Analysis and Evaluation High Demand

Name:

Class:

Date:

Time: **310 minutes**

Marks: **308 marks**

Comments:

1 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 ....

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2 ....

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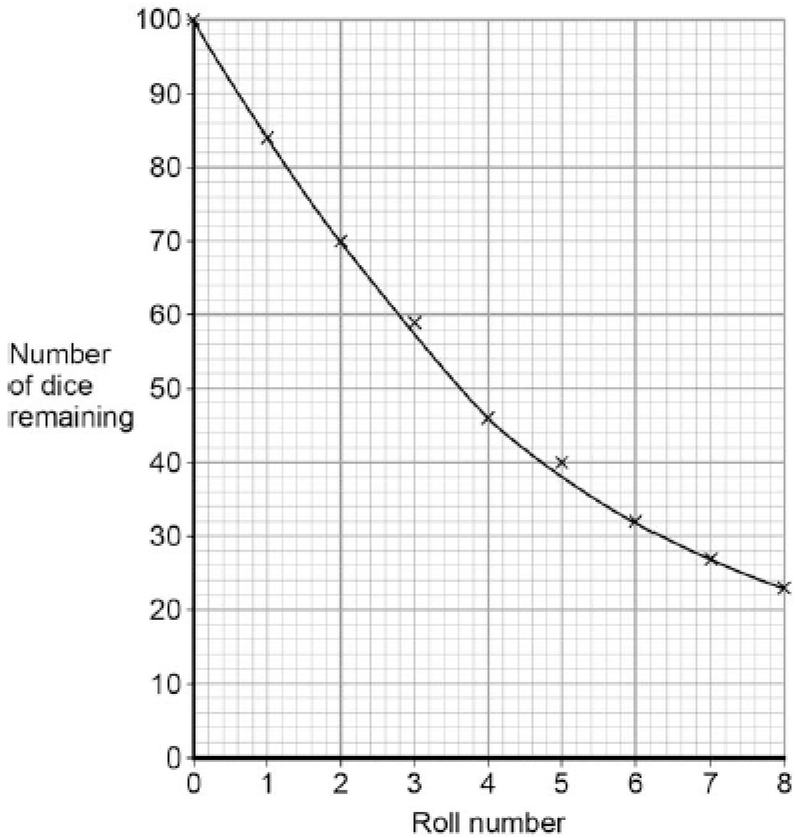
(2)

(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.

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(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.

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(2)
(Total 10 marks)

2 An electrician is replacing an old electric shower with a new one.

The inside of the old shower is shown in **Figure 1**.

Figure 1

© Michael Priest

(a) If the electrician touches the live wire he will receive an electric shock.

Explain why.

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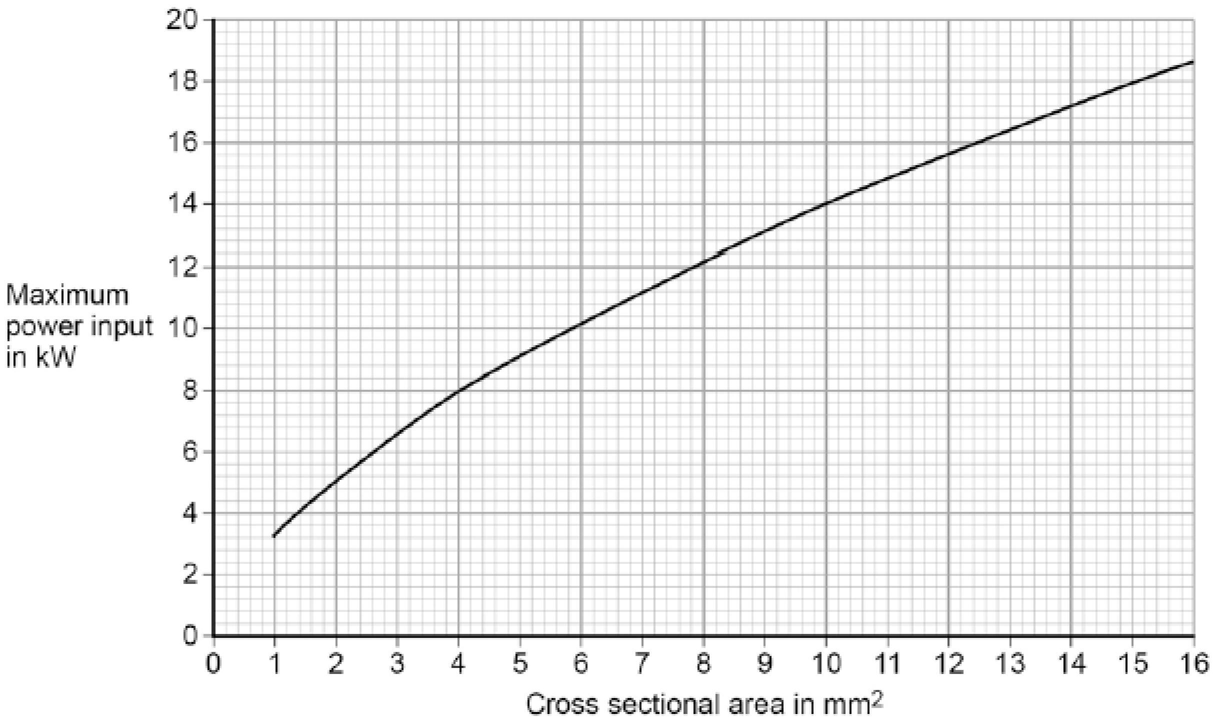
(4)

(b) Different electrical wires need to have a cross-sectional area that is suitable for the power output.

Figure 2 shows the recommended maximum power input to wires of different cross-sectional areas.

Figure 2



The new electric shower has a power input of 13.8 kW.

Determine the minimum **diameter** of wire that should be used for the new shower.

The diameter, d, can be calculated using the equation:

$$d = \sqrt{\frac{4A}{\pi}}$$

A is the cross-sectional area of the wire.

....

....

Minimum diameter = ... mm

(2)

(c) The charge that flows through the new shower in 300 seconds is 18 000 C.
The new electric shower has a power of 13.8 kW.

Calculate the resistance of the heating element in the new shower.

Write down any equations you use.

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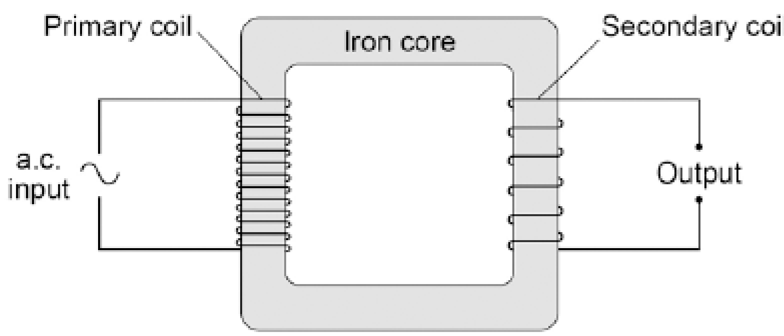
Resistance = ... Ω

(5)
(Total 11 marks)

3 **Figure 1** shows the construction of a simple transformer.

Figure 1



(a) Why is iron a suitable material for the core of a transformer?

Tick **one** box.

It is a metal. ☐

It will not get hot. ☐

It is easily magnetised. ☐

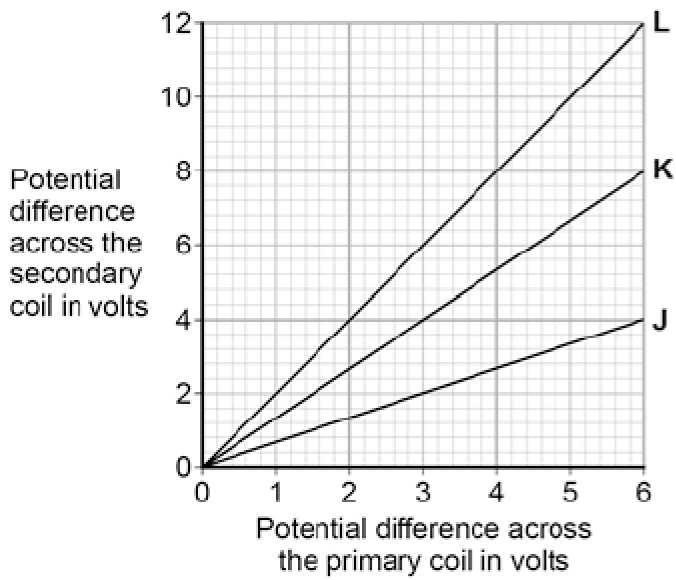
It is an electrical conductor. ☐

(1)

(b) A student makes three simple transformers, **J**, **K** and **L**.

Figure 2 shows how the potential difference across the secondary coil of each transformer varies as the potential difference across the primary coil of each transformer is changed.

Figure 2



How can you tell that transformer **J** is a step-down transformer?

....

....

(1)

(c) Each of the transformers has 50 turns on the primary coil.

Calculate the number of turns on the secondary coil of transformer **L**.

Use the correct equation from the Physics Equations Sheet.

....

....

....

Number of turns on the secondary coil = ...

(3)

(Total 5 marks)

4 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. ....

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(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.

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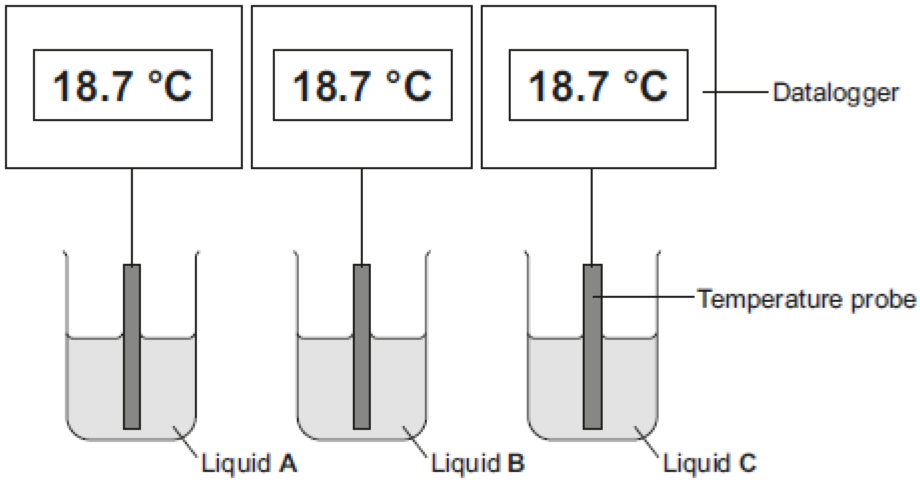
(2)
(Total 8 marks)

5 A student investigated the cooling effect of evaporation.
She used the equipment in **Figure 1** to measure how the temperature of three different liquids changed as the liquids evaporated.

Figure 1



(a) The temperature and volume of each liquid was the same at the start of the investigation.

State **one** further control variable in this investigation.

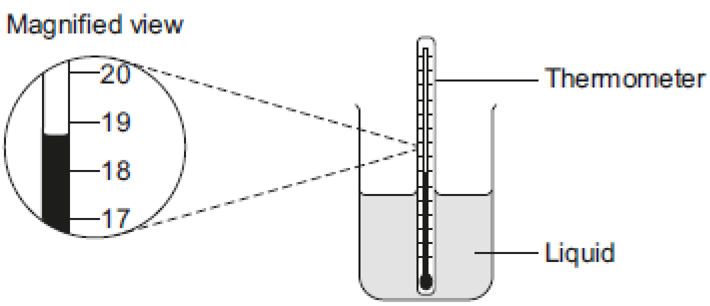
....

....

(1)

(b) Give **two** advantages of using dataloggers and temperature probes compared to using the thermometer shown in **Figure 2**.

Figure 2



1. ....

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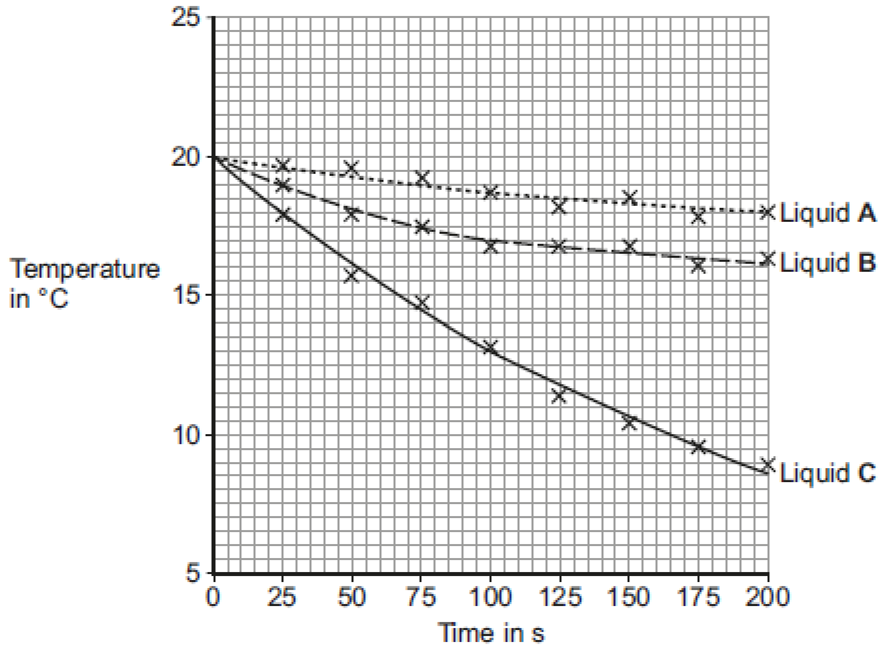
2. ....

....

(2)

(c) The student's results are shown in **Figure 3**.

Figure 3



(i) Calculate the average rate of temperature decrease of liquid **C** between 0 and 100 seconds.

....

....

Average rate of temperature decrease = ... °C / s

(2)

(ii) Give **one** conclusion that can be made about the rate of temperature decrease of **all three** liquids from the results in **Figure 3**.

....

....

(1)

(iii) Which liquid had the lowest rate of evaporation? Give a reason for your answer.

Liquid ....

Reason ....

....

(1)

(iv) A second student did the same investigation but using a smaller volume of liquid than the first student.

All other variables were kept the same.

What effect would this have on the results of the second student's investigation?

....

....

(1)

(d) Explain how the evaporation of a liquid causes the temperature of the remaining liquid to decrease.

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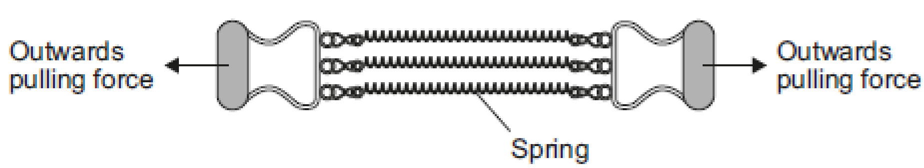
(3)
(Total 11 marks)

6 **Figure 1** shows an exercise device called a chest expander. The three springs are identical.

Figure 1



A person pulls outwards on the handles and does work to stretch the springs.

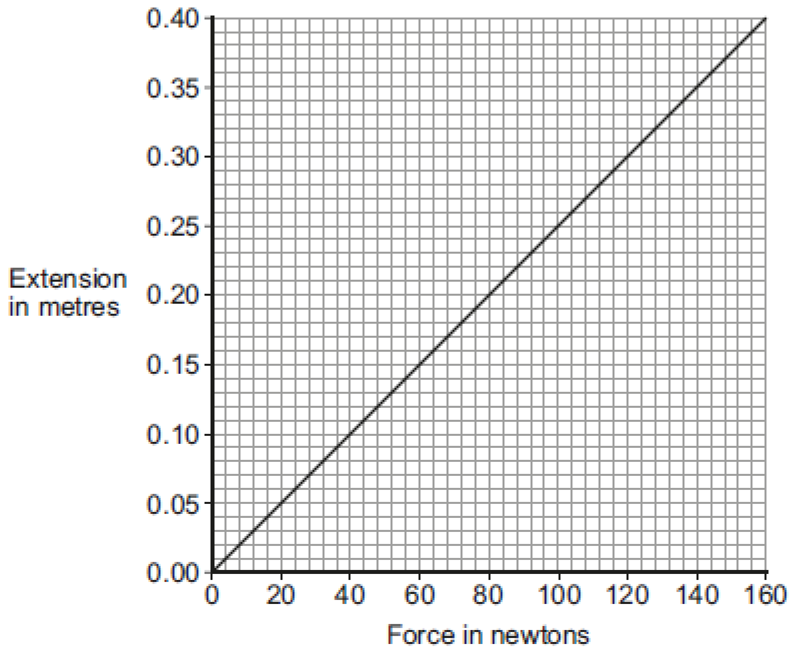
(a) Complete the following sentence.

When the springs are stretched .... energy is stored in the springs.

(1)

(b) **Figure 2** shows how the extension of a single spring from the chest expander depends on the force acting on the spring.

Figure 2



(i) How can you tell, from **Figure 2**, that the limit of proportionality of the spring has not been exceeded?

....

....

(1)

(ii) Use data from **Figure 2** to calculate the spring constant of the spring.
Give the unit.

....

....

....

Spring constant = ... Unit ....

(3)

(iii) Three identical resistors joined in parallel in an electrical circuit share the total current in the circuit.

In a similar way, the three springs in the chest expander share the total force exerted.

By considering this similarity, use **Figure 2** to determine the total force exerted on the chest expander when each spring is stretched by 0.25 m.

....

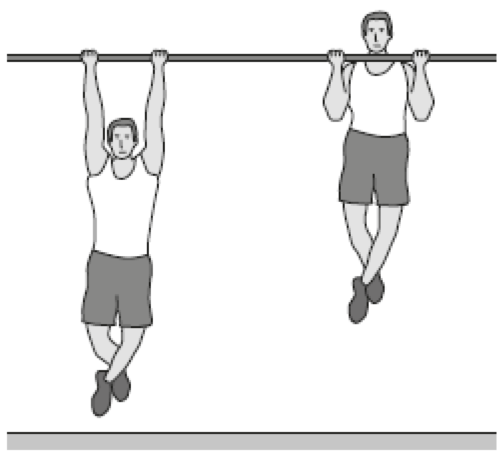
....

Total force = ... N

(2)

(c) The student in **Figure 3** is doing an exercise called a chin-up.

Figure 3



Each time the student does one chin-up he lifts his body 0.40 m vertically upwards.
The mass of the student is 65 kg.
The student is able to do 12 chin-ups in 60 seconds.

Calculate the power developed by the student.

Gravitational field strength = 10 N/kg

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....

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....

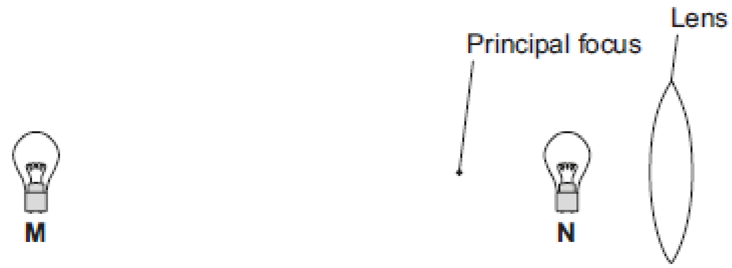
....

Power = ... W

(3)
(Total 10 marks)

7 (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**.

....

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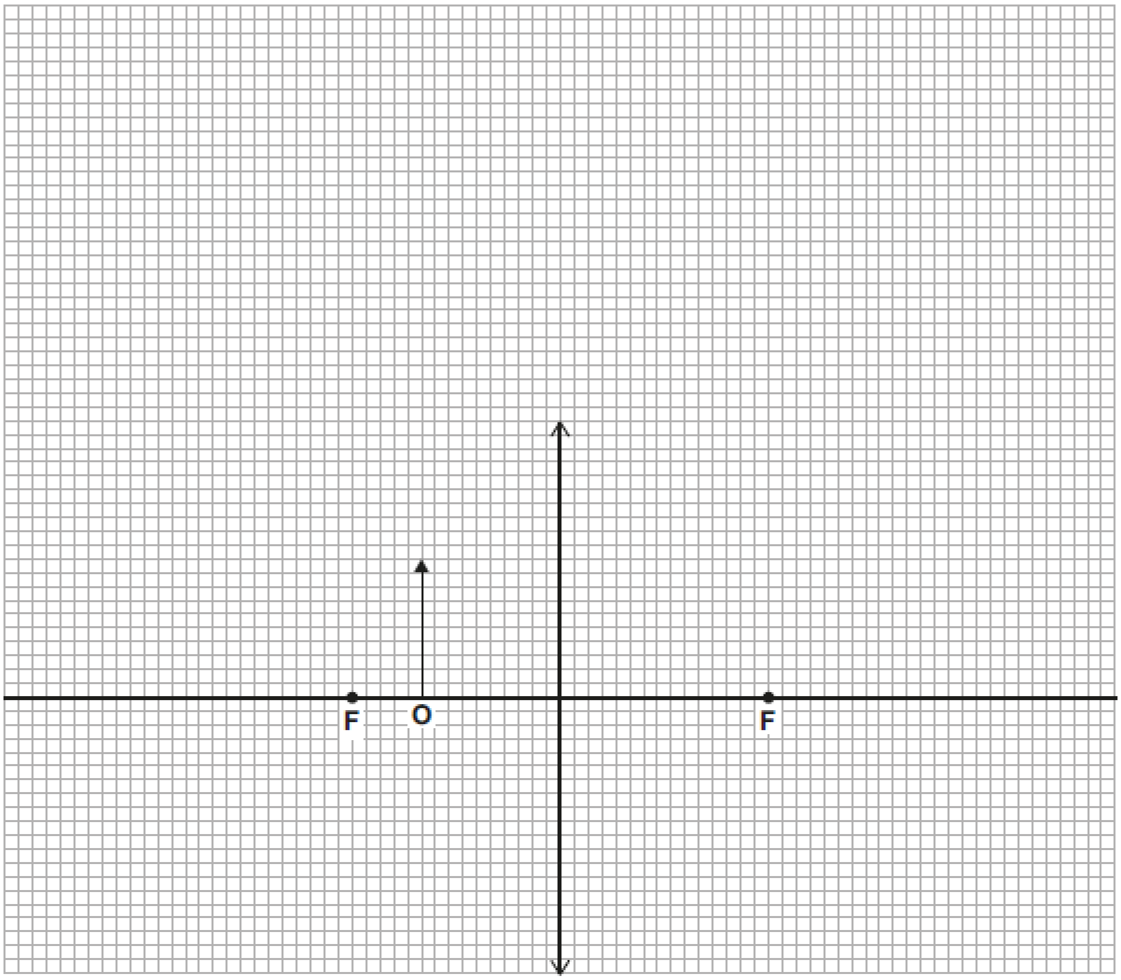
(3)

(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

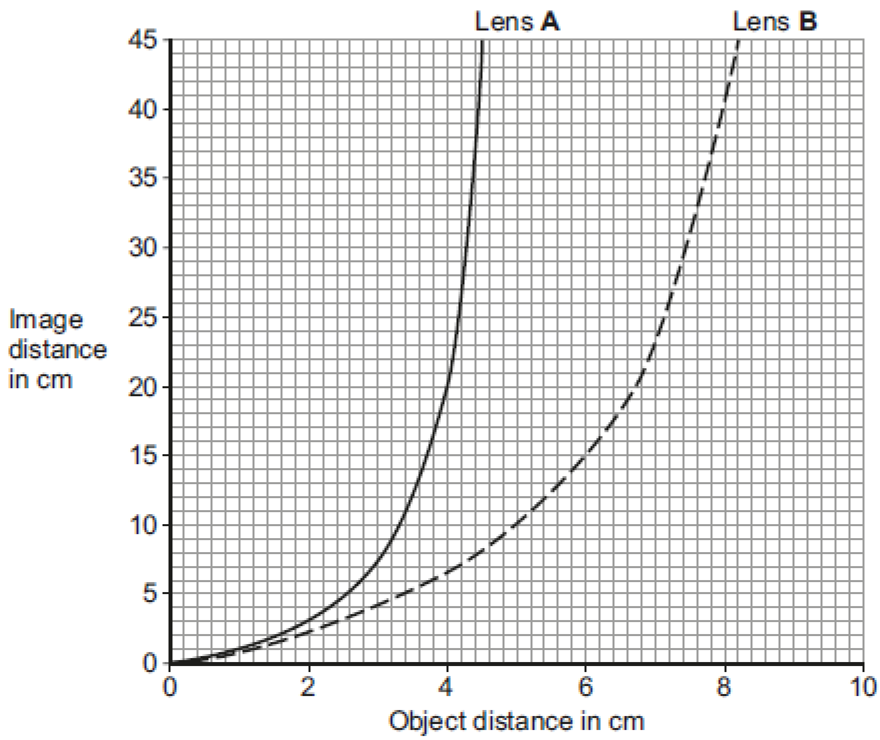


(3)

(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**.

....

....

....

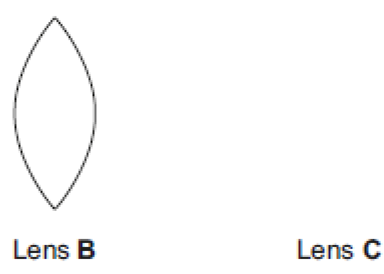
(2)

(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**.

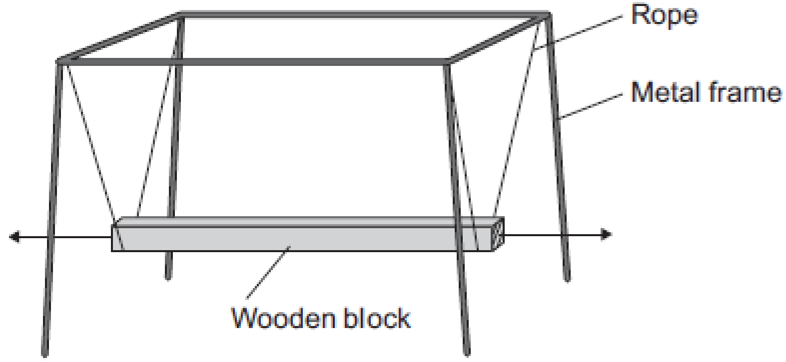
Figure 4



(1)
(Total 10 marks)

8 **Figure 1** shows the design of a playground ride.

Figure 1



A large wooden block rests on ropes. The ropes are attached to a metal frame.

Children sit on the wooden block.

When the wooden block is moved to the left and released it moves to and fro.

When the wooden block returns to the point of release it has completed one cycle.

(a) Identify **two** possible hazards of the ride in **Figure 1**.

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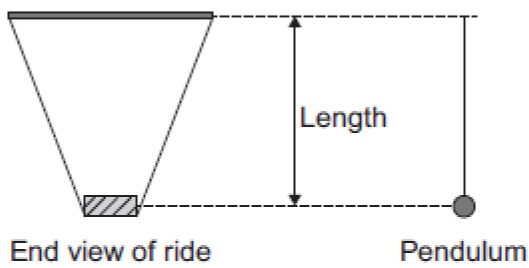
(2)

(b) The designer of the ride wants to know if the ride has the same time period as a pendulum of the same length.

The designer used a model of the ride and a pendulum as shown in **Figure 2**.

Figure 2



The designer measured the time taken to complete 10 cycles for different lengths of both the model ride and the pendulum.

The results for the model ride are shown in **Table 1**.

Table 1

Length in metres	**Time for 10 cycles in seconds**				**Mean time period in seconds**
	First time	**Second time**	**Third time**	**Mean**	
0.100	6.36	6.37	6.29	6.34	0.63
0.150	7.76	7.74	7.80		
0.200	8.97	8.99	8.95	8.97	0.90

The results for the pendulum are shown in **Table 2**.

Table 2

Length in metres	**Time for 10 cycles in seconds**				**Mean time period in seconds**
	First time	**Second time**	**Third time**	**Mean**	
0.250	10.00	10.04	10.02	10.02	1.00
0.300	10.99	11.01	10.94	10.98	1.10
0.350	11.88	11.83	11.87	11.86	1.19

(i) Complete **Table 1**, giving values to an appropriate number of significant figures.

....

....

(3)

(ii) The investigation already includes repeated readings.

Suggest **one** improvement that could be made to this investigation.

....

....

(1)

(iii) The designer reads in an Advanced Physics textbook that:
'The square of the time period, T, for a simple pendulum is proportional to its length, l.'

$$T^2 \propto l$$

Would the model ride have the same time period as a simple pendulum of the same length?

Use **one** row of data from **Table 1** and **one** row of data from **Table 2** to work out your answer.

State your conclusion.

....

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(3)

(c) The ride was redesigned and built to make it safer.

The wood was moving at maximum speed. The maximum kinetic energy of the wood was 180 J.

A parent applied a force to the wood and stopped it in a distance of 0.25 m.

Calculate the force required.

....

....

Force = ... N

(3)
(Total 12 marks)

9 Atoms are different sizes.

One of the heaviest naturally occurring stable elements is lead.

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

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

....

....

....

....

(2)

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

....

(1)

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

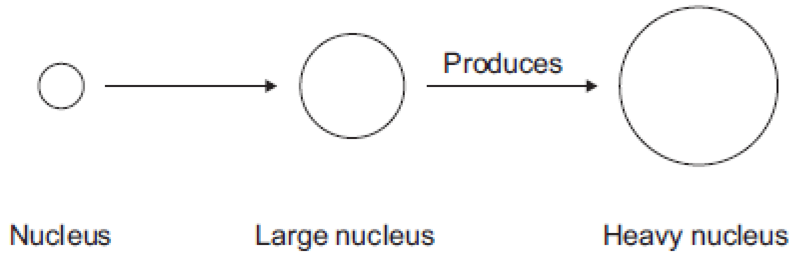
....

(1)

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

This is shown in **Figure 1**.

Figure 1



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

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

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

(3)

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

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

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

(1)

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

The speed of light is 3.00×10^8 m / s.

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

....

....

Time taken = ... s

(2)

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

Suggest why.

....

....

....

....

....

....

(3)

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

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

Tick (✓) **two** boxes.

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

(2)

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

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

(2)

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

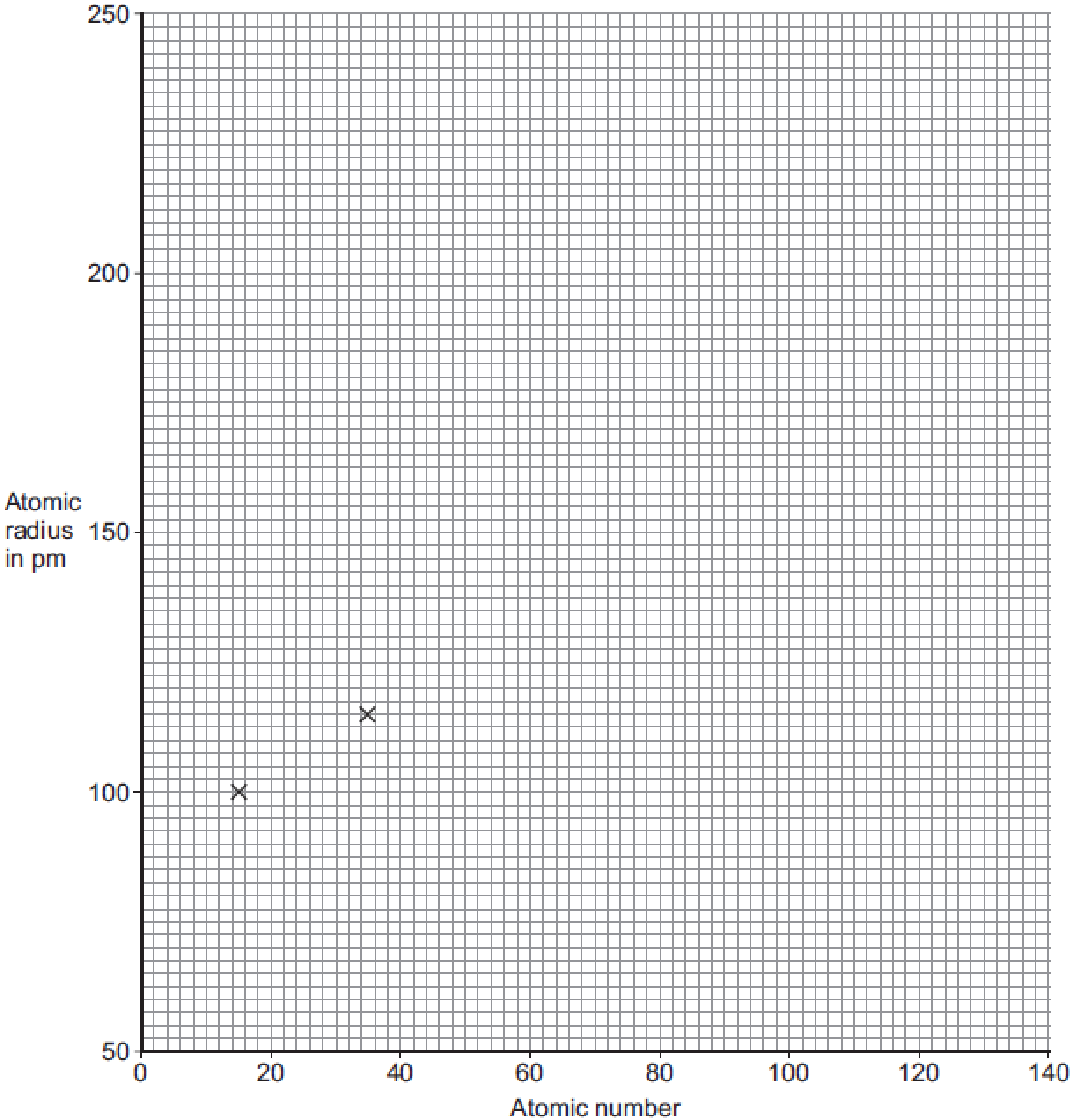
Atomic number	**Atomic radius in picometres (pm)**
15	100
35	115
50	130
70	150
95	170

$1 \text{ pm} = 10^{-12} \text{ m}$

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

Two points have been plotted for you.

Figure 2



(2)

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

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

Atomic radius = ... pm

(1)

(Total 20 marks)

10 Ultrasound waves can be passed through the body to produce medical images.

When ultrasound waves are directed at human skin most of the waves are reflected.

If a material called a ‘coupling agent ‘ is placed on the skin it allows most of the ultrasound waves to pass through the skin and into the body.

(a) What is ‘ultrasound’?

....

....

....

(2)

(b) Two ultrasound frequencies that are used are 1.1 MHz and 3.0 MHz.

The speed of ultrasound in water is 1500 m / s.

Calculate the wavelength of the 3.0 MHz waves in water.

....

....

....

Wavelength = ... m

(3)

(c) The coupling agent used with ultrasound is usually a gel.

Water would be a good coupling agent.

Suggest why water is **not** used.

....

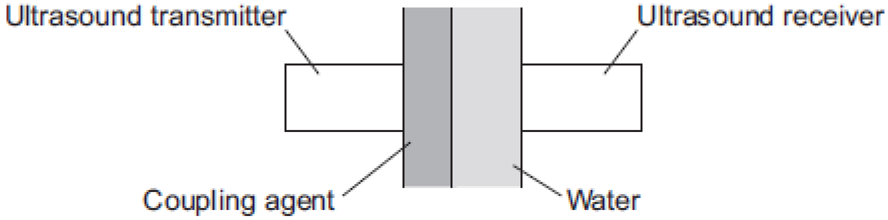
....

(1)

(d) **Figure 1** shows a coupling agent being tested.

- An ultrasound transmitter emits waves.
- The waves pass through the coupling agent and then through the water.
- The waves are detected by the ultrasound receiver.

Figure 1



A scientist tests different coupling agents.

Suggest which variables she must control.

Tick (✓) **two** boxes.

	Tick (✓)
The amount of light in the room	
The colour of the coupling agent	
The width of the coupling agent	
The width of the water	

(2)

(e) The table shows the results for coupling agents **A**, **B**, **C**, **D**, **E**, **F** and **G**.

They were tested using the two frequencies, 1.1 MHz and 3.0 MHz.

The results show how well the waves pass through the coupling agent compared with how they pass through water. The results are shown as a percentage.

100% means that the coupling agent behaves the same as water.

Coupling agent	**Coupling agent percentage using 1.1 MHz**	**Coupling agent percentage using 3.0 MHz**
A	108	100
B	105	100
C	104	98
D	100	98
E	98	98
F	95	99
G	89	88

(i) Which coupling agent allows most ultrasound to pass through at

both frequencies? ☐

(1)

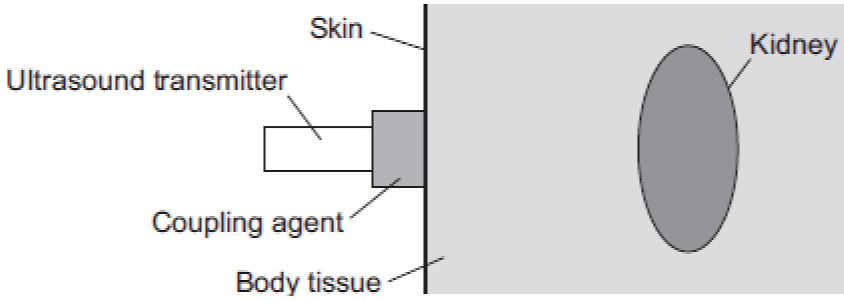
(ii) Which coupling agent performs the same for both frequencies? ☐

(1)

(f) **Figure 2** shows an ultrasound transmitter sending waves into a patient's body.

The waves enter the body and move towards a kidney.

Figure 2



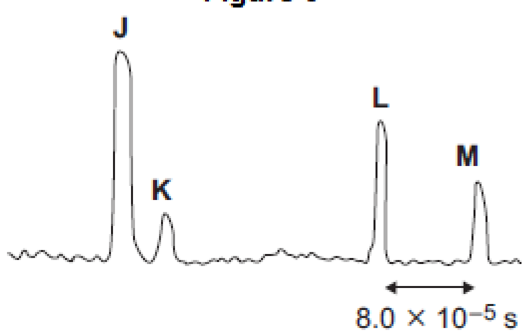
The transmitter also detects the ultrasound waves.

The transmitter is connected to an oscilloscope.

Figure 3 shows the trace on the screen of the oscilloscope.

J represents the intensity of the waves emitted by the transmitter.

Figure 3



(i) Explain the intensities at **K**, **L** and **M**.

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(6)

(ii) The speed of ultrasound waves in the body is 1500 m / s.

Use information from **Figure 3** to calculate the maximum width of the kidney.

....

....

....

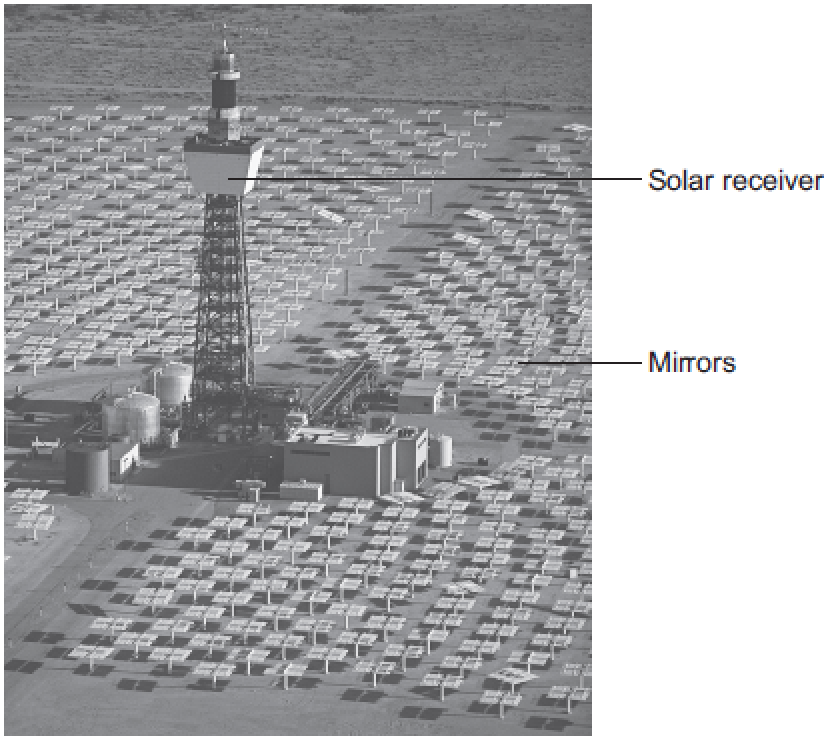
Maximum width of kidney = ... m

(3)
(Total 19 marks)

11 The image below shows a solar thermal power station that has been built in a hot desert.

The power station uses energy from the Sun to heat water to generate electricity.

Energy from the Sun is reflected towards a solar receiver using many mirrors.



(a) (i) Which part of the electromagnetic spectrum provides most of the energy to heat the water in a solar thermal power station?

....

(1)

(ii) Describe how heated water is used to generate electricity by this solar thermal power station.
The process is the same as in a fossil fuel power station.

....

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....

....

(3)

(b) A new type of solar power station, called a solar storage power station, is able to store energy from the Sun by heating molten chemical salts.
The stored energy can be used to generate electricity at night.

(i) It is important that the molten chemical salts have a high specific heat capacity.
Suggest **one** reason why.

....

....

(1)

(ii) The solar storage power station can store a maximum of 2 200 000 kWh of energy.
The solar storage power station can supply a town with a maximum electrical power of 140 000 kW.

Calculate for how many hours the energy stored by the solar storage power station can supply the town with electrical power.

Give your answer to 2 significant figures.

....

....

....

Time = ... hours

(3)

(iii) **Table 1** gives information about the place where the solar storage power station has been built.

Table 1

Season	**Mean number of daylight hours**	**Mean power received from the Sun per square metre in kW**
Spring	11.5	0.90
Summer	13.5	1.10
Autumn	12.0	0.95
Winter	10.5	0.71

The solar storage power station does not operate at the maximum possible electrical output every day of the year.

Suggest why.

....

....

....

....

(2)

(c) Power stations do not work at maximum possible electrical output all the time.The 'capacity factor' of a power station is calculated using the equation:

$$\text{Capacity factor} = \frac{\text{actual electrical output per year}}{\text{maximum possible electrical output per year}}$$

Table 2 shows capacity factors for different types of power station.

Table 2

Type of power station	**Renewable energy source**	**Capacity factor**
Coal	No	0.41
Natural gas	No	0.48
Nuclear	No	0.66
Solar thermal	Yes	0.33
Tidal	Yes	0.26
Wind turbine	Yes	0.30

(i) Compare the capacity factors of the renewable power stations with those of the non-renewable power stations in **Table 2**.
Explain the reason for the difference between the capacity factors.

....

....

....

....

....

....

(3)

(ii) The capacity factor of a solar storage power station is higher than for all other renewable power stations.
Suggest **one** reason why.

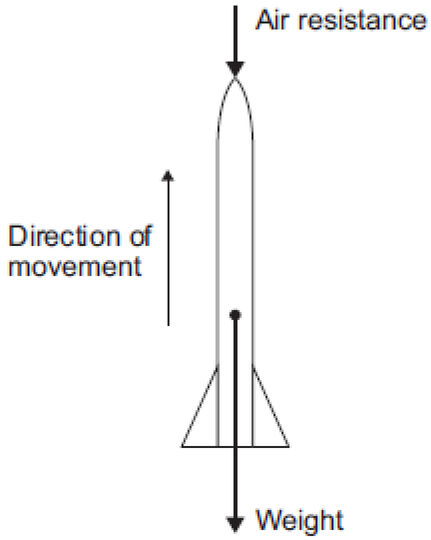
....

....

(1)
(Total 14 marks)

12 (a) **Figure 1** shows the forces acting on a model air-powered rocket just after it has been launched vertically upwards.

Figure 1



(i) How does the velocity of the rocket change as the rocket moves **upwards**?

....

Give a reason for your answer.

....

....

(2)

(ii) The velocity of the rocket is not the same as the speed of the rocket.

What is the difference between the velocity of an object and the speed of an object?

....

....

....

(1)

(b) The speed of the rocket just after being launched is 12 m / s.
The mass of the rocket is 0.05 kg.

(i) Calculate the kinetic energy of the rocket just after being launched.

....

....

....

Kinetic energy = ... J

(2)

(ii) As the rocket moves upwards, it gains gravitational potential energy.

State the maximum gravitational potential energy gained by the rocket.

Ignore the effect of air resistance.

Maximum gravitational potential energy = ... J

(1)

(iii) Calculate the maximum height the rocket will reach.

Ignore the effect of air resistance.

Gravitational field strength = 10 N / kg.

....

....

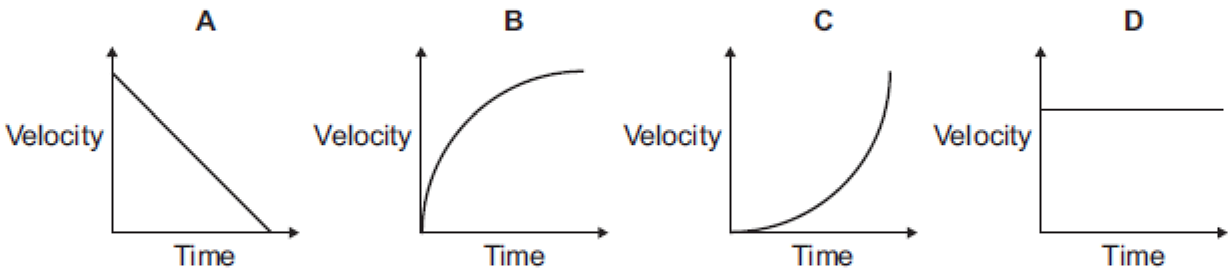
....

Maximum height = ... m

(2)

(iv) **Figure 2** shows four velocity−time graphs.

Figure 2



Taking air resistance into account, which graph, **A**, **B**, **C** or **D**, shows how the velocity of the rocket changes as it **falls** from the maximum height it reached until it just hits the ground?

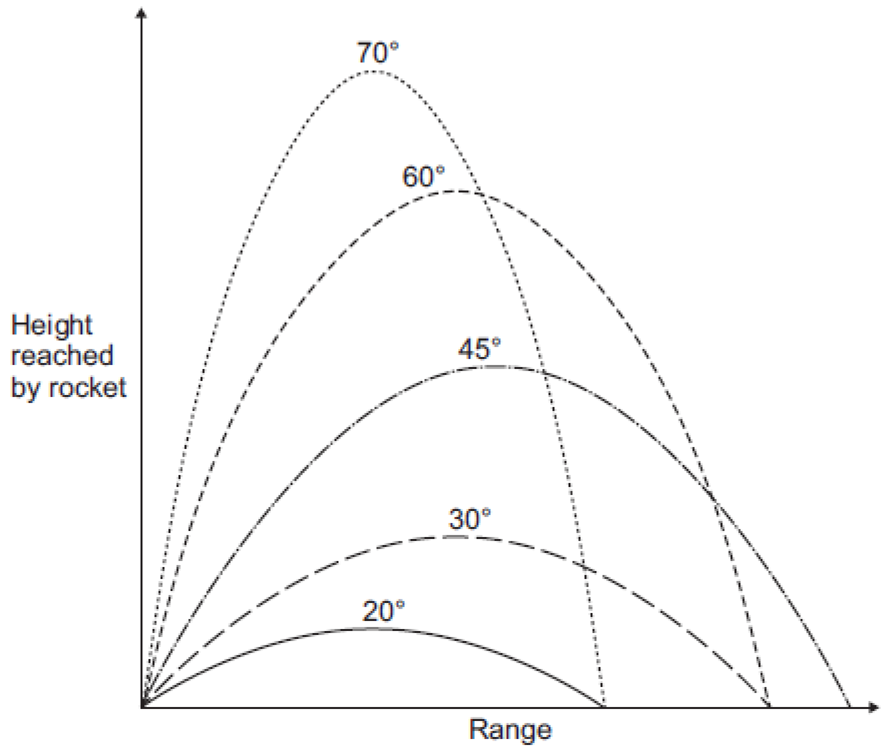
Write the correct answer in the box. ☐

(1)

(c) The rocket can be launched at different angles to the horizontal.
The horizontal distance the rocket travels is called the range.

Figure 3 shows the paths taken by the rocket when launched at different angles.
Air resistance has been ignored.

Figure 3



What pattern links the angle at which the rocket is launched and the range of the rocket?

....

....

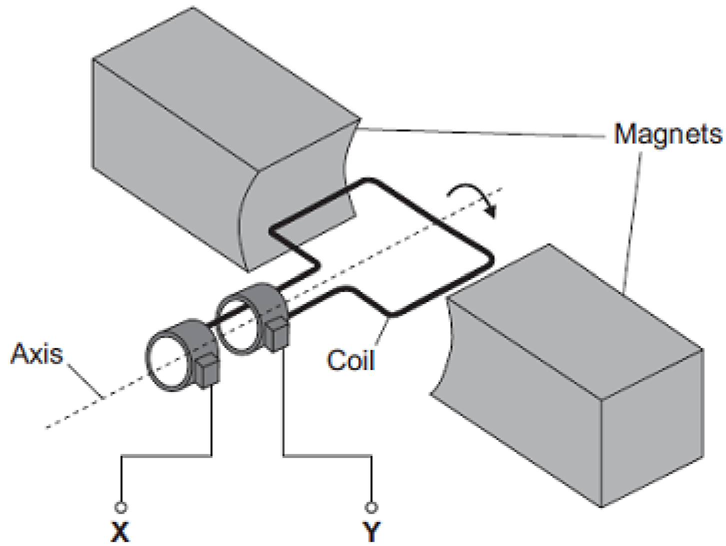
....

....

(2)
(Total 11 marks)

13 The diagram shows an a.c. generator.

The coil rotates about the axis shown and cuts through the magnetic field produced by the magnets.



(a) (i) A potential difference is induced between **X** and **Y**.

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

electric	**generator**	**motor**	**transformer**

This effect is called the .... effect.

(1)

(ii) What do the letters a.c. stand for?

....

(1)

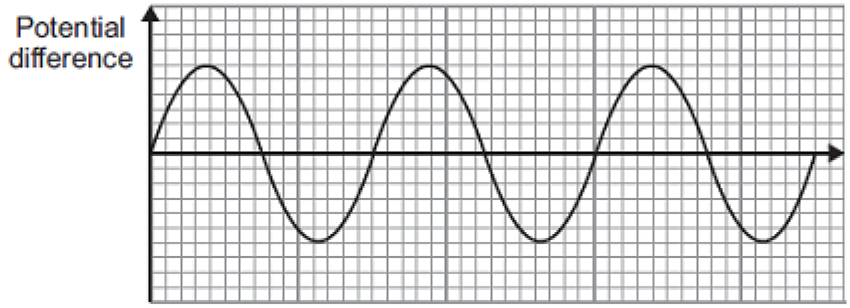
(iii) Name an instrument that could be used to measure the potential difference between **X** and **Y**.

....

(1)

(b) **Graph 1** shows the output from the a.c. generator.

Graph 1



(i) One of the axes on **Graph 1** has been labelled 'Potential difference'.

What should the other axis be labelled?

....

(1)

(ii) The direction of the magnetic field is reversed.

On **Graph 1**, draw the output from the a.c. generator if everything else remains the same.

(2)

(c) The number of turns of wire on the coil is increased. This increases the maximum induced potential difference.

State **two** other ways in which the maximum induced potential difference could be increased.

1 ....

....

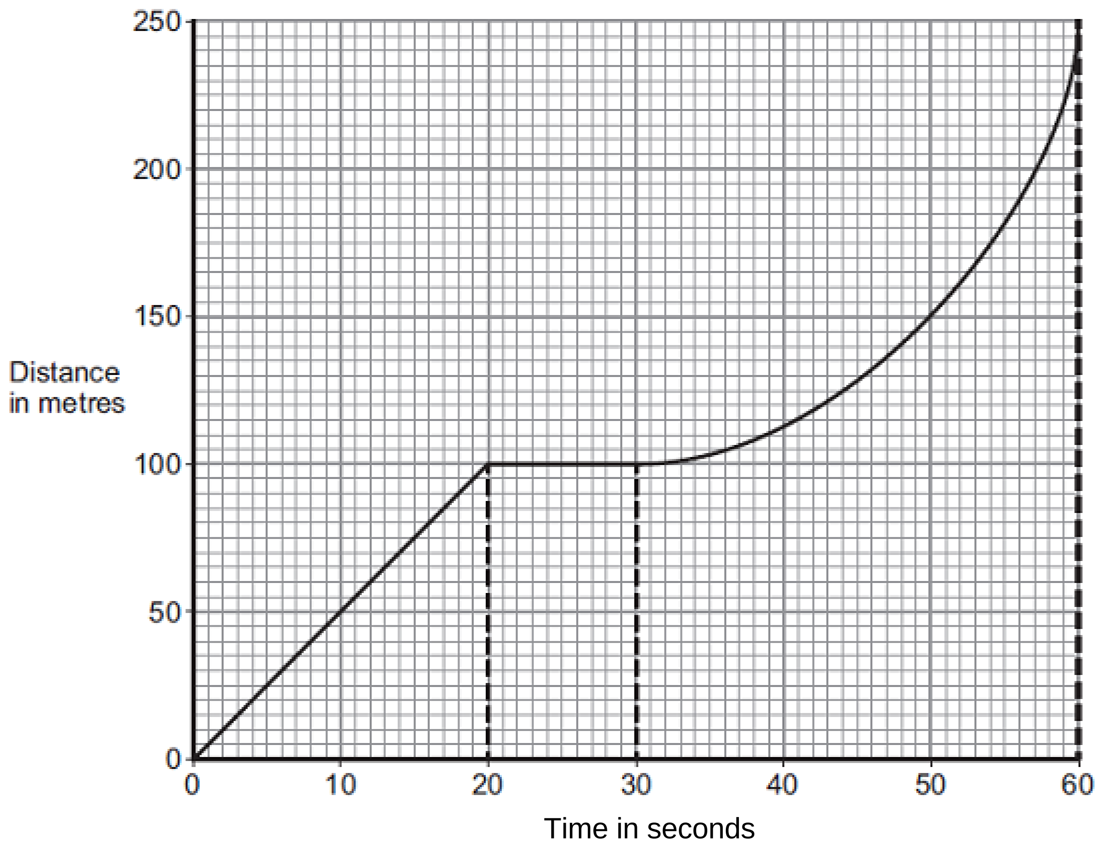
2 ....

....

(2)
(Total 8 marks)

14 A bus is taking some children to school.

(a) The bus has to stop a few times. The figure below shows the distance–time graph for part of the journey.



(i) How far has the bus travelled in the first 20 seconds?

Distance travelled = ... m

(1)

(ii) Describe the motion of the bus between 20 seconds and 30 seconds.

....

....

(1)

(iii) Describe the motion of the bus between 30 seconds and 60 seconds.

Tick (✓) **one** box.

	Tick (✓)
Accelerating	
Reversing	
Travelling at constant speed	

(1)

(iv) What is the speed of the bus at 45 seconds?

Show clearly on the figure above how you obtained your answer.

....

....

....

Speed = ... m / s

(3)

(b) Later in the journey, the bus is moving and has 500 000 J of kinetic energy.

The brakes are applied and the bus stops.

(i) How much work is needed to stop the bus?

....

Work = ... J

(1)

(ii) The bus stopped in a distance of 25 m.

Calculate the force that was needed to stop the bus.

....

....

Force = ... N

(2)

(iii) What happens to the kinetic energy of the bus as it is braking?

....

....

....

....

(2)
(Total 11 marks)

15 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.

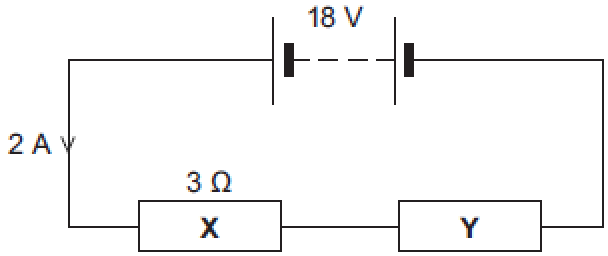
(2)

(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**.

....

....

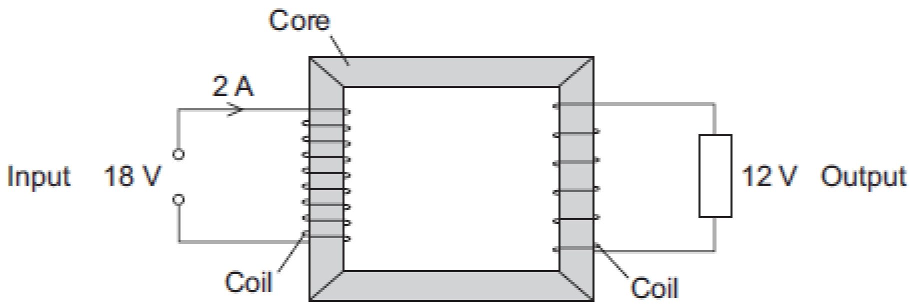
....

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**.

....

....

....

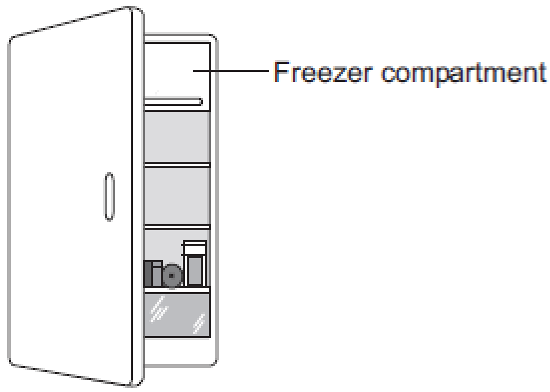
Output current = ... A

(2)

(Total 12 marks)

16 (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.

....

....

....

....

....

....

....

....

(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 ....

....

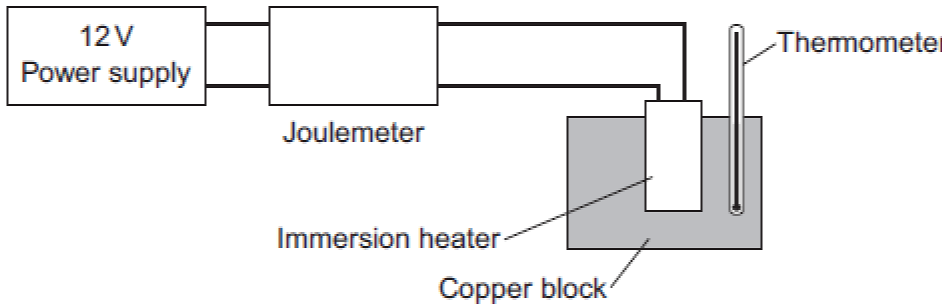
Disadvantage ....

....

(2)
(Total 8 marks)

17 A student used the apparatus in **Figure 1** to obtain the data needed to calculate the specific heat capacity of copper.

Figure 1



The initial temperature of the copper block was measured.

The power supply was switched on.

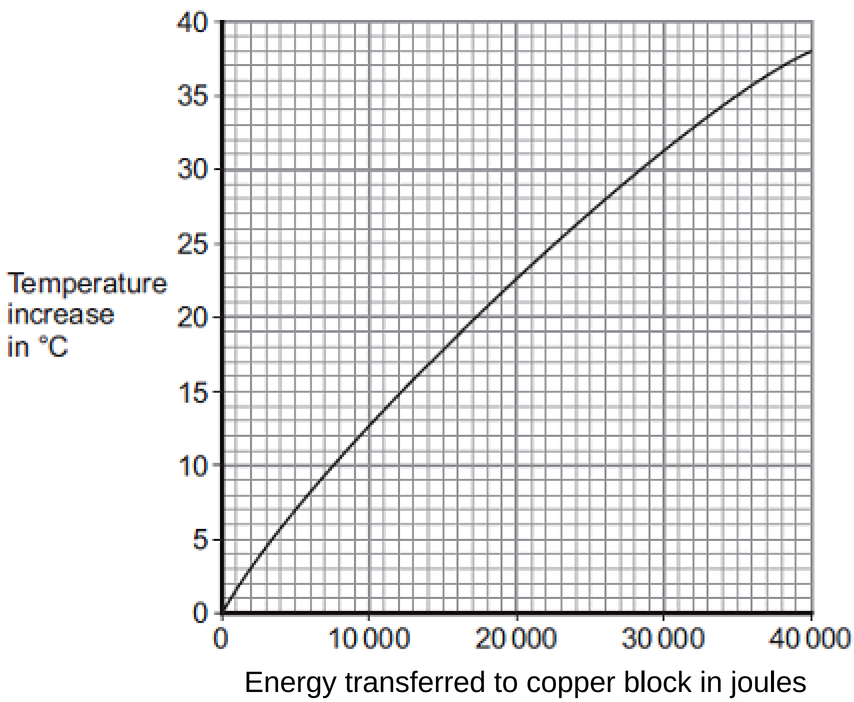
The energy transferred by the heater to the block was measured using the joulemeter.

The temperature of the block was recorded every minute.

The temperature increase was calculated.

Figure 2 shows the student's results.

Figure 2



(a) Energy is transferred through the copper block.

What is the name of the process by which the energy is transferred?

Tick (✓) **one** box.

Conduction ☐

Convection ☐

Radiation ☐

(1)

(b) Use **Figure 2** to determine how much energy was needed to increase the temperature of the copper block by 35 °C.

.... joules

(1)

(c) The copper block has a mass of 2 kg.

Use your answer to part (b) to calculate the value given by this experiment for the specific heat capacity of copper. Give the unit.

....

....

....

....

Specific heat capacity = ...

(3)

(d) This experiment does **not** give the correct value for the specific heat of copper.

Suggest **one** reason why.

....

....

(1)
(Total 6 marks)

18 **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.

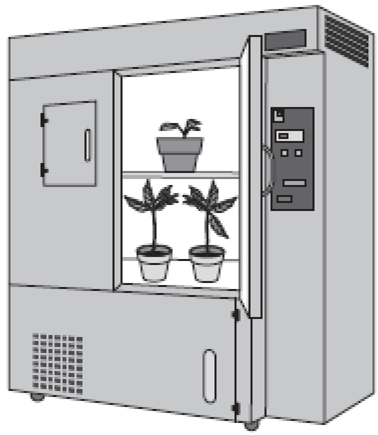
....

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.

....

....

....

....

....

....

(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)

19 A paintball gun is used to fire a small ball of paint, called a paintball, at a target.

The figure below shows someone just about to fire a paintball gun.

The paintball is inside the gun.

(a) What is the momentum of the paintball before the gun is fired?

....

Give a reason for your answer.

....

....

(2)

(b) The gun fires the paintball forwards at a velocity of 90 m / s.

The paintball has a mass of 0.0030 kg.

Calculate the momentum of the paintball just after the gun is fired.

....

....

....

Momentum = ... kg m / s

(2)

(c) The momentum of the gun and paintball is conserved.

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

equal to	**greater than**	**less than**

The total momentum of the gun and paintball just after the gun is fired

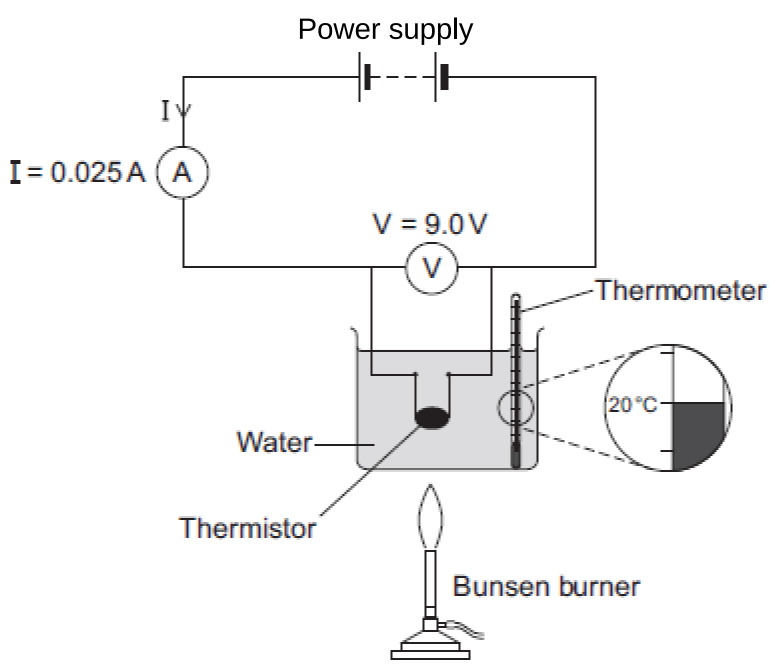
will be .... the total momentum of the gun and paintball

before the gun is fired.

(1)
(Total 5 marks)

20 (a) **Figure 1** shows the apparatus used to obtain the data needed to calculate the resistance of a thermistor at different temperatures.

Figure 1



(i) In the box below, draw the circuit symbol for a thermistor.

(1)

(ii) Use the data given in **Figure 1** to calculate the resistance of the thermistor at 20 °C.

....

....

....

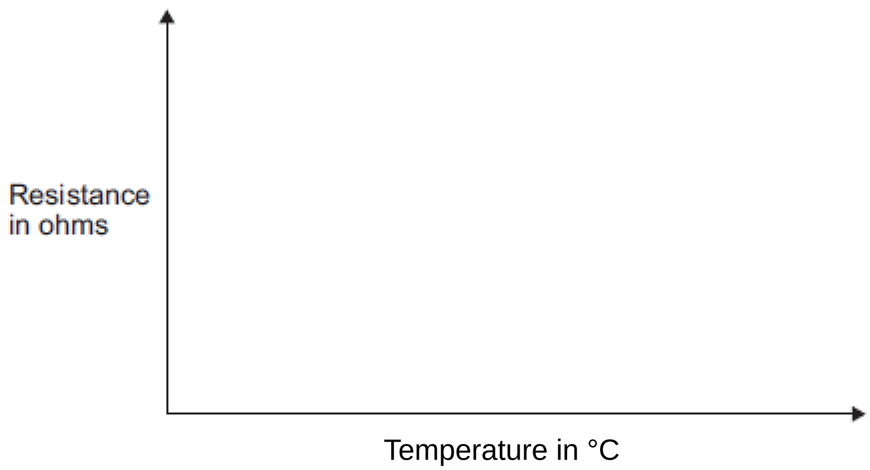
Resistance = ... ohms

(2)

(iii) **Figure 2** shows the axes for a sketch graph.

Complete **Figure 2** to show how the resistance of the thermistor will change as the temperature of the thermistor increases from 20 °C to 100 °C.

Figure 2



(1)

(iv) Which **one** of the following is most likely to include a thermistor?

Tick (✓) **one** box.

An automatic circuit to switch a plant watering system on and off. ☐

An automatic circuit to switch an outside light on when it gets dark. ☐

An automatic circuit to switch a heating system on and off. ☐

(1)

(b) The ammeter used in the circuit has a very low resistance.

Why is it important that ammeters have a very low resistance?

....

....

(1)

(c) The table below gives the temperature of boiling water using three different temperature scales.

Temperature	Scale
100	Celsius (°C)
212	Fahrenheit (°F)
80	Réaumur (°Re)

Scientists in different countries use the same temperature scale to measure temperature.

Suggest **one** advantage of doing this.

....

....

....

(1)

(d) A student plans to investigate how the resistance of a light-dependent resistor (LDR) changes with light intensity.

The student starts with the apparatus shown in **Figure 2** but makes three changes to the apparatus.

One of the changes the student makes is to replace the thermistor with an LDR.

Describe what other changes the student should make to the apparatus.

....

....

....

....

(2)
(Total 9 marks)

21 The figure below shows a skateboarder jumping forwards off his skateboard.

The skateboard is stationary at the moment the skateboarder jumps.

(a) The skateboard moves backwards as the skateboarder jumps forwards.

Explain, using the idea of momentum, why the skateboard moves backwards.

....

....

....

....

....

....

....

....

(3)

(b) The mass of the skateboard is 1.8 kg and the mass of the skateboarder is 42 kg.

Calculate the velocity at which the skateboard moves backwards if the skateboarder jumps forwards at a velocity of 0.3 m / s.

....

....

....

....

....

....

Velocity of skateboard = ... m / s

(3)
(Total 6 marks)

22 (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.

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

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'?

....

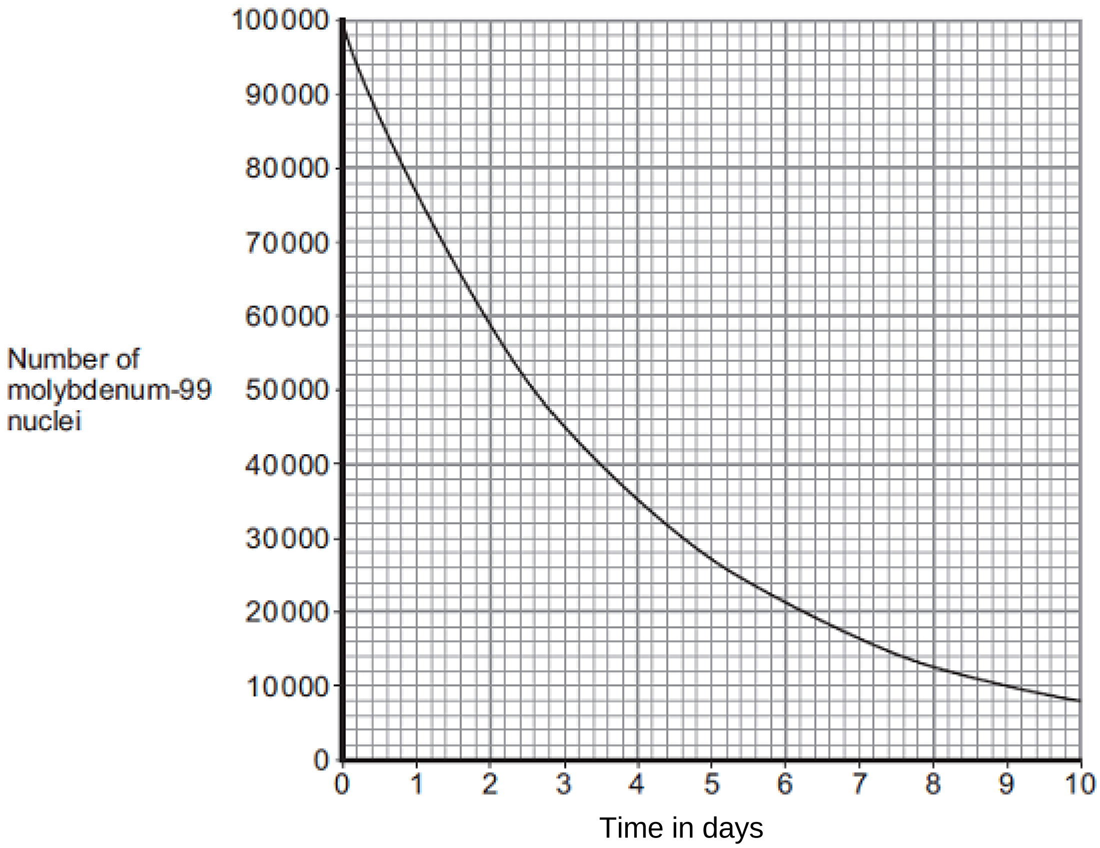
....

....

(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.

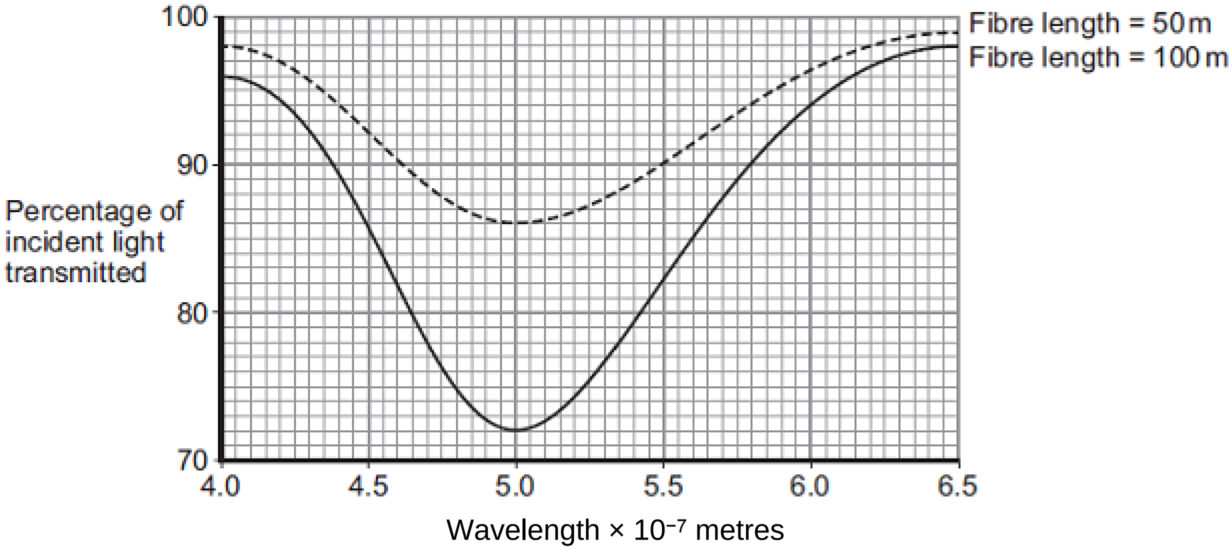
....

....

(1)
(Total 11 marks)

23 Different wavelengths of light can be used to transmit information along optical fibres.

The graph below shows how the percentage of incident light transmitted through a fibre varies with the wavelength of light and the length of the fibre.



Compare the percentages of incident light transmitted through the two different fibres over the range of wavelengths shown.

....

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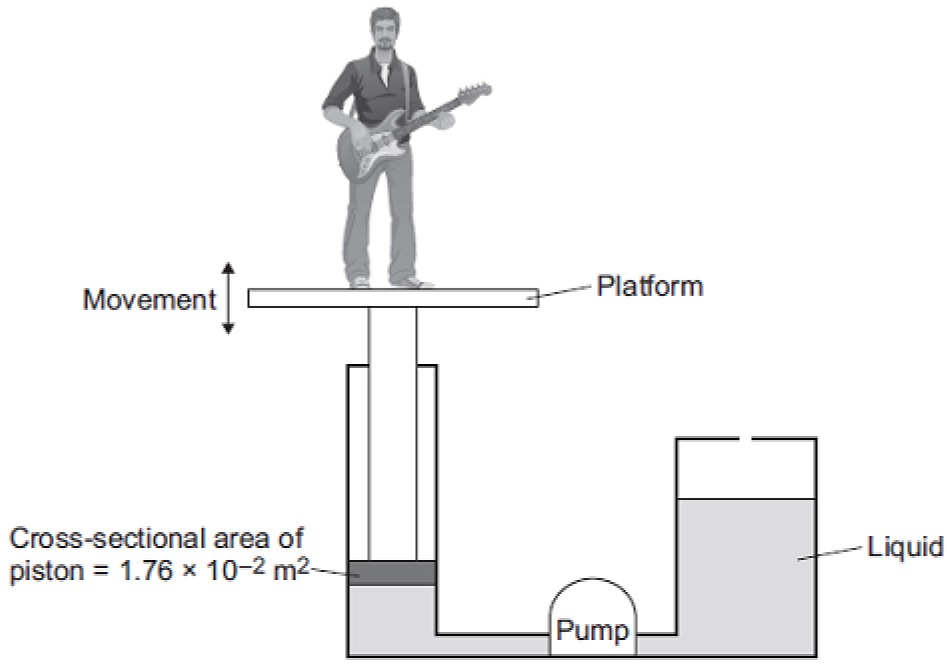
(Total 3 marks)

24 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.

....

....

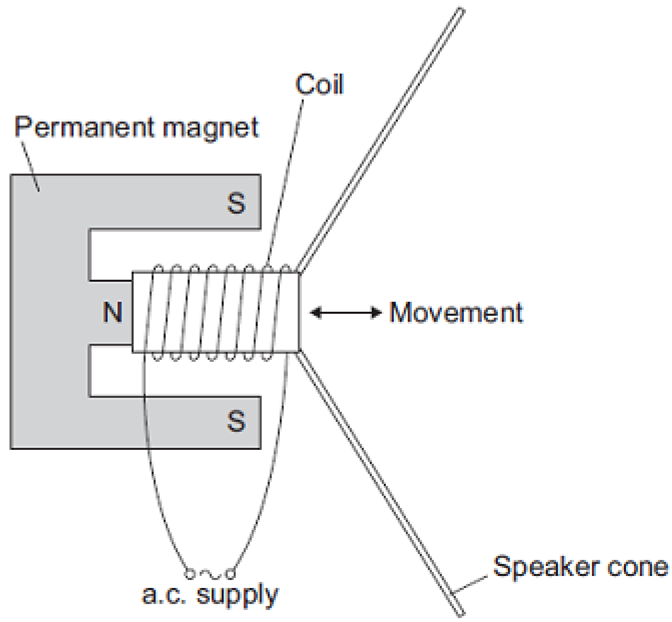
....

(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.

....

....

....

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....

....

(4)
(Total 8 marks)

25 Some students fill an empty plastic bottle with water.
The weight of the water in the bottle is 24 N and the cross-sectional area of the bottom of the bottle is 0.008 m^2.

(a) Calculate the pressure of the water on the bottom of the bottle and give the unit.

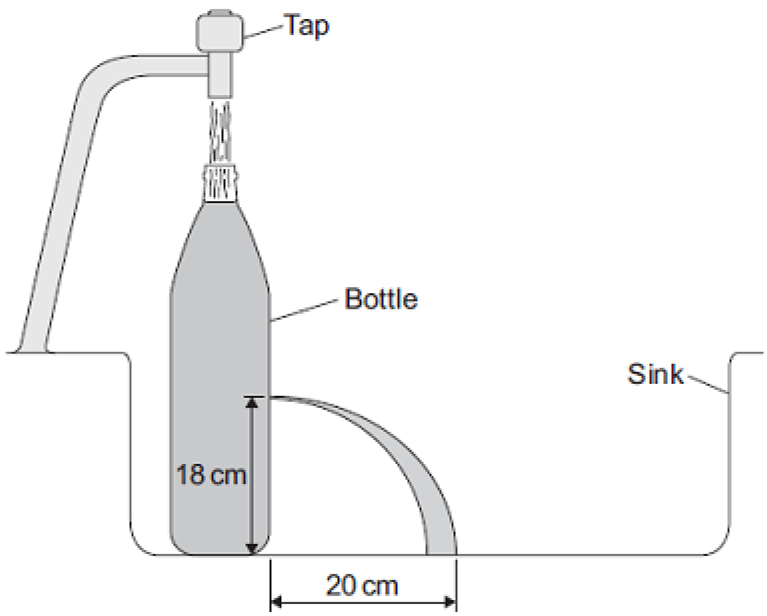
....

....

Pressure = ...

(3)

(b) The students made four holes in the bottle along a vertical line.
They put the bottle in a sink. They used water from a tap to keep the bottle filled to the top.



The students measured and recorded the vertical heights of the holes above the sink.
They also measured the horizontal distances the water landed away from the bottle.
A pair of measurements for one of the holes is shown in the diagram.

The complete data from the experiment is shown in the table.

Hole	**Vertical height in cm**	**Horizontal distance in cm**
J	24	15
K	18	20
L	12	30
M	6	40

(i) Which hole is shown in the diagram?

Draw a ring around the correct answer.

J **K** **L**

(1)

(ii) On the diagram, draw the path of the water coming out of hole **M**.

Use the information in the table to help you.

(2)

(c) Suggest **one** problem that might arise from trying to collect data from a fifth hole with a vertical height of 1 cm above the sink.

....

....

(1)
(Total 7 marks)

26 Forces have different effects.

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

slowing	**stretching**	**turning**

The moment of a force is the .... effect of the force.

(1)

(ii) What is meant by the centre of mass of an object?

....

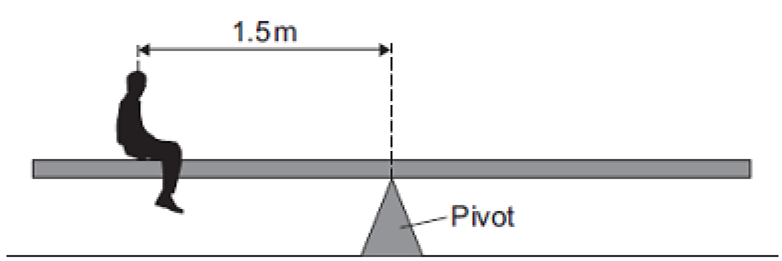
....

(1)

(b) Some children build a see-saw using a plank of wood and a pivot.
The centre of mass of the plank is above the pivot.

Figure 1 shows a boy sitting on the see-saw. His weight is 400 N.

Figure 1



Calculate the anticlockwise moment of the boy in Nm.

....

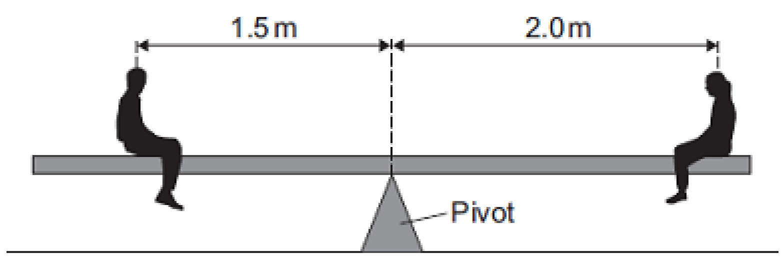
....

Anticlockwise moment = ... Nm

(2)

(c) **Figure 2** shows a girl sitting at the opposite end of the see-saw. Her weight is 300 N.

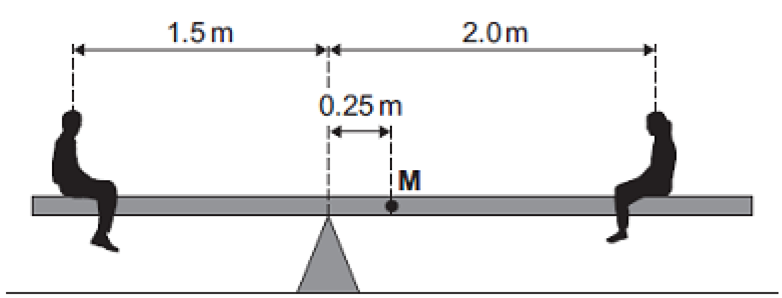
Figure 2



The see-saw is now balanced.

The children move the plank. Its centre of mass, **M**, is now 0.25 m from the pivot as shown in **Figure 3**.

Figure 3



The boy and girl sit on the see-saw as shown in **Figure 3**.

(i) Describe **and** explain the rotation of the see-saw.

....

....

....

....

....

....

....

(3)

(ii) The boy gets off the see-saw and a bigger boy gets on it in the same place. The girl stays in the position shown in **Figure 3**. The plank is balanced. The weight of the plank is 270 N.

Calculate the weight of the bigger boy.

....

....

....

....

....

....

Weight of the bigger boy = ... N

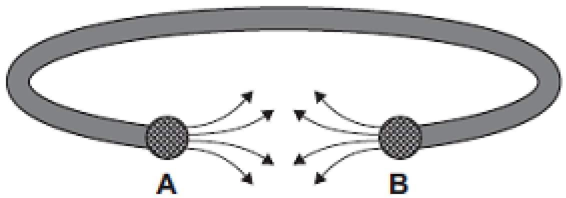
(3)
(Total 10 marks)

27 (a) Some people wear magnetic bracelets to relieve pain.

Figure 1 shows a magnetic bracelet.

There are magnetic poles at both **A** and **B**.
Part of the magnetic field pattern between **A** and **B** is shown.

Figure 1



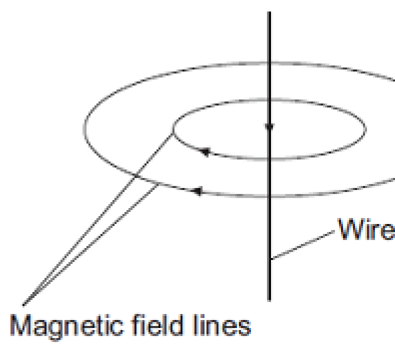
What is the pole at **A**? ....

What is the pole at **B**? ....

(1)

(b) **Figure 2** shows two of the lines of the magnetic field pattern of a current-carrying wire.

Figure 2



The direction of the current is reversed.

What happens to the direction of the lines in the magnetic field pattern?

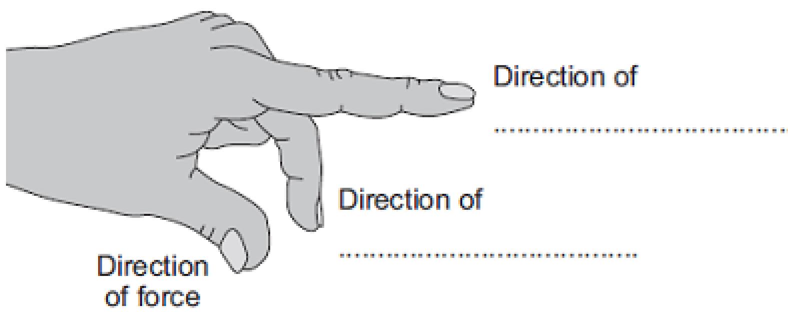
....

(1)

(c) Fleming's left-hand rule can be used to identify the direction of a force acting on a current-carrying wire in a magnetic field.

(i) Complete the labels in **Figure 3**.

Figure 3

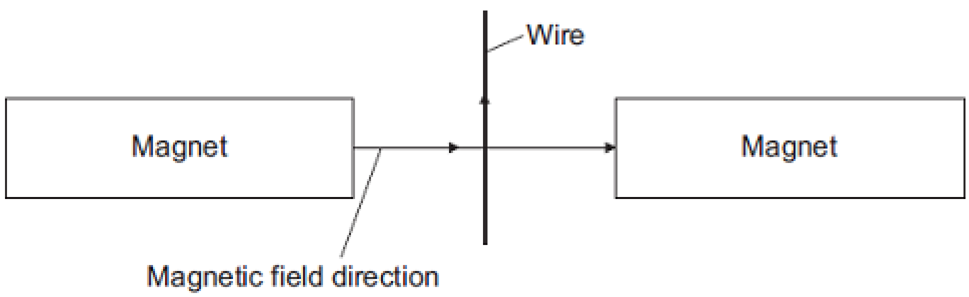


(2)

(ii) **Figure 4** shows:

- the direction of the magnetic field between a pair of magnets
- the direction of the current in a wire in the magnetic field.

Figure 4



In which direction does the force on the wire act?

....

(1)

(iii) Suggest **three** changes that would **decrease** the force acting on the wire.

1 ....

2 ....

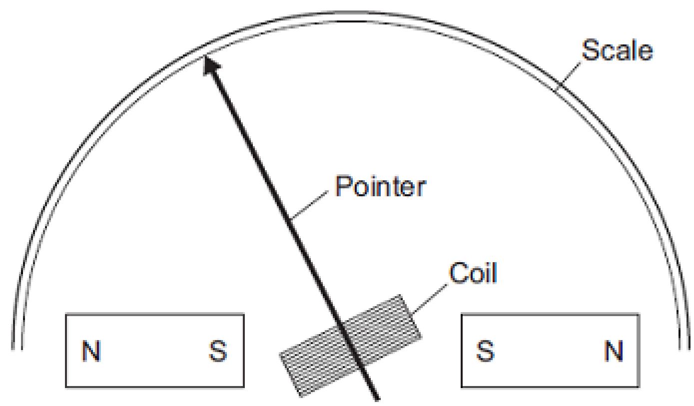
3 ....

(3)

(d) **Figure 5** shows part of a moving-coil ammeter as drawn by a student.

The ammeter consists of a coil placed in a uniform magnetic field.
When there is a current in the coil, the force acting on the coil causes the coil to rotate and the pointer moves across the scale.

Figure 5



(i) The equipment has **not** been set up correctly.

What change would make it work?

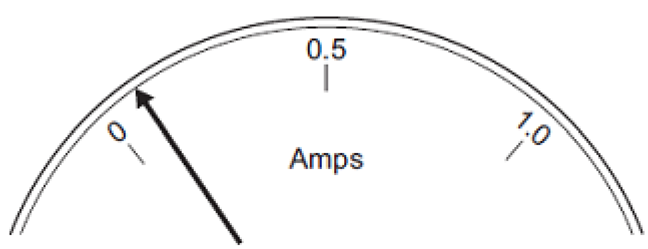
....

....

(1)

(ii) **Figure 6** shows the pointer in an ammeter when there is no current.

Figure 6



What type of error does the ammeter have?

....

(1)
(Total 10 marks)

28 Solar panels are often seen on the roofs of houses.

(a) Describe the action and purpose of a solar panel.

....

....

....

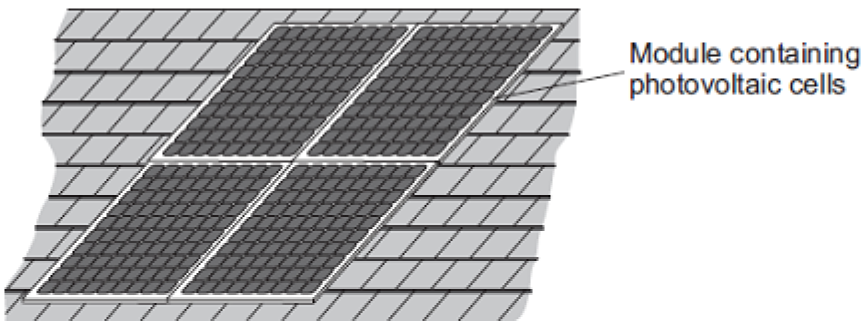
....

(2)

(b) Photovoltaic cells transfer light energy to electrical energy.

In the UK, some householders have fitted modules containing photovoltaic cells on the roofs of their houses.

Four modules are shown in the diagram.



The electricity company pays the householder for the energy transferred.

The maximum power available from the photovoltaic cells shown in the diagram is 1.4×10^3 W.

How long, in minutes, does it take to transfer 168 kJ of energy?

....

....

....

....

....

.... Time = ... minutes

(3)

(c) When the modules are fitted on a roof, the householder gets an extra electricity meter to measure the amount of energy transferred by the photovoltaic cells.

(i) The diagram shows two readings of this electricity meter taken three months apart. The readings are in kilowatt-hours (kWh).

21 November	0	0	0	4	4
21 February	0	0	1	9	4

Calculate the energy transferred by the photovoltaic cells during this time period.

....

Energy transferred = ... kWh

(1)

(ii) The electricity company pays 40p for each kWh of energy transferred.

Calculate the money the electricity company would pay the householder.

....

....

Money paid = ...

(2)

(iii) The cost of the four modules is £6000.

Calculate the payback time in years for the modules.

....

....

Payback time = ... years

(3)

(iv) State an assumption you have made in your calculation in part **(iii)**.

....

....

(1)

(d) In the northern hemisphere, the modules should always face south for the maximum transfer of energy.

State **one** other factor that would affect the amount of energy transferred during daylight hours.

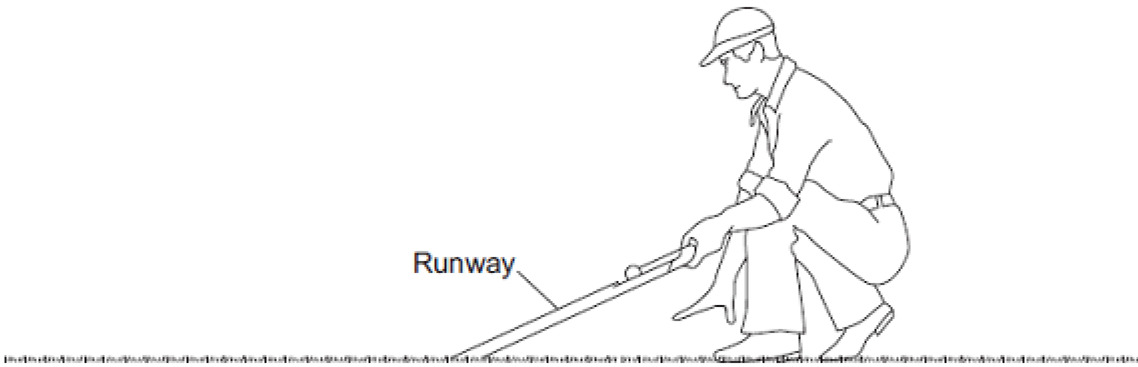
....

....

(1)
(Total 13 marks)

29 **Figure 1** shows a golfer using a runway for testing how far a golf ball travels on grass.
One end of the runway is placed on the grass surface.
The other end of the runway is lifted up and a golf ball is put at the top.
The golf ball goes down the runway and along the grass surface.

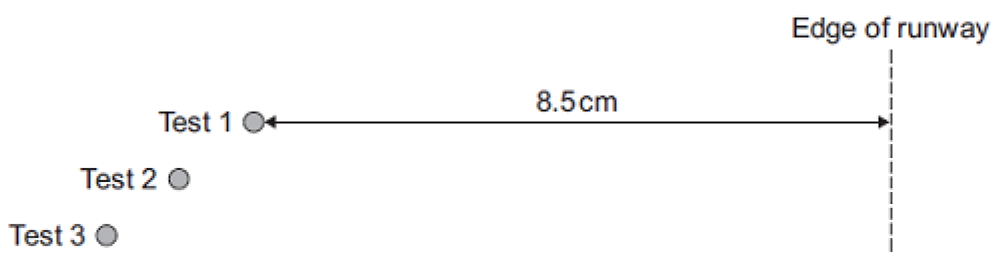
Figure 1



(a) A test was done three times with the same golf ball.

The results are shown in **Figure 2**.

Figure 2



(i) Make measurements on **Figure 2** to complete **Table 1**.

Table 1

Test	Distance measured in centimetres
1	8.5
2	
3	

(2)

(ii) Calculate the mean distance, in centimetres, between the ball and the edge of the runway in **Figure 2**.

....

Mean distance = ... cm

(1)

(iii) **Figure 2** is drawn to scale.
Scale: 1 cm = 20 cm on the grass.

Calculate the mean distance, in centimetres, the golf ball travels on the grass surface.

....

Mean distance on the grass surface = ... cm

(1)

(iv) The distance the ball travels along the grass surface is used to estimate the 'speed' of the grass surface.

The words used to describe the 'speed' of a grass surface are given in **Table 2**.

Table 2

'Speed' of grass surface	Mean distance the golf ball travels in centimetres
Fast	250
Medium fast	220
Medium	190
Medium Slow	160
Slow	130

Use **Table 2** and your answer in part **(iii)** to describe the 'speed' of the grass surface.

....

(1)

(b) The shorter the grass, the greater the distance the golf ball will travel.
A student uses the runway on the grass in her local park to measure the distance the golf ball travels.

(i) Suggest **two** variables the student should control.

....

....

....

(2)

(ii) She carried out the test five times.
Her measurements, in centimetres, are shown below.

75 **95** **84** **74** **79**

What can she conclude about the length of the grass in the park?

....

....

(1)

(c) Another student suggests that the 'speed' of a grass surface depends on factors other than grass length.

She wants to test the hypothesis that 'speed' depends on relative humidity.

Relative humidity is the percentage of water in the air compared to the maximum amount of water the air can hold. Relative humidity can have values between 1% and 100%.

The student obtains the data in **Table 3** from the Internet.

Table 3

Relative humidity expressed as a percentage	**Mean distance the golf ball travels in centimetres**
71	180
79	162
87	147

(i) Describe the pattern shown in **Table 3**.

....

....

(1)

(ii) The student writes the following hypothesis:
'The mean distance the golf ball travels is inversely proportional to relative humidity.'

Use calculations to test this hypothesis and state your conclusion.

....

....

....

....

....

....

(3)

(iii) The data in **Table 3** does **not** allow a conclusion to be made with confidence.

Give a reason why.

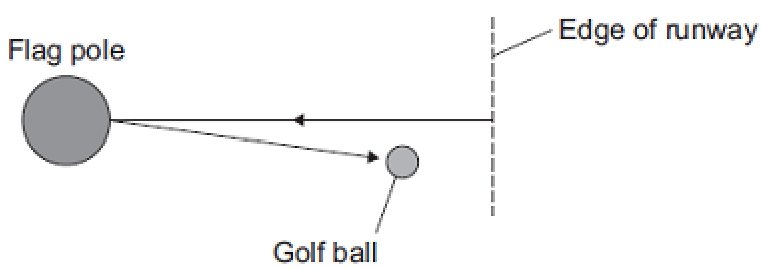
....

....

(1)

(d) In a test, a golf ball hits a flag pole on the golf course and travels back towards the edge of the runway as shown in **Figure 3**.

Figure 3



The distance the ball travels and the displacement of the ball are **not** the same.

What is the difference between distance and displacement?

....

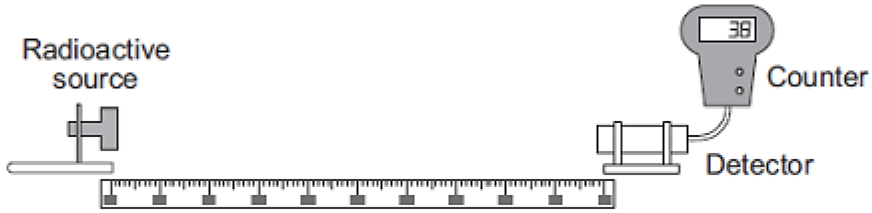
....

....

....

(2)
(Total 15 marks)

30 A teacher used the equipment shown in the diagram to measure the count rate at different distances from a radioactive source.



Metre rule

(a) Her results are shown in **Table 1**.

Table 1

Distance in metres	Count rate in counts per minute	Corrected count rate in counts per minute
0.4	143	125
0.6	74	56
0.8	49	31
1.0	38	20
1.2	32	14
1.4	28	10
1.6	18	0
1.8	18	0
2.0	18	0

The background count rate has been used to calculate the corrected count rate.

(i) What is the value of the background count rate?

Background count rate = ... counts per minute

(1)

(ii) What information does the corrected count rate give?

....

....

(1)

(iii) The radioactive source used in the demonstration emits only one type of radiation.

The radioactive source is **not** an alpha emitter.

How can you tell from the data in the table?

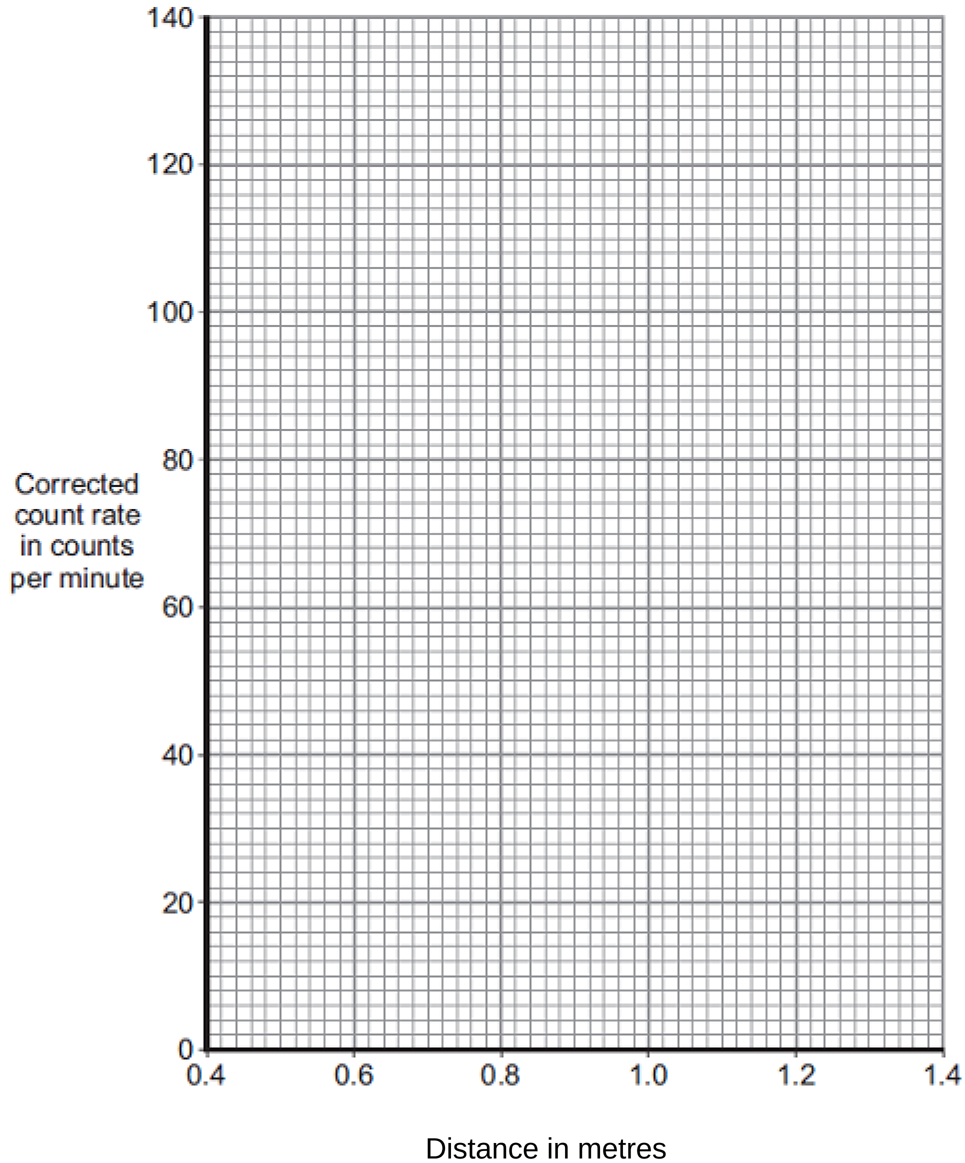
....

....

(1)

(iv) Plot a graph of corrected count rate against distance for distances between 0.4 m and 1.4 m.

Draw a line of best fit to complete the graph.



(3)

(v) The 'half-distance' is the distance a detector has to be moved away from a radioactive source for the corrected count rate to halve.

A student has the hypothesis:
A radioactive source has a constant 'half-distance'.

Table 1 has been repeated for your information.

Table 1

Distance in metres	**Count rate in counts per minute**	**Corrected count rate in counts per minute**
0.4	143	125
0.6	74	56
0.8	49	31
1.0	38	20
1.2	32	14
1.4	28	10
1.6	18	0
1.8	18	0
2.0	18	0

Use **Table 1** to determine if the hypothesis is correct for this radioactive source.

You should use calculations in your answer.

....

....

....

....

....

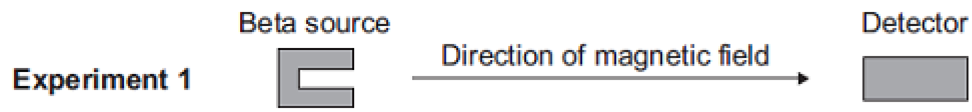
....

....

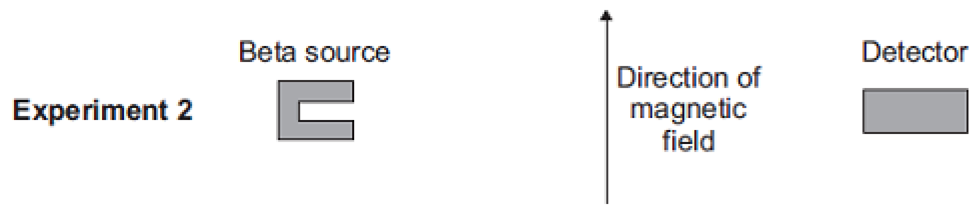
(3)

(b) A teacher places a beta source and a detector in a magnetic field.

The arrangement of the magnetic field is shown.



.......The teacher repeated the experiment with the magnetic field in a different direction.



A set of results is shown in **Table 2**.

Table 2

Distance between source and detector in metres	**Count rate in counts per minute without magnetic field**	**Count rate in counts per minute in Experiment 1**	**Count rate in counts per minute in Experiment 2**
0.8	48	48	32

(i) Describe **and** explain the effect of the magnetic field on the count rate detected by the detector.

....

....

....

....

....

....

(2)

(ii) The experiment is repeated with a different distance between the source and the detector.

Table 3 shows the repeated results.

Table 3

Distance between source and detector in metres	**Count rate in counts per minute without magnetic field**	**Count rate in counts per minute in Experiment 1**	**Count rate in counts per minute in Experiment 2**
1.8	19	18	20

Explain these results.

....

....

....

....

....

....

(2)
(Total 13 marks)

Mark schemes

1 (a) cannot predict <u>which</u> dice / atom will 'decay'

accept answers given in terms of 'roll a 6'

1

cannot predict <u>when</u> 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]

2 (a) (because the) potential of the live wire is 230 V

1

(and the) potential of the electrician is 0 V

1

(so there is a) large potential difference between live wire and electrician

1

charge / current passes through his body

allow voltage for potential difference

1

(b) diameter between 3.50 and 3.55 (mm)

*allow correct use of value of cross-sectional area of 9.5 to 9.9 (mm^2) with no final answer given for **1** mark*

2

(c) 18000 = I × 300

1

$I = 18000 / 300 \quad = 60$

1

$13\,800 = (60^2) \times R$

1

$R = 13\,800 / 60^2$

1

3.83 (Ω)

1

*allow 3.83(Ω) with no working shown for **5** marks*

answer may also be correctly calculated using P = IV and V = IR if 230 V is used.

[11]

3 (a) It is easily magnetised.

1

(b) p.d. across the secondary coil is smaller (than p.d. across the primary coil)

1

(c) ratio $\frac{V_p}{V_s} = \frac{6}{12}$

accept any other correct ratio taken from the graph

1

$\frac{6}{12} = \frac{50}{N_p}$

use of the correct turns ratio and substitution or correct transformation and substitution

1

$N_p = 100$

*allow 100 with no working shown for **3** marks*

1

[5]

4 (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]

5 (a) surface area

or

duration of experiment

accept shape of beaker

size of beaker is insufficient

1

(b) any **two** from:

- takes readings automatically

  *ignore easier **or** takes readings for you*

- takes readings more frequently
- reduces / no instrument reading error

  ignore human error

- higher resolution

  allow better resolution

- don't need to remove probe to take reading
- more accurate

2

(c) (i) 0.07 (°C/s)

*allow **1** mark for obtaining a temperature drop of 7 (°C)*

*allow **1** mark for an answer between 0.068 and 0.069 (°C/s)*

2

(ii) rate of temperature change is greater at the start

accept rate of evaporation is greater at the start

or

rate of temperature change decreases

allow rate of evaporation decreases

allow temperature decreases faster at the start

1

(iii) A

reason only scores if A is chosen

lower temperature decrease (over 200 seconds)

accept lower gradient

1

(iv) no effect (as rate of evaporation is unchanged)

allow larger temperature change (per second as mass of liquid is lower)

1

(d) particles with more energy

accept particles with higher speeds

1

leave the (surface of the) liquid

1

(which) reduces the average (kinetic) energy (of the remaining particles)

allow reference to the total energy of the liquid reducing

1

[11]

6 (a) elastic potential

1

(b) (i) line is straight

accept line does not curve

1

(ii) 400

*allow **1** mark for correct substitution of any pair of numbers correctly taken from the graph e.g.160 = k × 0.40*

2

newtons per metre **or** N/m

if symbols are used they must be correct

1

(iii) 300

*allow **1** mark for correctly obtaining force on 1 spring = 100N*

2

(c) 52

*allow **2** marks for calculating change in gpe for 1 chin-up as 260 (J) or for 12 chin-ups as 3120 (J)*

*an answer 4.3 gains **2** marks*

*allow **1** mark for correct substitution into gpe equation ie gpe = 65 × 10 × 0.4 (× 12)*

or

correct use of power equation with an incorrect value for energy transferred

3

[10]

7 (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

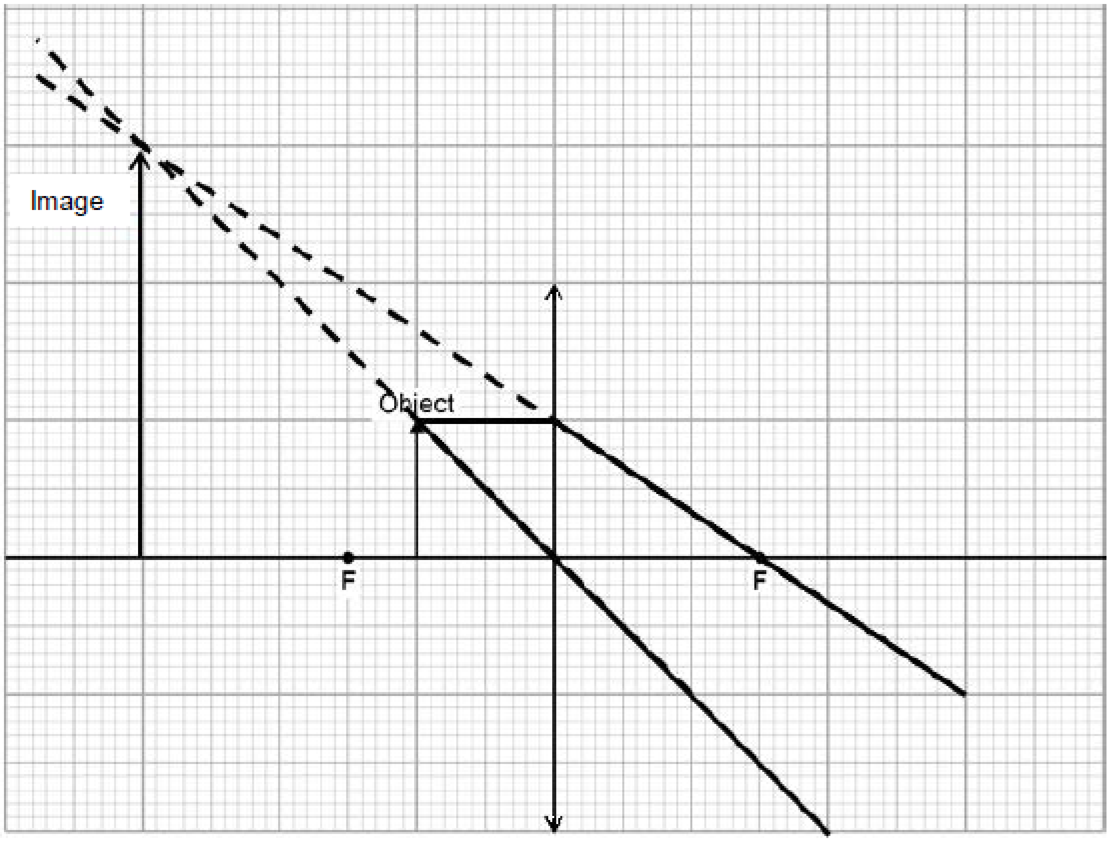
accept a ray drawn as if from the principal focus to the left of the lens, emerging parallel to the principal axis

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]

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

- wood falls off ropes
- child falls off
- wood hits child standing at side.

accept any reasonable suggestion

2

(b) (i) 7.77

1

0.78

*0.777 or 0.77 gain **1** mark*

*their mean value / 10 gains **1** mark*

2

(ii) use longer lengths (so longer times)

or

do both with the same lengths (so comparison can be made)

timing more than 10 cycles is insufficient

1

(iii) **1** value of k from **table 4**

k values 3.969…

4.056…

4.05

$k = T^2 / l$

allow full credit for an equivalent correct method

eg. allow inverse of

$k = l / T^2 = 0.25$

1

1 value of k from **table 5**

k values 4

4.03…

4.046

allow if average time for 10 cycles used

1

conclusion that matches student's results

1

(c) 720 N

*180 = F × 0.25 gains **2** marks*

*work done = maximum kinetic energy gains **1** mark*

3

[12]

9 (a) (i) (atoms with the) same number of protons

allow same atomic number

***or** same proton number*

1

(atoms with) different number of neutrons

allow different mass number

1

(ii) 82

1

(iii) 124

1

(b) (i)

$$^{58}_{\boxed{26}}\text{Fe} + ^{\boxed{208}}_{\boxed{82}}\text{Pb}$$

***1** mark for each correct box*

3

(ii) (a) neutron

1

(iii) 4.0×10^{-4} (s)

or

0.0004

$3.00 \times 10^{8} \times 0.1 = 12\ 000 / t$

*gains **1** mark*

2

(iv) particles need to travel a large distance

1

equipment would have to be very long

1

with circular paths long distances can be accommodated in a smaller space

1

(c) (i) the average time for the number of nuclei to halve

1

the time for count rate to halve

1

(ii) $^{261}_{106}\text{Sg} + {}^{4}_{2}\alpha$

__1__ mark if top boxes total = 265

__and__ bottom boxes total = 108

__1__ mark for 4 and 2 for alpha

2

(d) (i) 3 plotted points

± ½ small square

1

best line through points

1

(ii) 190−205 (pm)

or correct from student's line

1

[20]

10 (a) high frequency sound (waves)

1

with a frequency above limit of human hearing
or with a frequency greater than 20 000 Hz

above limit of human hearing

__or__ greater than 20 000 Hz gains maximum __1__ mark

1

(b) $5(.0) \times 10^{-4}$ (m)
or
0.0005 (m)

$1500 = 3 \times 10^{6}\ \lambda$ gains __2__ marks

answer of 500 gains __2__ marks

$1500 = 3.0\ \lambda$ gains __1__ mark

3

(c) it will run off the surface of the skin
or
water is not a gel

accept water would evaporate

1

(d) The width of the coupling agent

1

The width of the water

1

(e) (i) A

1

(ii) E

1

(f) (i) **K**

reflection from skin

maximum 5 marks if no mention of reflection

1

very little reflection, so small peak

1

L

reflection from front of kidney

1

large amount of reflection, so large peak

1

M

reflection from back of kidney

1

smaller peak due to absorption of ultrasound in kidney

or

smaller peak as further from source

or

front of the kidney already reflected a lot, so there is now less to be reflected

reflection from a boundary gains 1 mark if no other mark given

1

(ii) 0.06 (m)

or

$6(.0) \times 10^{-2}$

*0.12 (m) gains **2** marks*

*distance = $1500 \times 8 \times 10^{-5} \times 0.5$ gains **2** marks*

*distance = $1500 \times 8 \times 10^{-5}$ gains **1** mark*

3

[19]

11 (a) (i) infrared (radiation)

accept IR (radiation)

1

(ii) (heated) water turns to steam

ignore reference to fossil fuels

*do **not** accept water evaporates to steam*

1

steam turns a turbine

1

turbine turns a generator

accept turbine connected to a generator

1

(b) (i) (so the molten salts) can store large amounts of energy

accept there is a small temperature change for a large energy transfer

accept heat for energy

1

(ii) 16 (hours)

*an answer that rounds to 16 gains **2** marks eg 15.71*

*allow **1** mark for a correct substitution ie 2 200 000 = 140 000 × t*

3

(iii) the number of daylight hours varies

less sunlight is insufficient

1

the (mean) power (received from the Sun per square metre) varies

*accept an answer in terms of maximum possible electrical output only possible during Summer for **1** mark*

1

(c) (i) non-renewable power stations have higher Capacity Factors than renewable power stations

1

fuel (for non-renewable power stations) is always available

reference to non-renewable power stations operating all the time is insufficient

non-renewable energy sources are reliable is insufficient

1

(most) renewable energy sources are unpredictable / unreliable

accept (most) renewable energy sources depend on the weather

1

(ii) the (proportion of) time that solar storage power stations can generate electricity is greater (than for other renewable energy sources)

1

[14]

12 (a) (i) decreases (to zero)

1

resultant force acts in opposite direction to motion

accept air resistance and weight for resultant force

accept resultant force acts downwards

*do **not** accept air resistance increases*

1

(ii) velocity includes direction

or

velocity is a vector (quantity)

1

(b) (i) 3.6

allow 1 mark for correct substitution i.e.

$\frac{1}{2} \times 0.05 \times 12^2$ provided no subsequent step

2

(ii) 3.6 **or** their (i)

1

(iii) 7.2

or

their (ii) ÷ 0.5 correctly calculated

*allow **1** mark for correct substitution i.e.*

3.6 or their (ii) = $0.05 \times 10 \times h$

2

(iv) **B**

1

(c) range increases up to 45° **1**

range decreases from 45°

the range is a maximum at 45° gains both marks

for any two angles that add up

to 90° the range is the same gains both marks

*the range increases then decreases gains **1** mark*

1

[11]

13 (a) (i) generator **1**

(ii) alternating current **1**

(iii) voltmeter / CRO / oscilloscope / cathode ray oscilloscope **1**

(b) (i) time **1**

(ii) peaks and troughs in opposite directions **1**

amplitude remains constant

dependent on first marking point

1

(c) any **two** from:

- increase speed of coil
- strengthen magnetic field
- increase area of coil

*do **not** accept larger*

2

[8]

14 (a) (i) 100 (m) **1**

(ii) stationary **1**

(iii) accelerating **1**

(iv) tangent drawn at t = 45 s **1**

attempt to determine slope

1

speed in the range 3.2 – 4.2 (m / s)

dependent on 1st marking point

1

(b) (i) 500 000 (J)

ignore negative sign

1

(ii) 20 000 (N)

ignore negative sign

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

500 000 = F × 25

***or** their part (b)(i) = F × 25*

provided no subsequent step

2

(iii) *(kinetic) energy* transferred by heating

1

to the brakes

ignore references to sound energy

*if no other marks scored allow k.e. decreases for **1** mark*

1

[11]

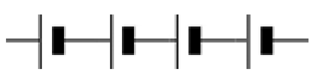
15 (a) *attempt to draw four cells in series*

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*

*$18 \times 2 = 12 \times I_s$ scores **1** mark*

2

[12]

16 (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]

17 (a) conduction

1

(b) 35 000

1

(c) 500

*their (b) = 2 x c x 35 correctly calculated scores **2** marks*

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

ie 35000 = 2 x c x 35

or

their (b) = 2 x c x 35

2

J / kg°C

1

(d) energy lost to surroundings

or

energy needed to warm heater

accept there is no insulation (on the copper block)

*do **not** accept answers in terms of human error or poor results or defective equipment*

1

[6]

18 (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]

19 (a) Zero / 0

Accept none

Nothing is insufficent

1

velocity / speed = 0

accept it is not moving

paintball has not been fired is insufficient

1

(b) 0.27

*allow **1** mark for correct substitution, ie p = 0.003(0) × 90 provided no subsequent step*

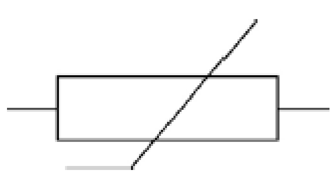
2

(c) equal to

1

[5]

20 (a) (i)



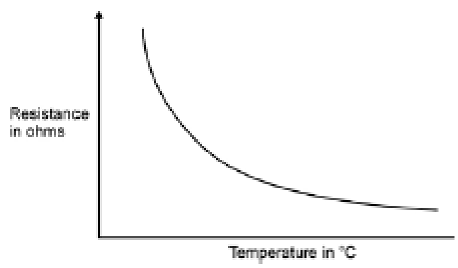
1

(ii) 360

*allow **1** mark for correct substitution, ie 9 = 0.025 × R*

2

(iii) sketch graph of correct shape, ie



1

(iv) An automatic circuit to switch a heating system on and off.

1

(b) so ammeter reduces / affects current as little as possible

accept so does not reduce / change the current (it is measuring)

accurate reading is insufficient

not change the resistance is insufficient

1

(c) gives a common understanding

accept is easier to share results

accept can compare results

do not need to be converted is insufficient

prevent errors is insufficient

1

(d) replace Bunsen (and water) with a lamp

accept any way of changing light level

1

replace thermometer with light sensor

accept any way of measuring a change in light level

datalogger alone is insufficient

1

[9]

21 (a) momentum before (jumping) = momentum after (jumping)

accept momentum (of the skateboard and skateboarder) is conserved

1

before (jumping) momentum of skateboard and skateboarder is zero

accept before (jumping) momentum of skateboard is zero

accept before (jumping) total momentum is zero

1

after (jumping) skateboarder has momentum (forwards) so skateboard must have (equal) momentum (backwards)

answers only in terms of equal and opposite forces are insufficient

1

(b) 7

*accept –7 for **3** marks*

*allow **2** marks for momentum of skateboarder equals 12.6*

or

$0 = 42 \times 0.3 + (1.8 \times -v)$

or

*allow **1** mark for stating use of conservation of momentum*

3

[6]

22 (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]

23 (for both fibres) increasing the wavelength of light decreases and then increases the percentage / amount of light transmitted

*accept for **1** mark:*

(for both fibres) increasing the wavelength (of light) to 5 (x 10^{-7} metres), decreases the (percentage) transmission

1

(for both fibres) the minimum transmission happens at 5 (x 10^{-7} metres)

or

maximum transmission occurs at 6.5 (x 10^{-7} metres)

*accept for a further **1** mark:*

(for both fibres) increasing the wavelength of the light from 5 (x 10^{-7} metres) increases the amount of light transmitted

increasing wavelength (of light), decreases the percentage transmitted is insufficient on its own

1

the shorter fibre transmits a greater percentage of light (at the same wavelength)

*accept for **1** mark:*
Any statement that correctly processes data to compare the fibres

1

[3]

24 (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]

25 (a) 3000

*correct substitution of 24 / 0.008 gains **1** mark provided no subsequent steps are shown*

2

N / m^2 or Pa

1

(b) (i) K

accept ringed K in table

1

(ii) water exiting bottle one-third of vertical height of K

allow less than half vertical height of spout shown, judged by eye

1

water landing twice the distance of the spout shown in the diagram

accept at least one and a half times further out than spout shown, judged by eye

do ***not*** *accept water hitting the side of the sink*

ignore trajectory

1

(c) water will land on the (vertical) side of the sink

accept sink ***not*** *long / wide / big enough*

or

water will dribble down very close to the bottle

or

that part of the bottle is curved

do ***not*** *accept goes out of the sink*

1

[7]

26 (a) (i) turning

accept turning ringed in the box

1

(ii) point at which mass (or weight) may be thought to be concentrated

accept the point from which the weight appears to act

allow focused for concentrated

do ***not*** *accept most / some of the mass*

do ***not*** *accept region / area for point*

1

(b) 600 (Nm)

400 × 1.5 gains ***1*** *mark provided no subsequent steps shown*

2

(c) (i) plank rotates clockwise

accept girl moves downwards

do ***not*** *accept rotates to the right*

1

(total) CM > (total) ACM

accept moment is larger on the girl's side

1

weight of see-saw provides CM

answer must be in terms of moment

maximum of ***2*** *marks if there is no reference to the weight of the see-saw*

1

(ii) W = 445 (N)

*W × 1.5 = (270 × 0.25) + (300 × 2.0) gains **2** marks*

*allow for **1** mark:*

total CM = total ACM either stated or implied

or

(270 × 0.25) + (300 × 2.0)

if no other marks given

3

[10]

27 (a) north (pole)

accept N

north (pole)

both needed for mark

1

(b) reverses

accept changes direction

1

(c) (i) first finger:
(direction of) (magnetic) field

1

second finger:
(direction of) (conventional) current

1

(ii) into (plane of the) paper

1

(iii) less current in wire

accept less current / voltage / more resistance / thinner wire

1

weaker field

allow weaker magnets / magnets further apart

*do **not** accept smaller magnets*

1

rotation of magnets (so) field is no longer perpendicular to wire

1

(d) (i) reverse one of the magnets

*do **not** accept there are no numbers on the scale*

1

(ii) systematic or zero error

accept all current values will be too big

accept it does not return to zero
accept it does not start at zero

1

[10]

28 (a) water heated by radiation (from the Sun)

accept IR / energy for radiation

1

water used to heat buildings / provide hot water

*allow for **1** mark heat from the Sun heats water if no other marks given*

*references to photovoltaic cells / electricity scores **0** marks*

1

(b) 2 (minutes)

$$1.4 \times 10^3 = \frac{168 \times 10^3}{t}$$

*gains **1** mark*

*calculation of time of 120 (seconds) scores **2** marks*

3

(c) (i) 150 (kWh)

1

(ii) £60(.00) or 6000 (p)

*an answer of £6000 gains **1** mark*

*allow **1** mark for 150 × 0.4(0) 150 × 40*

*allow ecf from **(c)(i)***

2

(iii) 25 (years)

an answer of 6000 / 240
or
*6000 / their **(c)(ii)** × 4*
*gains **2** marks*

an answer of 6000 / 60
or
*6000 / their **(c)(ii)** gains **1** mark, ignore any other multiplier of **(c)(ii)***

3

(iv) any **one** from:

- will get £240 per year

  *accept value consistent with calculated value in **(c)(iii)***
- amount of light is constant throughout the year
- price per unit stays the same
- condition of cells does not deteriorate

1

(d) any **one** from:

- angle of tilt of cells
- cloud cover
- season / shade by trees
- amount of dirt

1

[13]

29 (a) (i) 9.5

accept ±1 mm

1

10.5

1

(ii) 9.5

*ecf from **(a)(i)***

1

(iii) 190

*20 × **(a)(ii)** ecf*

1

(iv) medium

*ecf from **(a)(iii)***

1

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

- position of ball before release
- same angle **or** height of runway
- same ball
- same strip of grass

2

(ii) long
or
longer than in part **(a)**
or
uneven

*do **not** allow reference to speed*

1

(c) (i) as humidity increases mean distance decreases

accept speed for distance

1

(ii) 71 × 180 = 12780
79 × 162 = 12798
87 × 147 = 12789

*all three calculations correct with a valid conclusion gains **3** marks*

or
find k from R = k / d

*all three calculations correct gains **2** marks*

or
87 / 71 × 147 = 180.1 ~ 180
87 / 79 × 147 = 161.9 ~ 162

*two calculations correct with a valid conclusion gains **2** marks*

conclusion based on calculation

*one correct calculation of k gains **1** mark*

3

(iii) only three readings **or** small range for humidity

accept not enough readings

accept data from Internet could be unreliable

ignore reference to repeats

1

(d) distance is a scalar **or** has no direction **or** has magnitude only

allow measurements from diagram of distance and displacement

1

displacement is a vector **or** has direction

1

[15]

30 (a) (i) 18

1

(ii) the count rate for the source

1

(iii) the alpha radiation would not cover such a distance

1

(iv) plots correct to within ½ small square

*allow **1** mark for 4 correct points plotted*

2

correct curve through points as judged by eye

1

(v) two attempts at finding ‘half-distance’ using the table

20 to 10 cpm d = 0.4 m
125 to 56 cpm d = 0.2 m
31 to 14 cpm d = 0.4 m

*allow **1** mark for one attempted comparison*

2

obeyed or not obeyed

dependent on previous two marks

1

(b) (i) there is no effect on the count rate in experiment 1 because the field is parallel **or** beta particles are not deflected **or** there is no force

1

count rate is reduced in experiment 2 because field is perpendicular **or** beta particles are deflected **or** there is a force

1

(ii) only background radiation (as beta do not travel as far)

1

slightly different values show the random nature of radioactive decay

1

[13]

Examiner reports

4 (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.

5 (a) A fifth of students scored 1 mark for this question. Given that the apparatus was shown in the question, the expected answers were 'surface area' or 'duration of experiment'. Therefore, the material / size of beaker was insufficient, as was air temperature since all experiments would likely have taken place at the same time and this is unlikely to vary much over 200 s. Shape of beaker was creditworthy as this would have affected the surface area of the liquid.

(b) Just under a fifth of students scored 2 marks, while two thirds of students scored 1 mark only. 'More accurate' and the implication of a 'better resolution' were common creditworthy points. It's disappointing to see students still using terms like 'precise' as precision refers to the spread of repeat readings, not the smallest interval being capable of being read by an instrument. Some students were confused and gave an advantage of each of the different pieces of equipment. The datalogger having a larger range was a point that was insufficient, as this could not be known from this investigation. The datalogger being 'faster' or 'quicker' was insufficient for 'more frequent readings' which was very rarely seen, but it is surely one of the most obvious advantages of the datalogger.

(c) (i) A quarter of students scored 2 marks. Some students used the plotted point to calculate the change as 0.068 or 0.069 which scored 1 mark. 1 mark was also given if a student calculated the temperature change as 7°C.

(ii) Less than a fifth of students scored a mark on this question. The most common insufficient responses were 'temperature of all decreased over 200 s'. Comments on differences between A, B and C were also insufficient. Statements that implied rate of change were creditworthy, e.g. 'quicker temperature decrease'. Students who referred to specific times, usually 'in the first 100 s the temperature decreased quickly, whereas after that the temperature decreased slowly', were allowed. 'As time goes on the rate of heat loss decreases' was insufficient as the SHC of each material is not known, so this conclusion isn't necessarily true.

(iii) Just over half the students scored the mark for this question, which was given for the reason, not for choosing 'A'. 'Less heat lost' was insufficient as the SHC of each liquid was not given, so this conclusion could not be made. 'Lower temperature decrease' or 'higher temperature at the end' or 'lowest gradient' were commonly seen answers. Insufficient answers included rewords of the question e.g. fewer particles leaving so lower evaporation, the belief being that a description of the physical process was required.

(iv) Just under a third of students scored a mark on this question. As all other factors are unchanged, changing the volume should have no effect on the temperature decrease per second, so the student's results should be unaffected. However, if a student thought that having a lower mass might mean that the cooling effect would be more noticeable due to the reduced thermal mass of the system, a 'larger temperature change' (per second), or 'a quicker temperature change' was allowed.

(d) Just over half of students scored 0 in this question. Less than a tenth of students scored all 3 marks. Lots of students described aspects of convection, which scored zero, whereas others didn't score any marks due to lack of precision in their language, for example, referring to the energy of the liquid decreasing, rather than the mean energy of the particles, failing to state that the particles left the liquid. Most students said that the 'particles evaporated' which was insufficient. A large number of students stated that 'the liquid was heated', which will have stopped them from scoring all 3 marks.

6 (a) Over half of the students got this correct although some students gave two types of energy rather than one type comprising two words.

(b) (i) Only just over a third of the students scored this mark. The most common incorrect answers were references to the graph being directly proportional rather than describing the graph line itself as straight or having a constant gradient. Many students said 'the line is constant'.

(ii) A quarter of the students scored all three marks with a further half of all students gaining 2 marks. Students could identify correct points from the graph but weaker students struggled with rearranging the formula to change the subject to k. Some students attempted to take values from the graph but didn't read the graph correctly and wrote values down such as 0.5 instead of 0.05. A significant number of students incorrectly used the equation Work = F x d. Incorrect units were mostly Nm or reversed m/N, or not capitalised n/m, with a variety of other incorrect options eg N, W, J, or nothing. A few students correctly gave the answer as 4 N/cm.

(iii) A third of the students scored both marks and a further third scored one mark. Some students correctly extrapolated 100N from the graph but then did not take into account the fact that there were 3 springs so did not multiply by 3 and therefore only scored 1 mark.

(c) Two thirds of the students scored some marks on this question, although fewer than a fifth scored full marks. Most students were able to calculate the energy required for one chin up, but did not take into account that they were being asked about 12 chin-ups. Some students were able to gain a compensation mark by clearly showing that they were dividing an incorrect energy by time to work out the power.

7

(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.

8

(a) Only a tiny number of students failed to point out a reasonable hazard of the obviously dangerous playground ride and nine-tenths gained both marks.

(b) (i) Half of all students gained all 3 marks on this question, correctly calculating the mean time, dividing by ten and rounding off both correctly to two decimal places. Some lost the first mark by rounding down instead of up but still gained the next two marks.

(ii) Only a third of students suggested that the models should be tested with the same lengths for easy comparison. Vague answers about using more lengths or repeating more times were not credited.

(iii) Half of the students gained at least two marks. The question asked students to compare the relationship between the square of the time and the length for the two sets of data and there were many ways that they could do this, but many students failed to attempt to use the square. Some who came up with a valid method then came to a wrong conclusion, for example calculating a k-value of 4.06 from table 4 and a k-value of 4.05 from table 5 and then firmly conclude that the numbers were so different that they were not similar. A better understanding of proportionality and uncertainty would have helped students in this question.

(c) The great majority of students gained all three marks here. Some gained one mark for identifying the work done as being equal to the kinetic energy, but those who failed to gain the marks did so because they either rearranged or substituted into the equation incorrectly.

9

(a) (i) Two thirds of students scored both marks. Those failing to score often confused which particle had the same number and which had different numbers or included incorrect references to electrons but more commonly referred to ‘elements’ rather than ‘an element’ or ‘atoms’. Few students scored the marks by referring to atomic number and mass number.

(ii) Nine tenths of students gained the mark on this question for identifying the atomic number.

(iii) Similarly, nine tenths of students gained the mark on this question for correctly calculating the number of neutrons.

(b) (i) More than half of students gained all three marks here. Poor arithmetic was as much to blame as poor understanding for those who made mistakes.

(ii) Three-quarters of students correctly identified the neutron. Incorrect answers included electron, proton, hydrogen, uranium and gamma.

(iii) Half of students gained both marks, but nearly as many scored zero. The most common mistake was to not recognise the speed of the iron nuclei as one-tenth the speed of light resulting in their answer being incorrect by a factor of ten. Omitting the 0.1 gave a value of 0.00004 but often seen was some other power of 10 error - possibly due to calculator misuse. Occasionally students rearranged incorrectly and got a value of 2500. The use of standard form was not as common as hoped; approximately half the correct answers were not in standard form and many partially correct answers were expressed as a fraction.

(iv) Three fifths of students scored zero marks on this question. Very few realised that a linear accelerator would need to be very long, while a circular accelerator could be built in a smaller space. Some students described acceleration in a circle and centripetal forces. Many students clearly did not understand what the question was asking.

(c) (i) Nearly all students gained at least one mark and three-quarters gained both. Some students failed to tick two boxes.

(ii) Two thirds of students gained both marks. Most students realised that the combined mass numbers and proton number should total 265 / 108. There were often unusual mass and atomic numbers written for the alpha particle; 0 & -1 were often seen, but also numbers containing figures to the right of a decimal point and numbers greater than 4.

(d) (i) Two thirds of students scored both marks for correct plotting and a suitable line of best fit. Only a small number of students did not draw a straight line. Some straight lines were drawn to far from the data and so did not score a mark. Mis-plotting could lead the student to draw a curve and these were accepted if they were drawn well.

(ii) Nine tenths of students gained the mark for correctly extrapolating the line and estimating a suitable number.

10

(a) Two -fifths of students gained both marks. Some students omitted to include ‘frequency’ in their answer, and would simply talk about ‘sound above the limit of human hearing’ or ‘sound over 20 000Hz’. Those scoring no marks would talk about ‘sound outside the human hearing range’ or ‘sound that humans cannot hear’. Some students gave answers that explained what ultrasound is used for and referred to electromagnetic waves.

(b) Half of the students gained two marks and a quarter gained all three. Those who were awarded two marks had usually made a mistake in either not translating megahertz to hertz or had done so incorrectly. Expressing numbers in standard form was a problem for many and also what the letter M meant in MHz.

(c) Two thirds of students gained the mark here for a reasonable suggestion, with answers varying between ‘running off’, ‘too runny’, ‘not viscous like gel’ and ‘evaporating’.

(d) This question was well answered with nine tenths of students gaining both marks. Some students did not tick two boxes.

(e) (i) Nine tenths of students gained the mark here.

(ii) Almost all students gained this mark.

(f) (i) This question required students to identify the reflections of ultrasound from three boundaries and explain the intensity of each. Two fifths of the students gained no marks at all. Some students simply repeated the information given in the stem of the question. Others had not related the trace to the diagram and described bones and kidney stones which were not in the diagram. Many wrote about transmission through the boundaries but never mentioned reflection.
In K: students often gave the boundary as gel or body tissue − not skin − and sometimes the kidney; the second mark for a small amount of reflection was rarely seen
In L: there was a lack of precision in terms of identifying the reflection from the *front* of kidney, however the large amount reflected often scored.
In M: there was a lack of precision about the rear of kidney and lack of understanding of why this gave a smaller reflection.
Quite a few students scored one mark for describing a reflection from a boundary.
Three marks were often scored by the first marking point for each of K, L and M.

(ii) Three quarters of students gained at least two marks. Apart from the occasional conversion of metres into kilometres, the majority of students correctly worked out the total distance travelled by the waves whilst in the kidneys and gained two marks. Few remembered to halve this distance, because they forgot about the reflection of the waves at the back wall of the kidney. Using speed = distance x time was a common error, as was misuse of the powers of ten.

11

(a) (i) Almost half of students scored a mark by identifying infra-red radiation. Common incorrect answers were ultra-violet, visible light or the Sun.

(ii) Many good answers were seen, with about a quarter of students scoring all 3 marks. A number of students thought that water evaporates to form steam which is incorrect and therefore negated the first marking point. A minority of students thought that water turned the turbine which negated the first and second marking points. Some students thought the turbine generated electricity negating the third marking point.

(b) (i) Almost a third of students understood that a high specific heat capacity meant lots of energy could be stored. Most incorrect answers referred to the salts melting (they were already molten) or changing state, which was insufficient.

(ii) The majority of students gained 2 or 3 marks for this question. The most common mistake was to incorrectly round their answer to 15 or to ignore the instruction about significant figures and give an answer of '15.7' or a similar un-rounded figure.

(iii) Many students failed to realise that the table for this part question held the information needed to answer it. Many students thought that the weather or other associated problems were responsible, when in fact summer is the only time when the power station can operate at maximum capacity because of the highest power per m^2 and the longest number of daylight hours. Some students answered with the expected response that the power varies and so do the number of daylight hours, but these were few.

(c) (i) Most students scored the first marking point, comparing the Capacity Factor for renewable with non-renewable sources. Many scored the third marking point for the unreliability of non-renewable sources.

Few students scored the 2nd marking point for stating that non-renewable fuels were always available. Many students just stated that non-renewable sources were reliable which was insufficient.

(ii) Very few students scored this mark. The idea that for the Capacity Factor to be higher the solar storage power station was generating electricity for more time was needed. It was insufficient to say that the Sun is reliable or it is in a hot desert or that it stores energy.

12 (a) (i) Nearly two thirds of the students scoring zero. Some students had the idea of the weight and air resistance combined being greater than the upward force, but then failed to mention the direction of the forces so missed out on the second mark. Very few students used the term 'resultant force' but when it was used it was more often used to explain an increasing speed, suggesting that the students couldn't believe the rocket was getting slower as it went up. Unfortunately, many students stated that air resistance would increase and hence would start to push down on the rocket and reduce its velocity.

(ii) Nearly three quarters of the students scored this mark, most giving a clear explanation of the directional difference between speed and velocity.

(b) (i) Just over three quarters of the students scored both marks, a great improvement on similar calculations in previous years.

(ii) Many answers seemed to be spontaneous, incorrect and obscure numbers. Many of the students clearly did not understand that the command word 'state' in an exam question means that no calculation was required. Many students wrote 36 for this answer, omitting the decimal place, and then correctly used 36 in the final part of the question, getting an answer of 72 m instead of 7.2 m.

(iii) This was poorly done with half of the students scoring zero. A small number of students made a fresh start with this part question and scored both marks for correctly calculating 7.2 m, despite having gained no marks for the first two parts of the question.

(iv) Surprisingly, only half of the students scored this mark.

(c) About one third of the students scored both marks. Many students who stated a pattern wrote that "the greater the angle the greater the range" but did not comment on what happened after 45 degrees and so scored zero. Those who did not state a pattern just picked out a couple of angles and commented on the range for those angles specific angles i.e. 'big' or 'small'. A significant number of students wrote about the relationship between height and range or angle and height, instead of angle and range.

14 (a) (i) Almost all students answered this question correctly.

(ii) Almost all students answered this question correctly.

(iii) Almost all students answered this question correctly.

(iv) Just over a fifth of students drew a tangent and correctly calculated its gradient. Nearly two-thirds scored no marks, with the most common incorrect answer being to find the average speed by dividing total distance travelled by time.

(b) (i) The vast majoriy of students answered this questiion correctly.

(ii) Almost all students scored full marks for this question.

(iii) Whilst the majority of students correctly identified the transfer of energy taking place, only about a fifth stated the effect that this would have on heating up the brakes. The most common response was to indicate that the energy was transferred 'to the surroundings'.

15 (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.

16 (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.

17 (a) A very small amount of students did not identify conduction as the process by which energy is transferred through copper.

(b) The majority of students answered correctly, of those who did not score the mark, the most common error was misreading the number on the x-axis (for a temperature increase of 35°C) as 30,500 instead of 35,000.

(c) Around half of students scored two of the three marks available. This was usually for performing the calculation correctly, but failing to give the correct unit.

(d) A very low proportion of students did not attempt this question, with less than a fifth scoring the mark. The most common incorrect answers referred to faulty apparatus, incorrect measurements or values not as stated in the question, e.g. the block was not 2kg.

18 (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.

19 (a) Many students did not appreciate that the question simply wanted an answer of zero and the simple reason that the paintball was not moving. Many students tried to explain how the gun worked or give an answer in terms of forces.

(b) The correct numerical value was given by the majority of the students. Those students not scoring both marks generally made the error of multiplying or dividing their correct answer by a factor of 10.

(c) Only a small proportion of the students scored this mark. Most students thought that the momentum would be ‘greater than’, presumably these students did not know the law of conservation of momentum or did not appreciate that the question referred to both the gun and paintball.

20 (a) (i) Fewer than two fifths of the students drew the correct thermistor symbol. Some of the students drew a symbol for an incorrect component, often a variable resistor, LED or LDR. Drawings of bead thermistors were quite common, as were a box or circle with just the letter T in it.

(ii) The majority of the students substituted the data and calculated the correct answer. There were very few calculation errors, but a number of the students did not rearrange the equation correctly. The most common mistake was to use the temperature value, 20°C, for either current or potential difference.

(iii) This question was poorly answered with only a small proportion of students scoring the mark. The majority of the students drew an upwards sloping straight line.

(iv) The majority of the students were able to answer this question correctly.

(b) Only a quarter of the students answered this question correctly. There were some high quality explanations of why the ammeter in series should have low resistance so as not to affect the current it is measuring. Many of the students scored zero with answers such as ‘it lets the current flow easily’, ‘it lets more current go through’ and ‘it stops it overheating’.

(c) This question was well answered by just over half of the students. Some students failed to score the mark because they merely threw in a word from the ‘How Science Works’ lexicon, for example ‘it makes it more accurate / reliable / valid / fair’. A few misunderstood the question and explained why scientists in different countries use different temperature scales or stated that it made it easier to convert the units.

(d) Nearly half of the students scored one mark, usually for recognising that a light source was needed to replace the Bunsen burner. A smaller number of the students went on to gain the second mark for realising that the thermometer was redundant and a light meter was required. Some did not know the name of the scientific apparatus but gave an acceptable description of ‘a device that measures the amount of light’. Many of the students missed marks because they gave answers like ‘use light not heat’ but did not refer to the specific apparatus. Others stated what needed removing but not what should replace it, or vice versa. There were a few totally wrong ideas e.g. ‘use a better thermometer’, ‘increase / decrease the battery voltage’ and ‘add / remove change the ammeter / voltmeter’. It was clear that many students did not make good use of the example given in the stem of the question.

21 (a) A large proportion of the students scored zero on this question, many because of their failure to use the idea of momentum. The majority of these answers included reference to forces, commonly beginning ‘every action has an equal and opposite reaction’ etc. Some of the students picked up marks for stating that momentum is conserved or words to that effect and a smaller number picked up a mark for realising that the initial momentum was zero. Some students related the situation to an explosion but still struggled to score more than one mark. However, those who understood the situation were able to give clear answers gaining full marks.

(b) Over half of the students scored zero on this calculation. Many added the masses together before attempting to calculate any momentum, and there was a general lack of clear understanding. Very few of the students scored a mark for stating that momentum was conserved but some compensation marks were scored for finding the final momentum of the skateboarder.

22 (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.

23 Many students failed to process the information supplied in the graph, and often just stated values. Less than one student in twenty gained all 3 marks.

24 (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.

25 (a) About two-thirds of the students scored full marks for the calculation of pressure when given values for force and cross-sectional area. The remainder lost a mark for giving an incorrect unit for pressure.

(b) (i) Nearly all students were able to match the dimensions given on a diagram with those in a table of results.

(ii) Nearly all students were able to draw the trajectory of water from a bottle giving both the vertical and horizontal distances of the trajectory.

(c) About half of the students were able to suggest a problem that might arise from trying to collect data from a hole close to the bottom of the bottle.

26 (a) (i) Nearly all students knew that the moment of a force is the turning effect of the force.

(ii) Less than half of the students were able to state what is meant by centre of mass of an object. Many referred to a region within the object rather than a point.

(b) Almost all students were able to calculate a moment of a force.

(c) (i) Very few students scored the three marks for describing and explaining the movement of a previously-balanced plank whose pivot had been moved away from the centre of mass of the plank. The idea that the weight of the plank now provided a moment was not understood.

(ii) This high-demand calculation was successfully performed by about a quarter of the students.

27 (a) Just over half of the students knew that a magnetic field of repulsion between two poles with lines of force moving outward from the poles was that between two north poles.

(b) Nearly all students knew that reversing the current through a wire also reversed the direction of the field lines associated with it.

(c) (i) Three-quarters of students knew which directions the first two fingers represent in Fleming's left-hand rule.

(ii) Students were given a diagram of a wire carrying a current in a magnetic field. Using Fleming's left-hand rule the wire would move into the paper. Many students were able to use the rule successfully, but their answers were ambiguous, such as 'downwards' and 'away from you'. Less than a fifth of students scored the mark.

(iii) Over three quarters of the students knew that decreasing the current and the strength of the magnetic field would decrease the force acting on the wire. Only a tenth of the students knew that rotating the magnets so that the field was no longer perpendicular to the wire would also have the same effect.

(d) (i) Most students observed that two south poles facing each other would not give a uniform magnetic field and suggested that one of the magnets should be rotated.

(ii) Less than three quarters of students knew that an ammeter pointing to a value above zero when no current was in it, had a systematic or zero error.

28 (a) Only a tenth of students correctly described the action of a solar panel. The remainder described a photovoltaic cell which is not in the specification.

(b) The remainder of the question concerned photovoltaic cells which were introduced here.

The calculation to find the time to transfer a certain amount of energy, given a certain value of power available gained full marks from a quarter of the students. The calculation involved the interpretation of data given in standard form, the conversion of kJ to J and the final answer given in minutes. Another quarter of the students only dropped one mark for leaving the answer in seconds.

(c) (i) Students were required to take the difference between two meter readings in this part

(ii) multiply the answer by 40p in this part

(iii) work out a payback time for some photovoltaic cells in this part.

The two readings were three months apart and many students had problems relating this time to the correct fraction of a whole year. Although nine-tenths of students correctly completed the first two steps far less scored the marks in this part.

(iv) Almost two-thirds of students correctly stated the assumption behind the calculation of payback time.

(d) Most students knew that specific weather conditions such as cloud cover would affect the energy transferred during daylight hours.

29 (a) (i) Nearly all students correctly measured two lengths with a ruler, found the mean of this and one other value, multiplied by a scale factor and interpreted the answer correctly from a table.

(ii) Nearly all students correctly measured two lengths with a ruler, found the mean of this and one other value, multiplied by a scale factor and interpreted the answer correctly from a table.

(iii) Nearly all students correctly measured two lengths with a ruler, found the mean of this and one other value, multiplied by a scale factor and interpreted the answer correctly from a table.

(iv) Nearly all students correctly measured two lengths with a ruler, found the mean of this and one other value, multiplied by a scale factor and interpreted the answer correctly from a table.

(b) (i) Only half of the students could name two variables that had to be controlled when using the runway elsewhere. The most common non-scoring answer was 'keep the length of the runway the same'.

(ii) Eight-tenths of students correctly interpreted the results of a test using the runway in a park showing the grass to be long and uneven.

(c) (i) Nearly all students correctly described the pattern in a table of relative humidity and distance travelled by the ball.

(ii) Less than a quarter of students were able to show that the data in the table showed inverse proportionality.

(iii) Three quarters of students were able to give a reason why the data used in part **(ii)** might not allow a conclusion to be made. The answer 'it is from the Internet so might be unreliable' was accepted, but the more astute answer was that the data was taken from a very small range of values of relative humidity.

(d) The question 'What is the difference between distance and displacement?' alone might have produced better answers than was seen here. Because it was set in the context of the question, students mostly forgot to state that one is scalar and one is a vector. More than half of the students scored zero.

30 (a) (i) Nearly all students were able to determine the value of background count from a table listing values of count rate and corrected count rate.

(ii) Only half of the students stated that corrected count is the count rate due to the source.

(iii) Well over half of the students knew that the data given in the table was not related to an alpha source. Some stated that it could not be an alpha source because the readings of count rate were not high enough. Others backed up their correct answers with realistic ranges for alpha particles.

(iv) The standard of graph plotting was very high and more than two thirds of students scored full marks for accurate plotting and drawing a curve through the points.

(v) Students were introduced to the idea of half-distance and were asked to state whether a constant value of half distance could be seen from the data given in the table. Some very good answers were seen with over a third of students scoring all three marks.

There was conflicting evidence in the table and students were expected to make a judgement on the data that they used. Many students were stuck with the idea of half-life and used this term throughout.

A common error was 'if the count rate did not halve when the distance doubled, then the hypothesis was invalid'. Here the doubling of distance is irrelevant; it is the change in distance that matters. Many students used the change in distance of 0.4 m resulting in the count rate halving from 20 to 10 as the basis of a successful answer.

Many students gave up immediately because 56 was not half of 125.

(b) (i) This question scored very poorly, with very few students able to describe the effect of a magnetic field on a beam of beta particles. Many thought that the magnetic field blocked the particles or that the particles went off in the direction of the field or were reflected backwards by the field. There were many loose statements such as 'when the magnetic field travels towards the detector'.

(ii) Hardly any students realised that the readings were due to background count. They often gave long explanations as to why the three readings were different including that in experiment 1 the magnetic field repels the particles back towards the source.