c) (inside) surface is a (good) reflector or poor absorber (of IR)

Ignore bounce for reflect

surface is a (good) reflector of light does not score

surface is a (good) reflector of light and infrared / heat does score

1

(and) <u>outside</u> surface is poor emitter (of IR)

1

(so) increases the energy reaching the biscuits

allow reduces energy loss or makes oven more efficient

*do **not** accept no energy losses*

keeps oven hotter is insufficient

1

[6]

39 (a) water moves (from a higher level to a lower level)

1

transferring GPE to KE

1

rotating a turbine to turn a generator

accept driving or turning or spinning for rotating

moving is insufficient

1

transferring KE to electrical energy

transferring GPE to electrical energy gains ***1*** *mark of the* ***2*** *marks available for energy transfers*

1

(b) (TVs in stand-by) use electricity

accept power / energy

1

generating electricity (from fossil fuels) produces CO_2

accept greenhouse gas

accept sulfur dioxide

1

(CO_2) contributes to global warming

accept climate change for global warming

accept greenhouse effect if CO_2 given

accept acid rain if linked to sulfur dioxide

1

(c) a factor other than scientific is given, eg economic, political or legal

personal choice is insufficient

1

[8]

40 (a) air near freezer compartment is cooled or loses energy

accept air at the top is cold

1

cool air is (more) dense or particles close(r) together (than warmer air)

do ***not*** *allow the particles get smaller / condense*

1

so (cooler) air falls

1

air (at bottom) is displaced / moves upwards / rises

do ***not*** *allow heat rises*

accept warm air (at the bottom) rises

1

(b) if volume is doubled, energy use is not doubled
or
volume ÷ energy not a constant ratio

1

correct reference to data, eg 500 is 2×250 but 630 not 2×300

1

(c) accept suitable examples, eg

advantage:

- reduces emissions into atmosphere
- lower input power or uses less energy or wastes less energy
- costs less to run

cost of buying or installing new fridge is insufficient

ignore reference to size of fridge

1

disadvantage:

- land fill
- energy waste in production
- cost or difficulty of disposal
- transport costs

1

[8]

41 (a) (i) 5.88 (watts)

*an answer of 5.9 scores **2** marks*

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

$0.42 = \frac{\text{power out}}{14}$

*allow **1** mark for an answer of 0.0588 or 0.059*

2

(ii) 8.12

allow 14 – their (a)(i) correctly calculated

1

(b) (i) input power / energy would be (much) less (reducing cost of running)

accept the converse

electricity is insufficient

1

(also) produce less waste energy / power

accept 'heat' for waste energy

1

(as the waste energy / power) increases temperature of the cabinet

1

so cooler on for less time

1

(ii) line graph

need to get both parts correct

accept scattergram or scatter graph

both variables are continuous

allow the data is continuous

1

(c) number of bulbs used-halogen=24 (LED=1)

1

total cost of LED = £30 + £67.20 = £97.20

accept a comparison of buying costs of halogen £36 and LED £30

1

total cost of halogen= 24 x £1.50 + 24 x £16.00 = £420

or

buying cost of halogen is £36 **and** operating cost is £384

accept a comparison of operating costs of halogen £384 and LED £67.20

*allow for **3** marks the difference in total cost is £322.80 if the number 24 has not been credited*

1

statement based on correct calculations that overall LED is cheaper

*must be **both** buying **and** operating costs*

an alternative way of answering is in terms of cost per hour:

buying cost per hour for LED $\left(\frac{£30.00}{48000}\right)$ = 0.0625p/£0.000625

buying cost per hour for halogen = $\left(\frac{£1.50}{2000}\right)$ = 0.075p/£0.00075

*a calculation of both buying costs scores **1** mark*

operating cost per hour for LED = $\left(\frac{£67.20}{48000}\right)$ = 0.14p/£0.0014

operating cost per hour for halogen= $\left(\frac{£16.00}{2000}\right)$ = 0.8p/£0.008

*a calculation of both operating costs scores **1** mark*

all calculations show a correct unit

***all** units correct scores **1** mark*

statement based on correct calculations of **both** buying **and** operating costs, that overall LED is cheaper

*correct statement scores **1** mark*

1

[12]

42 (a) (i) neutron

1

(ii) neutron
proton

both required, either order

1

(iii) 2

1

number of protons

do not accept number of electrons

1

(b) (i) any **one** from:

- beta
- gamma

accept correct symbols

accept positron / neutrino / neutron

cosmic rays is insufficient

1

(ii) electrons

1

(iii) are highly ionising

1

(c) (i) mutate / destroy / kill / damage / change / ionise

Harm is insufficient

1

(ii) much smaller than

1

[9]

43 (a) (i)

Wire	Plug terminal
Live	C
Neutral	A
Earth	B

*all 3 correct for **2** marks*

*allow **1** mark for 1 correct*

2

(ii) plastic
or
rubber

accept:

ABS
UF / urea formaldehyde
nylon
PVC

1

(b) (i) 600

*allow **1** mark for correct substitution,*

ie $P = \frac{30\,000}{50}$

provided no subsequent step

2

(ii) power is greater than 820 (W)

power is 1200 W is insufficient

1

the lead /cable / wire <u>will</u> overheat / get (too) hot

accept lead / cable will melt

may overheat / get hot is insufficient

1

so there is a risk of fire

accept causing a fire

1

(c) X

any **one** from:

- most / more efficient
- smallest energy input (per second)
- cheapest to operate

mark only scores if X is chosen

mark is for the reason

accept smallest input (power) for same output (power)

accept wastes least energy

smallest (power) input is insufficient

uses least electricity is insufficient

1

[9]

44 (a) J

reason only scores if J is chosen

1

(only) stars (about) the same / smaller size / mass as the Sun become black dwarfs

accept smaller than the Sun

accept it is the smallest

accept (only) small stars become black dwarfs

1

(b) (i) become a supernova

or

it will explode

ignore subsequent correct stages

1

(ii) cannot take measurements needed

or

do not have the technology

*do **not** accept cannot measure mass*

1

(iii) advances in (measuring) techniques / technology / knowledge

1

(c) any **five** from:

ignore any information up to the end of the main sequence

Apply the list rule if more than 5 points are made

- star expands (to become)
- a red giant

red supergiant is incorrect

- heavier elements are formed (by fusion)

elements heavier than iron are formed is incorrect

- star shrinks (to become)
- a white dwarf

supernova, neutron star, black hole are incorrect

- star cools / fades
- star stops emitting energy / radiation

star loses all energy is insufficient

5

[10]

45 (a) (same) number of protons

same atomic number is insufficient

1

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii) (nuclear) reactor

1

(c) beta

1

any **one** from:

- atomic / proton number increases (by 1)

  accept atomic / proton number changes by 1
- number of neutrons decreases / changes by 1
- mass number does not change

  (total) number of protons and neutrons does not change
- a neutron becomes a proton

1

(d) (average) time taken for number of nuclei to halve

or

(average) time taken for count-rate / activity to halve

1

(e) (i) 6.2 (days)

Accept 6.2 to 6.3 inclusive
*allow **1** mark for correctly calculating number remaining as 20 000*
or
*allow **1** mark for number of*
80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii) radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]

46 (a) long

1

(b) lens A

1

it is a concave / diverging lens

this mark is only gained if lens A is stated

any reference to lens material or mass of lens negates this mark

allow it will focus light onto the retina

1

(c) The refractive index of the lens material

1

(d) 4

ignore any signs

*allow **1** mark for correct substitution, ie* $\frac{1}{0.25}$ *provided no subsequent step*

2

(e) Cauterising open blood vessels

1

(f) 5

*allow **1** mark for correct substitution, ie* $\frac{70}{14}$ *provided no subsequent step*

2

[9]

47 (a) hydraulic

1

(b) 9

*allow **1** mark for a correct substitution, ie* $\frac{1800}{200}$ *provided no subsequent step*

2

(c) an environmental

1

[4]

48 (a) (sound waves) which have a frequency higher than the upper limit of hearing for humans
or
a (sound) wave (of frequency) above 20 000 Hz

sound waves that cannot be heard is insufficient

a wave of frequency 20 000 Hz is insufficient

1

(b) 640

*an answer of 1280 gains **2** marks*

*allow **2** marks for the correct substitution*

ie 1600 × 0.40 provided no subsequent step

*allow **2** marks for the substitution* $\frac{1600 \times 0.80}{2}$
provided no subsequent step

*allow **1** mark for the substitution 1600 × 0.80 provided no subsequent step*

*allow **1** mark for the identification that time (boat to bed) is 0.4*

3

(c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

  accept heart

  *do **not** allow brain **or** lungs (either of these negates a correct answer)*
- Doppler scanning blood flow

1

(d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution

  clearer / better image is sufficient
- (scan) produces a slice through the body
- image can be viewed from any direction

  allow images are (always) 3D / 360°
- an image can be made of <u>any</u> part (inside the body)

  allow whole body can be scanned
- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are <u>ionising</u>

  allow a description of what ionising is
- mutate cells **or** cause mutations **or** increase chances of mutations

  allow for cells:

  DNA / genes / chromosomes / nucleus / tissue

- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells

  damage cells is insufficient
- shielding is needed

  can be dangerous (to human health) unqualified, is insufficient

1

[7]

49 (a) gravitational attraction (between the satellite and the Earth)

allow gravity

allow weight of the satellite

1

(b) any **two** from:

- mass of satellite
- speed / velocity (of satellite)
- radius of orbit / circle

  allow height above the Earth

  radius / height alone is insufficient

2

(c) (i) increasing the height (above the Earth's surface) increases the time (for one orbit)

allow a positive correlation

allow as one gets bigger, the other gets bigger, or vice versa

ignore they are directly proportional

1

(ii) there is no relationship / correlation

1

(d) Isaac Newton was a respected scientist who had made new discoveries before

1

[6]

50 (a) hydraulic (system)

1

(b) 15.40×10^2
or
1540

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

$8.75 \times 10^4 = \frac{F}{1.76 \times 10^{-2}}$

or

$87\,500 = \frac{F}{0.0176}$

or

$F = 8.75 \times 10^4 \times 1.76 \times 10^{-2}$

or

$F = 87\,500 \times 0.0176$

2

(c) any **one** environmental **advantage**:

stating a converse statement is insufficient, or a disadvantage of the usual oil, ie the usual oil is non-renewable

plant oil is renewable

using plant oil will conserve (limited) supplies **or** extend lifetime of the usual / crude oil.

plant oil releases less carbon dioxide (when it is being produced / processed)

plant oil will add less carbon dioxide to the atmosphere (when it is being produced / processed, than the usual oil)

plant oil removes carbon dioxide from **or** adds oxygen to the air when it is growing

stating that plant oil is carbon neutral is insufficient

1

(d) (the current flowing through the coil) creates a magnetic field (around the coil)

1

(this magnetic field) interacts with the permanent magnetic field
or
current carrying conductor is in a (permanent) magnetic field

it must be clear which magnetic field is which

1

this produces a (resultant) force (and coil / cone moves)

1

when the direction of the current changes, the direction of the force changes to the opposite direction

*accept for **2** marks the magnetic field of the coil interacts with the permanent magnetic field*

1

[8]

5

(a) Just over half the students scored all 3 marks, the most common mistake was to mix up geothermal and nuclear.

(b) Just over a third of students scored 3 marks on this question, with just under a third scoring 1 mark. The remaining third either scored 2 or 0 marks. Students found this question quite difficult, many believing that the water stored electrical energy.

(c) (i) Just under a third of students scored both marks for this question, a third of students scored 1 mark for this question. The most common mistake was to either omit the % symbol or add an incorrect one, MW, for example.

(ii) Almost two thirds of students scored this mark. Common incorrect responses included multiplying or dividing the power input and output for the power station. An answer of 10% was creditworthy, provided the % sign was given.

(iii) Two fifths of students scored this mark. Common incorrect responses seen included global warming and pollution. The 'turbine overheating' was insufficient for the mark.

6

(a) Over two thirds of students scored this mark. One of the most common correct responses was visible light; quite a few went to the very end of the EM spectrum and stated gamma rays, which was also creditworthy.

(b) Just under half of students scored 2 marks, few scored all 3 marks. Many students incorrectly thought that each response should only be used once, having not read the question carefully enough.

7

Foundation

(a) Less than a tenth of students scored this mark. There seemed to be a general belief that the National Grid only supplies electricity generated by non-renewable sources so it wouldn't be appropriate considering the small community is planning to generate renewable electricity. Many students thought that visual pollution or damage to habitats counted as an economic reason, which was insufficient.

(b) Approximately half the students scored 3 or more marks for this question, the mean was 2.71 and a good range of responses were seen. It was pleasing to see that students didn't just re-state information given in the question, but added value and made comparisons, too. To achieve Level 1, students needed to make 1 or 2 statements which could have been advantages or disadvantages, or 1 of each. Comparison statements did not count as both an advantage and as a disadvantage. To achieve Level 2 students needed to have at least an advantage and a disadvantage of 1 method and either an advantage or a disadvantage of the other method. To achieve Level 3 students needed at least 1 advantage and 1 disadvantage of each method that were separate ideas. 'Both renewable' would count as one idea.

Higher

(a) A third of students correctly answered by describing reasons why connecting to the grid would be expensive, cost to build pylons, cables, etc. Responses which specified cost but without stating what was expensive were insufficient. Answers in terms of the ‘small community’ needed to state that either the amount of electricity required (from the National Grid), or the amount of electricity they may sell back (to the National Grid) was too low.

(b) Four fifths of students scored 4 or more marks, the mean for the question was 4.42 and a good range of responses were seen. Students who failed to give Level 3 responses usually did so because they didn’t give at least one advantage and one disadvantage for each energy source. Comparative responses in terms of cost, power output or reliability only counted as an advantage of one or as the disadvantage of the other source. Therefore, a minimum number of four separate ideas needed to be described in order to be counted as a Level 3 answer.

8

(a) Two fifths of students scored 2 marks, while one third of students scored 1 mark. The vast majority of students scored 2 marks for 'remote controls' and 'mobile phones'. A reasonable number of students misread the question and wrote down any use of infrared (conventional oven) and microwave (the microwave) which were insufficient for communications. 'Phone' by itself was insufficient, but 'phone signals' was creditworthy, as was 'sending text messages'. While some mobile phones do have infrared ports, this was insufficient for a use of infrared as not all mobile phones have this facility. Satellite (communications) was another common answer seen for use of microwaves. TV alone was insufficient. Other insufficient answers included: key fobs for remote locking of cars, computer peripherals and walkie talkies, all of which typically use radio frequencies.

(b) A quarter of students scored 2 marks, while a fifth of students scored only 1 mark. Students should be reminded of the list principle: if two answers are required, only give two answers, otherwise incorrect answers can negate correct answers. One student stated 5 properties that were the same for both waves; fortunately for the student they were all correct. Insufficient responses included 'can't be seen with the human eye', 'not harmful', 'can heat food', 'used for communication'. Incorrect responses included 'same amplitude / frequency / wavelength'. A student who stated 'travel through a vacuum at the speed of light' and didn't write anything on the second line would score 2 marks for their single statement.

9

(a) This question was well answered with half the students scoring 1 mark and a third of students scoring 2 marks. The most common correct answers referred to the cost per kWh and the economic benefits, 'France can sell their excess electricity to other countries' type of statement. Insufficient responses included 'it's cheap', which wasn't comparative; or references to no CO2 released, as the renewables mentioned don't release CO2 either. Reliability was another commonly seen response, which was creditworthy.

(b) Just under a third of students scored 2 marks for this question. Answers that were insufficient were 'dangerous', or 'radiation may leak'. Naming nuclear accidents was insufficient for a mark, the idea of widespread or major implications was necessary too. Commissioning or decommissioning time was insufficient as the question was about generating electricity, so while the cost was an issue, time was too vague. A number of students thought that 'nuclear is a fossil fuel so contributes greatly to global warming', which is clearly incorrect.

(c) Three fifths of students scored 2 marks for this question. Some students incorrectly multiplied their answer by 100(%) and got an answer of 48, which scored 1 mark, or multiplied the power in W by 0.15 and got an answer of 480, which also scored 1 mark.

(d) Three fifths of students scored 1 mark for the idea that higher cost meant higher efficiency solar panel, quite a lot of students also scored 1 mark for the idea that if cheaper, more would be bought. Many students, however, incorrectly thought that if you purchased a larger number of solar panel C, the overall efficiency would increase. These students are likely to have scored a maximum of 1 mark for the idea that more could be bought, depending how they worded their answer. Only a tenth of students scored 2 marks for a well-reasoned answer e.g. The more efficient solar panels cost more, but you could buy more solar panel C for £40, that would generate more electricity than 1 solar panel A.

10 (a) Most students scored at least one mark with about one third scoring all three marks. A common error was to give 'friction' as the force that pulls particles together.

(b) The majority of the students scored this mark.

(c) The majority of the students scored this mark.

11 (a) Only about one third of the students scored this mark. A common incorrect answer was '40'.

(b) Again only about one third of the students scored this mark. The most common answer was '60'.

(c) (i) A significant number of the students did not attempt this question. About one third of the students scored the mark.

(ii) About a third of the students knew the potential difference would equal that of the supply and so scored the mark.

(iii) There were relatively few students who answered in terms of independent circuits i.e. if one bulb goes out the other is unaffected. Those students who mentioned increased brightness or increased power were successful. The majority of students attempted to answer in terms of increased p.d. or current; or referred to p.d. or current being the same for each bulb. Those who stated that both bulbs had the same brightness failed to appreciate that this would also be true in a series circuit. Few students scored this mark.

(d) Over half of the students scored zero. There were too many students thinking that a light fitting without an earth wire is safe because of the perceived dangers caused by an earth wire. Others suggested that the neutral wire acted as an earth wire in this instance. Many students had the idea of plastic being an insulator, although a surprising number stated it is a conductor. It was relatively rare to see an unambiguous statement that the outside case of the fitting is made of plastic. Some students were distracted by the insulation on the individual wires.

(e) A significant number of students did not attempt this question. Of those that did, few scored the mark; the reference to a circuit breaker was rarely seen. A large number of the students failed to read the question and gave 'fuse' as their answer. Other common incorrect answers were insulation tape, plastic sockets, crocodile clips and plastic-covered wires.

12 (a) Few of the students correctly gave 'neutrons'. The most popular answer was 'protons'.

(b) There were many incorrect answers such as ' power stations ' with the students not stating that in most nuclear reactors the energy released was to heat water to eventually generate electricity. Many students simply wrote the word "electricity" and did not score the mark.

(c) (i) Again few students correctly identified particle X as 'a neutron'.

(ii) Half of the students scored zero. A common error was to show only one neutron released from each U-235 nucleus or to show only one fragment produced. Others students showed 2 neutrons released from the given U-235 nuclei but did not show any fragments. A small number of students who did this went on to draw further U-235 nuclei which then released neutrons. This gained both marks as it did show the start of a chain reaction.

13 **Foundation**

(a) Nearly a quarter of the students did not attempt this question. Most of the students that did attempt the question scored zero.

(b) (i) Less than half of the students scored this mark.

(ii) There were very few correct answers to this question. Most of the incorrect answers were in terms of an atom changing size or shape or splitting into smaller fragments.

(c) A small majority of the students scored this mark by suggesting sensible precautions to limit the risk to their health from sources of radiation. However there were a large number of unacceptable suggestions such as 'wear a lead suit'.

(d) A large number of students did not attempt this question. Nearly one third of the students scored zero. The majority of the students that did score at least one mark were operating at Level 1 or 2 in terms of their knowledge, understanding, organisation of their answer and accuracy of their spelling, punctuation and grammar. Students scoring zero marks were either giving a reiteration of the question stem or a description of radiation properties or uses of radiation that were not relevant to this question. Of the three specific properties asked for, few candidates were able to provide creditable statements for the deflections (or not) of the radiations in a magnetic field. Many students thought that the radiations produced their own magnetic field or mistook deflection to mean reflection. References to positive and negative poles of a magnet were common. Of the other two properties, most candidates were able to order correctly the degree of penetration and often quote specific examples of the correct materials. Many candidates were also able to order the range of the radiations in air. However, in many cases, there were not specific references to what beta radiation could or could not actually do, other than be placed in the middle of the student's ordering.

Higher

(a) This was generally well done with almost half of the students scoring the mark although mention of electrons was frequent and negated the mark. Some students did not read the stem of the question carefully and described the properties of an alpha particle e.g. is ionising, and so did not score the mark. This question had one of the highest non-completion rates.

(b) (i) Nearly two thirds of the students scored this mark.

(ii) Only 40% of the students scored this mark. Many students confused ionisation with fission. Others knew that the atom would lose some parts but were not sure which so incorrectly guessed protons or neutrons so did not get the mark.

(c) Nearly four fifths of the students answered this correctly. However, students should think about how realistic their answers are when they write things like 'wear suits made out of lead'.

(d) There were mixed results on this question. Many students spent an unnecessary time discussing the ionising ability of the particles. Some students referred to the gold foil experiment, which didn't give relevant information. Most students did not gain full credit because they did not address all three properties (range, penetration, deflection in a magnetic field) for all three types of radiation. Most students responded reasonably well in terms of penetration and range but there was less clarity about the effect of magnetic fields. Many students wrote about being attracted to 'positive' or 'negative' sides without actually mentioning magnetic fields. Of those that did describe all the properties, most did well and got high marks. Over a third of the students gave a Level 3 answer.

14

(a) Surprisingly less than half of the students answered this correctly.

(b) Over two thirds of students answered this correctly. The symbol was almost universally known. Some students added more than one ammeter but gained credit provided all were correct. There were a number of students who connected the ammeter across the two voltmeters.

(c) (i) Only a fifth of the students scored both marks. A significant number of the students explained a choice of 6V by stating that (potential) difference means subtract so 9V – 3V = 6V.

(ii) A third of the students scored 1 mark for an answer of 600, but failed to explain the reason successfully for the second mark. The most popular response simply referred to the two lines meeting at 600.

(iii) Very few students showed evidence of total resistance of 800 or their (c)(ii) + 200. Many scored 1 mark for their (c)(i) (usually 6) divided by 200. There were, however, a significant number who gave the correct answer, despite not choosing 12V for (c)(i). providing evidence that many students were using the graph to answer this part of the question.

15 (a) Nearly one third of the students scored both marks; most others scored one mark, nearly always for the 'outer case'. Most students missed the first mark point because they did not name a specific metal or chose an incorrect metal such as iron or aluminium. A small number of the students scored zero by failing to name the materials used for each part; only giving the reason, or for naming materials but giving no reason. Other students who scored zero did not understand that the question was asking about the materials. These students did not name the materials and often wrote about the function of the pins or outer case e.g. 'to connect to the power supply', 'to hold everything inside the plug'. Some scored zero because they only referred to the thermal properties of the materials.

(b) (i) Nearly two thirds of the students scored this mark.

(ii) Nearly half of the students gave a correct answer. Some wrongly interpreted the question as asking 'what happens when the current becomes too high' and answered 'the fuse melts'. Others referred to the magnetic effects of the current, perhaps thinking of electromagnetic circuit breaker or to the wire's resistance. Some students showed a misunderstanding of electrical current with answers such as 'it gives the wire a charge'.

(iii) Surprisingly only two fifths of the students were able to carry out the calculation successfully and score both marks. Some students failed to convert the power into watts, or used an incorrect power value. Nearly half of the students scored zero because they made multiple errors. A lot of students could not transpose the equation correctly, a common wrong answer being 230 / 2 = 115.

(c) Nearly half of the students scored 1 mark, with a small number, less than a tenth, scoring both. Although many students mentioned current in the earth wire, they missed the first mark point because they did not say where the current flowed from. Others wrote of electricity or energy in the earth wire and did not use the correct term 'current'. Most students scored the second mark point for correctly stating that the fuse melts / blows, but a number used insufficient or incorrect descriptions such as the fuse breaks / snaps / burns. Many students believed the fuse broke the circuit then the earth wire cleared the rest of the electricity into the metal case. A significant number of students referred to the fuse 'detecting' the increase in current, suggesting the fuse was a monitoring device.

(d) Over four fifths of the students scored this mark, usually by identifying some risk (electrocution, fires) caused by the hazard, and sometimes by explaining that understanding the hazards leads to safer practice. The majority of the students seem to believe mains electricity will always electrocute and kill rather than shock. The few who scored zero usually just stated a hazard ('because the voltage is very high') and did not identify an associated risk. A few misunderstood the question and answered in terms of global warming or running out of energy resources.

16 (a) (i) Nearly half of the students failed to score a mark, with the other half split roughly equally between 1 and 2 marks. Many good answers were as per the mark scheme, with the term nebula quite often used for dust and gas. Incorrect responses included "rocks in the atmosphere / air", or dust on its own. Many students also did not refer to gravity being the attracting force. Many students incorrectly referred to fission. Some students referred to fusion, but this was not relevant to the question.

(ii) Just over a third of the students scored this mark. The most common error was to use "atom" for nuclei. Some students confused fusion and fission. This question was not attempted by a significant minority of the students.

(iii) "Better / Improved Technology ", was the most frequent correct answer given. Quite a few answers confused telescopes with microscopes. Similarly satellites were often mentioned without any further indication how they might improve observations. Some students did not score the mark because they thought that the reason scientists had not detected them before was because they did not know what to look for or because light from these stars had only just reached us (in order to be observed).

(b) (i) "Other/different Planets", was the most common correct answer, scored by just over half of the students. It was strange to see that many students mentioned that the evidence might have proved there were other life forms in the universe as this didn't seem to be linked to the question.

(ii) Although the mark was scored by nearly half of all students, many correct answers were imprecise in their explanation of "proving / supporting ", the theory.

(c) Nearly one tenth of the students did not attempt this question. Of those that did less than a quarter scored the mark, as students failed to identify the key idea of "only". Too often the information in the stem of the question was fed back using slightly different words or simply the same words in a slightly different order.

17 (a) Despite the length of the arrows on the diagram giving a clue to this answer, only about a quarter of students answered this question correctly.

(b) Just under half of students correctly identified the moments as equal and opposite.

(c) This question proved to be challenging for students with nearly a fifth gaining the mark. A significant minority of students confused the moment of a force with the pressure created by a force, and referred to putting a larger area of the foot on the pedal. Most recognized that the distance of the force from the pivot needed to be increased. A very common response, that gained no credit, was to say that the length of the chain could be changed.

18 **Foundation**

(a) Less than a quarter of students realised that a magnetic field was produced, whereas other students thought that a current or p.d. was produced in the iron core. It was not common for students to gain the mark for realising that the magnetic field produced would be changing.

(b) This calculation was handled well by students, with just under three quarters gaining both marks.

(c) Many students confused the loss of power with it being a step-down transformer. The most common way of students gaining the mark was for noting that energy is transferred by heating. Just under one fifth of students answered correctly.

(d) (i) Few students were able to correctly identify the resolution, although many more students were along the right lines, with an answer of 2 decimal places occurring regularly. The reason for this being appropriate was less well answered with many students answering how they knew that this was the resolution, rather than answering the question of why this was a suitable resolution for this experiment. Just under a fifth of students gained marks on this question.

(ii) Just under one tenth of students correctly stated why the results were different.

(iii) Slightly more than a tenth of students answered this question correctly. Many students thought that a lack of anomalous results made the experiment reproducible, or just the fact that two students had carried out the experiment made it reproducible. Many students just quoted numbers given in the table.

(iv) Induction was clearly something which students struggled with, and the question was only attempted by about two thirds of students. Only a few students knew the name of the process.

(e) Just over half of students were able to suggest an advantage of the transformer. It was not uncommon for those who got the question wrong to have just repeated the stem of the question.

Higher

(a) Approximately two thirds of students realised that a magnetic field was produced, whereas other students thought that a current or p.d. was produced in the iron core. Only about a quarter of students realised that the magnetic field produced would be changing.

(b) This calculation was handled well by students, with the vast majority gaining both marks.

(c) Many students confused the loss of power with it being a step-down transformer. The most common way of students gaining the mark was for noting that energy is transferred by heating. Just under four tenths of students answered correctly.

(d) (i) Many students struggled to identify the correct resolution, although some were along the right lines, with answers of 2 decimal places or 0.00 occurring regularly. The reason for it being appropriate was less well done with many students answering how they knew that this was the resolution, rather than answering the question of why this was a suitable resolution for this experiment. Less than half of students gained marks on this question.

(ii) About a third of students answered this question correctly. Many students stated that part of the equipment being used was different, despite the stem of the question clearly stating that the two students used exactly the same equipment.

(iii) Just over a third of students answered this question correctly. Many students thought that similar results made it reproducible, rather than there being a similar pattern in results.

(iv) Fewer than half the students stated the correct process.

(e) Over two thirds of students suggested a correct advantage. Unrewarded responses frequently just repeated the stem of the question.

19

(a) The vast majority of students gained at least one mark, but less than half went on to give a complete answer including a reference to the ionising properties of X-rays.

(b) Just under half of students gained marks on this question. Many students understood that the sound reflected, but did not add that it was only partial reflection. The notion of time being recorded and used to calculate distance was only expressed by about one tenth of students.

(c) This calculation caused problems for students with only a tiny minority managing to obtain the correct final answer. The majority of students neglected to either halve the time or double the distance from the mother's skin to the fetus.

(d) (i) A common misconception here was that bone reflected X-rays and the reflected X-rays were then detected. It was also not uncommon to see students stating that X-rays contained gamma rays or alpha particles. Many students who gained two marks neglected to mention that the X-rays passing through are detected. Around a quarter of students gained three marks.

(ii) This question was well answered with just over three quarters of students identifying why X-rays are able to produce detailed images.

20 (a) (i) A large majority of students were unable to define the moment of a force. This gap in their knowledge then caused them further difficulties as the question progressed.

(ii) Just over one tenth of students answered this question correctly, with a majority comparing the size and direction of forces, rather than the moments of the forces.

(iii) Approximately half of students failed to score any marks on this question. About one tenth correctly calculated the moment caused by the drummer's toe, but then could not complete the calculation. Just under half of students gained three marks.

(b) Just under half of students gained the first mark on this question. The most common error was to describe how length would affect the speed of the drumstick, but not link this with the loudness of the sound. Very few students identified that the range of volumes that could be produced got larger as the length increased.

21 (a) Just under two thirds gained at least one mark on this question, with just under a fifth gaining all three marks. Many students who gained no marks referred to the image being blurry or more focussed, rather than describing the image as being inverted or upright, diminished or magnified and real or virtual.

(b) Slightly more than two thirds of students gained at least one mark on this question, with just under a third gaining all three marks. Many students forced their rays to cross to the right of the lens rather than forming a virtual image to the left of the lens.

(c) (i) Just under a fifth of students gained this mark, with many just stating that the refractive indices were different which was insufficient. A significant proportion of students suggested that the lenses were of different shapes, whereas the question stated that they were identical.

(ii) About half of students gained one mark on this question, but it was rare for students to gain both marks. The common cause of students failing to gain any credit was to describe the link between object distance and magnification, rather than image distance as was asked for.

(iii) Just under one third of students were able to show how the lens was different.

22

(a) Almost three quarters of the students scored this mark by either stating cancer or some form of damage to cells.

(b) (i) The students supplied a large number of sensible suggestions of how to reduce the teacher's exposure to the radioactive source in terms of increasing distance from the source, and the use of appropriate shielding. Some answers, involving wearing lead body suits, may have caused some trepidation in her students observing this experiment in a teaching laboratory environment.

(ii) Only a small proportion of students correctly answered ' background ' for this part question. The most common incorrect response being gamma.

(c) (i) This question was not answered well. The majority of the students tried to fit a straight line onto points which showed a distinct concave curvature.

(ii) This question was not answered well with most students responding in terms of the amount of radiation passing through the lead rather than the increase in the amount of radiation being absorbed by an increase in the thickness of the lead sheets.

(iii) Just less than half of the students answered with numerical values which fell within the tolerance range given in the mark scheme.

(d) About half of the students correctly chose gamma but few obtained credit for stating that this form of radiation is the only one able to pass through thin layers of lead.

23 (a) (i) Less than half of the students scored this mark. The most common error was to use colloquial terminology of ‘splitting the atom’ rather than referring to the nucleus.

(ii) Just fewer than half of the students named the particle as a neutron to score this mark. Common errors were ‘alpha particles’ or ‘Uranium 235’.

(b) (i) Although this was quite accessible, many of the students simply quoted a rule like ‘like charges repel’ without relating their answer to nuclei. Others did not interpret the question properly and attempted to explain about forces within the nucleus or between the nucleus and electrons. About half of the students scored this mark.

(ii) This question was better answered with most of the students scoring the mark. The students that failed to score the mark either gave far too general answers like ‘in space’ or focussed on other contexts − both biological and geological − with references to fertilisation and to volcanoes.

(c) (i) Many students had a good attempt at this question with almost half of the students scoring one mark and a further third scoring both. Many students gave an economic argument which was not creditworthy.

(ii) This was poorly answered. Correct answers were not common, but referrals to reducing reliability on other fuel sources and reducing environmental damage were the most frequent. In suggesting an important consequence of developing fusion technology, many students expressed concern over the release of radioactive material, meltdown and references to the reactors running out of control. Incorrect responses like ‘difficult to dispose of the radioactive waste’ or ‘lots of carbon dioxide emissions’ were common.

(d) Of those students that did attempt an approach which resembled a half-life calculation, those that identified there were three half-lives were awarded one mark and in most cases these students went on to correctly calculate the answer and score both marks. There were a significant number of students who identified the sequence 80-40-20-10 and then incorrectly thought this made four half-lives and another group that divided into 36 years to arrive at an answer of 4.5 years. Only one third of the students scored both marks.

24

(a) Many of the students did not attempt to write down the minimum frequency of ultrasound, and a lot of the students were not aware that the wavelength of an X-ray is similar to the diameter of an atom, leading to some interesting responses. Only a small proportion of the students scored both marks with a further third of the students scoring one mark.

(b) This question was attempted by the vast majority of students, most of whom wrote a reasonably lengthy answer. Almost half of the students scored at least 4 marks. Some students chose to write down everything they knew about X rays or ultrasound, including lots of details about how they work which was not asked for in the question. There was a common misconception that X-ray photography uses gamma rays to produce images, and also that X-rays are radioactive. A lot of students limited themselves to level 2 by failing to write about the precautions necessary when using X-rays. Most students (perhaps prompted by the photographs in the question) were aware that ultrasound is used for fetal scanning, but a fair number of students stated that it was just used for scanning for babies, failing to mention that the babies in question were still in the womb. A lot of students stated that ultrasound was used to look for babies in the mother's stomach, which was allowed here but raises some questions about their knowledge of biology. A number of students got mixed up between CT scans and MRI scans.

32

(a) (i) This question was answered well with over three-quarters of students scoring the mark.

(ii) This question was answered well with most students scoring both marks.

(b) Whilst around three-quarters of students correctly chose wave **D**, less than a third were able to link the choice to the size of the gap needed for diffraction. A common incorrect response was that the wavelength itself was too long to fit in a classroom.

(c) (i) Around three-quarters of students correctly chose position **Q**.

(ii) Most students were able to gain one mark for the sound wave reflecting however, less than a fifth scored all three marks.

(iii) Less than half of responses were correct. There was evidence that students had not looked at the diagram in detail, and answered in terms of surface **EF** rather than **GH**.

(iv) Nearly all students correctly calculated the wavelength and scored both marks.

(v) Over two-thirds of students correctly linked the given frequency with the range of human hearing.

33 (a) (i) Around three-quarters of students correctly identified the defect as ‘short sight’. Many others attempted to explain the defect, without naming it.

(ii) This question was well answered with the majority of students answering correctly. A very small minority of students failed to include an answer. Students should be encouraged not to leave blank spaces where a choice of answers is listed.

(b) Almost all students answered this question correctly.

(c) The Quality of Communication question was very well answered, with almost all students scoring four or more marks out of the six available. A number of students answered in bullet point form, but failed to write in full sentences. The information at the beginning of the question reminds students that they will be assessed on using good English, amongst other criteria. A well thought-out answer including many salient points is preferable to an extended account where the same point is repeated several times.

(d) Around a fifth of responses scored one of the two marks for the suggestion of moving the lens, but failed to score the second mark by being vague about the direction of movement; ‘up’, ‘down’ ‘backwards’ and ‘forwards’ were often seen. There were also a number of answers relating to inserting a diverging lens in front of the camera lens, as in the correction of eye defects. The specification makes a distinction between the two methods of focusing for the eye and the camera.

34 (a) Of the whole exam paper, this question had the highest percentage of students who did not attempt an answer. Around three-quarters of students correctly identified that four cells would be needed and drew the correct symbols. However, these were often joined by dotted lines, or not joined at all.

(b) The calculations were very well answered with nearly all students scoring both marks for part (i) and more than three-quarters scoring full marks for parts (ii) and (iii).

(c) (i) Around half of students had the correct idea. However, some failed to score both marks by just referring to either the fact that the transformer needs alternating current to work, or that the battery supplies direct current, but not referring to both. Incorrect answers commonly referred to the voltage being too high, or too low.

(ii) This calculation question was well answered, with around three-quarters of students scoring both marks.

35

(a) Just over half of the students gave a correct definition of half-life.

(b) The vast majority of students were able to obtain a value of half-life from a graph of count rate against time.

(c) Parts (i), (ii), (iii) and (iv) required students to look at the type of radiation emitted and the half-life of five radioactive isotopes shown in the table, and select one for a particular task or set of circumstances. Marks were often dropped by students not naming the source.

(i) Over three-quarters of students knew the source that emits radiation that is not deflected by a magnetic field.

(ii) The majority of students were able to score at least one mark. Less than a quarter of students could explain which source should be used for monitoring the thickness of paper during production.

(iii) Over three-quarters of students knew which source would have to be replaced most often, but very few could give a full explanation.

(iv) Half of the students knew which of the sources emitted radiation that could penetrate the box and a further third of students gave an adequate explanation.

36

(a) Three-quarters of students knew why an energy storage system would work if the road surface was black. Many answers stated that 'black surfaces absorb heat' rather than 'absorb heat well'.

(b) (i) A quarter of students gave a correct definition of specific latent heat of fusion. However, many incorrect responses referred to melting rather than a change from solid to liquid.

(ii) Nearly all students correctly calculated the amount of energy required to melt the ice.

(c) (i) Two-thirds of students correctly stated that the variable to be controlled was mass of ice. The remainder stated that the mass of salt had to be controlled.

(ii) Two-thirds of students correctly ticked two boxes with suggestions as to why the student stirred the crushed ice.

(iii) Nearly all students could correctly describe the pattern of how mass of salt added to some crushed ice affected the melting point of the ice.

(d) Just under half of students scored full marks for a calculation of energy transferred given values of power and time in non-SI units. Conversion from: kW to W; and minutes to seconds, was required. The spread of marks demonstrated this, with a third of students dropping one mark.

(e) The Quality of Communication question brought together the elements of the entire question and asked for advantages and disadvantages of using energy storage, salt and undersoil heating for keeping a road free from ice in the winter. Most students used the available space and many used additional pages.

Three-quarters of students scored four marks or more. Some excellent work was seen, but many students wasted time by repeating much of what was in the question. Also they ended a very good account with an unnecessary summary. Some very well written work only addressed either an advantage or a disadvantage of each system.

37

(a) A low proportion of students could give an advantage and a disadvantage of a nuclear power station compared with a gas-fired power station. A further quarter could give either an advantage or a disadvantage. Too many answers were vague and referred simply to pollution, rather than naming a gas. A common misunderstanding was to say that nuclear power stations give out carbon dioxide gas. A common misreading of the question was to give an advantage for a nuclear power station and a disadvantage for a gas-fired power station.

(b) (i) Nearly two thirds of the students were able to substitute a power and time value into the correct equation. A low proportion of students were able to convert the given power into kilowatts.

(ii) Just over a half of students were able to state that the wind is a variable and unreliable source of energy. The figure of 30% proved a distractor for weaker students who often quoted that 70% of the energy was wasted. Those students who mentioned that the output was weather-dependent were not given credit. The key aspect is variation in wind speed or power. Some students appear to believe that wind turbines are operated by supplying them with electrical energy, and are shut down to conserve energy.

(c) Two fifths of the students were able to give an advantage of underground cables compared with overhead cables. Too many statements were vague, students were expected to give some detail of why underground cables are less likely to be damaged. There are still a large number of students who believe that birds will be electrocuted if they land on overhead power cables.

38

(a) Only a fifth of the students could state that hot objects emit infrared radiation.

(b) About half of the students could identify that increasing the power and decreasing the speed would increase the energy incident on the biscuits and therefore make them browner.

(c) Responses did not often include information specifying whether they were referring to the inside or the outside surface of the oven. Several explicitly referred to reflection of light, while others stated what would have occurred if the surfaces had been black. About half of the students appreciated that light shiny surfaces are good reflectors of infrared radiation. Only the most able students stated that a shiny outer surface would reduce emission of infrared, or that the amount of radiation reaching the biscuits would be increased.

39 (a) A very low proportion of students did not attempt this question. Out of those who did answer nearly one-quarter failed to score any marks; answers referring to burning fossil fuels, wind turbines, waves and tides were not uncommon. Some answers started correctly with water falling, but then reverted to the water being heated up. A significant number of students either failed to include the useful energy transfers taking place, or just referred to the kinetic energy of the moving water transferring to ‘electricity’.

(b) The majority of students were able to gain at least one mark out of the three, with more than one-fifth giving good descriptions of the consequences of burning fossil fuels. Some missed the reference to ‘better for the environment’ and answered in terms of saving money on fuel bills.

(c) Slightly less than half of students scored the mark. Many demonstrated an understanding of legal power made by government, but few mentioned economic factors. Incorrect suggestions included ‘letting the people decide’ or concern about the disposal of appliances which did not comply with the suggested new rule.

40 (a) This question was well answered on the whole, with around half of students scoring at least three of the four marks. Many answers started with warmer air rising, rather than with the cooler air falling. Whilst many students made reference to changes in density, they often incorrectly referred to the ‘particles becoming denser’.

(b) Around a fifth of students achieved both marks. Many answers indicated that ‘directly proportional’ meant that the two values had to be the same, as in fridge D. Some students worked out the difference in volume between each fridge and the previous one, and also the difference in energy used. As these were not the same, they stated that the data did not show proportionality.

To check if results are directly proportional, either the ratio of the volume to energy used needs to be a constant or the volume and energy used needs to change by the same multiplier.

(c) Nearly two-thirds scored at least one mark, but only around a fifth scored both. Many students seem to have overlooked the instruction to ignore the cost of buying a new fridge. Many answers indicated that ‘more efficient’ meant that the new fridge was colder, or kept food fresher for longer.

41 (a) (i) Three fifths of the students were able to substitute into the equation and rearrange it to find the useful power output. The main error was not selecting the equation using efficiency as a fraction rather than as a percentage.

(ii) Around half of the students answered correctly. Common incorrect responses were to subtract their answer to the previous part from 1 or from 100.

(b) (i) Around three-quarters of students scored at least one mark, usually for stating that the input power was less for the LED bulbs. Whilst many appreciated that the efficiency was also less, few explained the consequence of this in terms of less energy wasted meaning the temperature of the cabinet would increase more slowly, resulting in the cooler unit being used less often.

(ii) This was a standard demand question. Whilst the majority of answers recognised that a line graph (or scattergram) should be drawn, a small proportion gave a correct reason by saying that both variables were continuous. It would appear that many students do not think to transfer their knowledge from ISAs to this written paper.

(c) Around a fifth of students scored full marks. Good answers included clearly drawn, mathematically-based conclusions, showing all calculations. Those who chose to write a larger amount of prose often missed a vital part of the information, for instance just comparing the purchase costs and ignoring the operating costs.

42 (a) (i) Just over three fifths of the students scored this mark.

(ii) Just over half of the students scored this mark.

(iii) Just over half of the students correctly chose 2 for their numerical answer, however only a small proportion of the students did so for the correct reason.

(b) (i) The majority of students gave a correct answer with an equal split between beta and gamma.

(ii) About three fifths of the students gave the correct answer.

(iii) This was not well known with only just over half of the students giving the correct answer. The most common incorrect answer given was ‘Have a long range in air’.

(c) (i) The majority of the students were aware of what the radiation would do to healthy body cells with the most popular incorrect answer being that the cells would be denatured.

(ii) Nearly two thirds of the students scored this mark.

43

(a) (i) Most students could correctly identify one of the plug terminals but surprisingly, fewer than half of the students could correctly identify all three.

(ii) Virtually all of the students were aware that a suitable insulating material was needed for the casing of a three-pin plug. Most students gave the answer 'plastic' or an acceptable named plastic.

(b) (i) About four fifths of the students were able to substitute into the correct equation chosen from the Physics Equation Sheet and to calculate the power of the drill.

(ii) Very few of the students scored all of the three marks available. Many of the students were able to deduce from the information provided about the 1200W drill that it would cause the cable inside the casing to be overloaded but fewer of the students stated that this would definitely result in heating with the possibility of a fire developing. Some students thought that the extension cable provided the power and so the 1200W drill would not work. A significant number of students answered in terms of fuses blowing and there are still many students that state that anything electrical will blow up if there is a problem of any kind.

(c) Although many of the students correctly identified X as the best drill, under half of the students were able to give the reason for their choice in terms of the increased efficiency or smallest energy input or least money to operate.

44

(a) Most of the students scored very well here, with nearly three quarters gaining both marks. 'J' was usually seen with 'it is the smallest'. Some students tried to elaborate further and ended up by confusing their answer. Another popular answer was '(only) small stars become Black Dwarfs'.

(b) (i) Both 'become a supernova' and 'it will explode' were seen here although only one response was needed. About a quarter of the students scored zero and those that did often had either a subsequent incorrect stage written down or 'it will implode'.

(ii) This was not done very well with over four fifths of the students scoring zero. Most of the students mentioned the lack of weighing machines or another method for measuring the mass. Another popular response was the idea that we cannot visit Betelgeuse.

(iii) This was generally done very well with half of the students giving one of the responses involving advances in measuring, scientific knowledge, or technology. Unfortunately a few of the students continued with the idea of technology extending to the building of spaceships enabling people to visit Betelgeuse.

(c) This was usually done well, with two fifths of the students scoring 3 or more marks. Some of the students were very unsure of the different stages and just wrote down Red Giant and White Dwarf and this enabled them to obtain two marks. The last stage was a little confusing to some of the students as they wrote about the star losing all of its energy or running out of energy rather than the star stopping emitting energy.

45

(a) Nearly three fifths of the students gave the correct answer, 'number of protons'. Many of the students did not understand the term 'in common' and instead, wrote about the differences between isotopes.

(b) (i) About two fifths of the students correctly stated that nuclei are split in nuclear fission. Most of the remaining students had an idea of what happens but used ambiguous and vague terminology, using 'break apart', 'divide' 'particles' without supporting explanation and thus lacked sufficient clarity to obtain the mark.

(ii) A lack of clarity again stopped students obtaining this mark with only about two fifths naming the reactor as the part where molybdenum is produced.

(c) About two thirds of the students identified the radiation as beta. However the reasons given were often confused, imprecise and sometimes contradictory. Examples seen include: 'atomic number stays the same but number of protons goes up', 'nucleus loses a proton and gains a neutron', 'nucleus loses a neutron but gains a proton and an electron', etc. Less than a third of the students gave complete answers that correctly gave the marking points in the mark scheme.

(d) Only less than a third of the students gave answers sufficient to score the mark. A small proportion of the students gave an answer in terms of the count rate halving.

(e) (i) About two thirds of the students recognised that the number remaining was 20,000 but then less than half of these students used the graph to correctly identify 6.2-6.3 days as the time required. A small amount of students drew lines on the graph at 80,000 and identified 0.8 days but half of them, then carried out further calculations on this and consequently lost the compensation mark.

(ii) Fewer than a third of the students scored the mark for the ionising effect of radiation; of those who did, they usually went on to score the second mark. Most of the students that scored the second mark did so for general terms about radiation 'causing cancer' or some form of harm. Few students linked the ionising effect of radiation to damage or harm to individual cells or DNA.

(iii) Many of the students reiterated statements from part e(ii) about the dangers of radiation rather than answering the question asked. Students' phrasing of their response was often confused with only about a fifth being able to describe that the benefits outweighed the risks.

46 (a) This was poorly answered with very few students able to identify that short-sight can be caused by the eyeball being too long.

(b) Over half of the students failed to identify lens A, and so scored zero. Of those students that did select lens A, only half stated the correct reason. Some students referred to the properties of the material rather than the optics here.

(c) Over two thirds of the students gained the mark.

(d) Most students gained both marks in this calculation.

(e) Only a fifth of the students failed to gain the mark.

(f) The majority of students were able to select and apply the correct equation but then inverted the calculation when using the calculator, ie 14 / 70.

47 (a) The vast majority of students could identify the system as hydraulic.

(b) The majority of students scored both marks for the calculation.

(c) Most students correctly identified the advantage as environmental.

48 (a) Many students attempted to describe how ultrasound is used rather than defining it. Other answers were vague, eg ‘cannot be heard’ but without further qualification. Some thought ultrasound was an electromagnetic wave and some thought ultrasound was the gel applied when a scan is carried out.

(b) Few students gained all 3 marks for this calculation. Over two thirds of the students failed to take the echo into account and so scored 2 marks. About one student in ten failed to gain any marks.

(c) Just under two thirds of the students stated a correct medical use of ultrasound scanning. Many students who did not gain the mark were often not specific enough in their answer; ‘baby scanning’ was a common response that was not sufficient.

(d) Many students did not read the question carefully, so the advantages and disadvantages given were not comparative. Many responses were about patient perceptions or cost. A number of students reversed their responses giving the advantages as disadvantages.

49 (a) Two thirds of the students identified that gravity provided the centripetal force on the satellite.

(b) A few students correctly stated two factors that affected the size of the centripetal force on the satellite, with just over a third identifying one factor correctly. Answers that failed to score lacked sufficient detail e.g. ‘mass’ or ‘radius’, which could equally apply to the Earth as well as the satellite, so were not sufficient to gain marks.

(c) (i) Very few students failed to correctly state the correct relationship.

(ii) About two thirds of the students correctly identified that there was no relationship between the mass of a satellite and its orbital period.

(d) Most students identified that Isaac Newton was a respected scientist who had made new discoveries before.

50 (a) Over four fifths of students recalled it was a hydraulic system, but there was a range of misspellings used.

(b) About four fifths of the students gained full marks for the calculation using standard form.

(c) Half of the students gained 1 mark in this societal aspects of science question. Many did not score as their answer was too vague or because they gave a disadvantage of the usual oil. A small number wrote correctly about the conservation of fossil fuels but most who answered in terms of fossil fuels wrote about the negative side of using them.

(d) Students struggled to apply their knowledge to the given situation of a loudspeaker. Written responses often failed to show a logical progression. A small proportion of students scored 3 or 4 marks. There was widespread confusion with the transformer. Few students referred to a force or to the direction of the force changing as the direction of the current changes. Very few mentioned ‘force’ but some stated ‘attraction / repulsion’. Descriptions often did not include the direction of the force changing when then current changed direction.