New Document 1

Name: ______________________

Class: ______________________

Date: ______________________

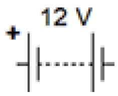
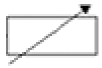
Time: **398 minutes**

Marks: **393 marks**

Comments:

1 A student wants to investigate how the current through a filament lamp affects its resistance.

(a) Use the circuit symbols in the boxes to draw a circuit diagram that she could use.

12 V battery	**variable resistor**	**filament lamp**	**voltmeter**	**ammeter**
				

(2)

(b) Describe how the student could use her circuit to investigate how the current through a filament lamp affects its resistance.

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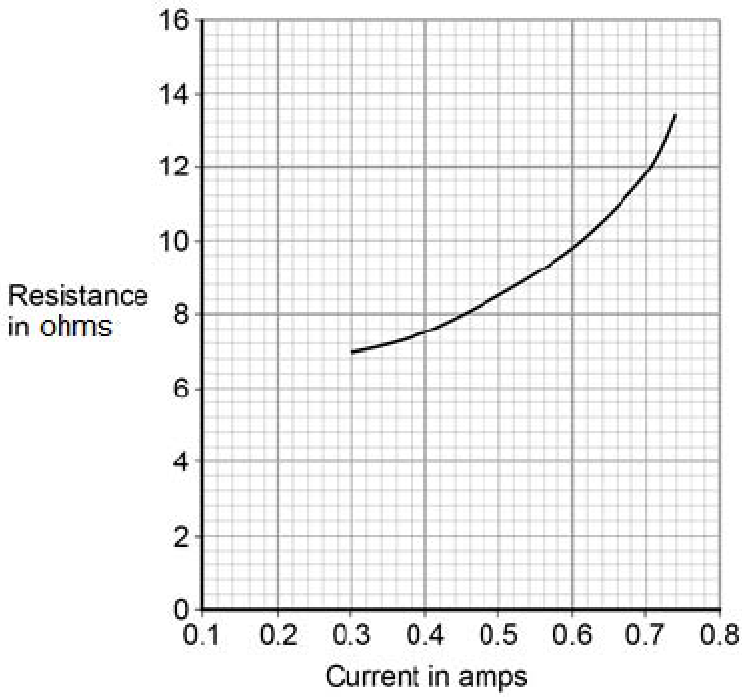
(4)

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

Figure 1



Describe how the resistance of the filament lamp changes as the current through it increases.

....

....

(1)

(d) Use **Figure 1** to estimate the resistance of the filament lamp when a current of 0.10 A passes through the lamp.

Resistance = ... Ω

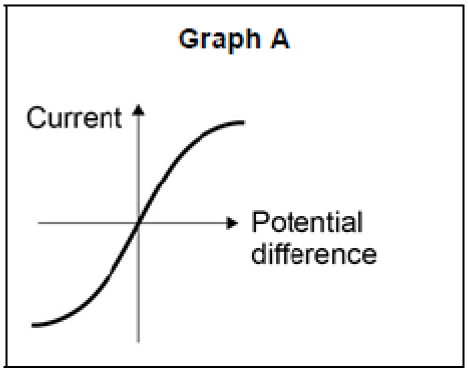
(1)

(e) The current-potential difference graphs of three components are shown in **Figure 2**.

Use answers from the box to identify each component.

diode	**filament lamp**	**light dependent resistor**
resistor at constant temperature		**thermistor**

Figure 2



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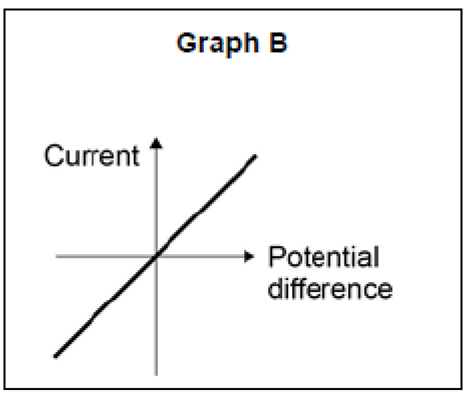

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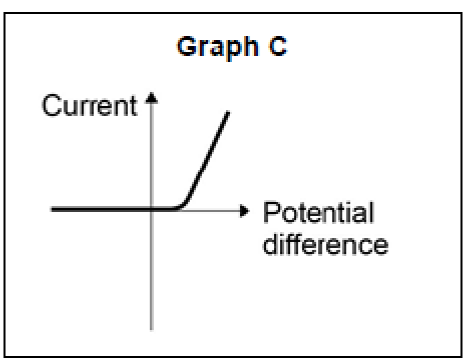


....

(3)
(Total 11 marks)

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

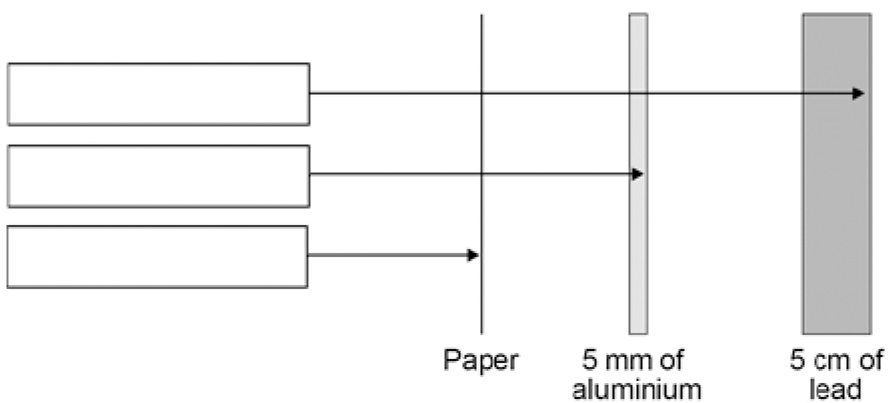
(a) Draw **one** line from each type of radiation to what the radiation consists of.

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

(3)

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

The demonstration is shown in the figure below.



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

(2)

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

1 ....

....

2 ....

....

(2)

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

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

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

....

....

(2)

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

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

....

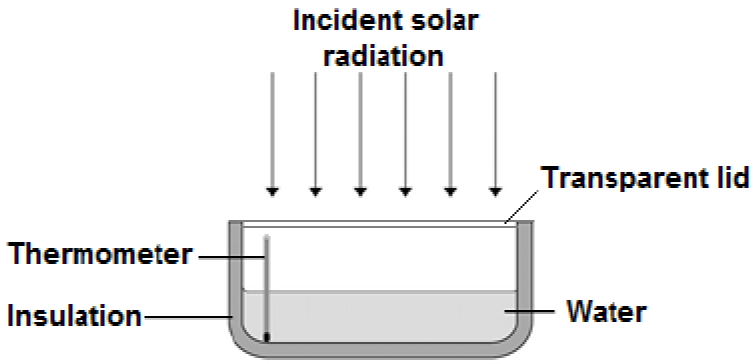
....

(1)
(Total 10 marks)

3 A student investigated how much energy from the Sun was incident on the Earth's surface at her location.

She put an insulated pan of water in direct sunlight and measured the time it took for the temperature of the water to increase by 0.6 °C.

The apparatus she used is shown in the figure below.



(a) Choose the most appropriate resolution for the thermometer used by the student.

Tick **one** box.

0.1 °C ☐

0.5 °C ☐

1.0 °C ☐

(1)

(b) The energy transferred to the water was 1050 J.

The time taken for the water temperature to increase by 0.6 °C was 5 minutes.

The specific heat capacity of water is 4200 J / kg °C.

Write down the equation which links energy transferred, power and time.

....

(1)

(c) Calculate the mean power supplied by the Sun to the water in the pan.

....

....

....

Average power = ... W

(2)

(d) Calculate the mass of water the student used in her investigation.

Use the correct equation from the Physics Equation Sheet.

....

....

....

Mass = ... kg

(3)

(e) The student's results can only be used as an estimate of the mean power at her location.

Give **one** reason why.

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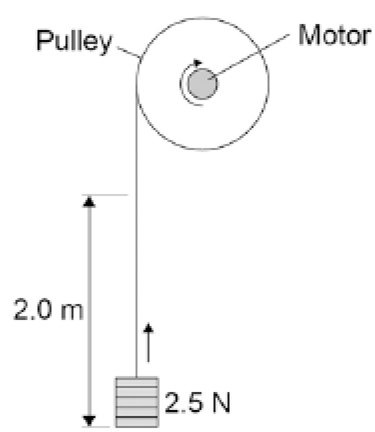
(1)

(Total 8 marks)

4 A student investigated the efficiency of a motor using the equipment in **Figure 1**.

Figure 1



He used the motor to lift a weight of 2.5 N a height of 2.0 m.

He measured the speed at which the weight was lifted and calculated the efficiency of the energy transfer.

He repeated the experiment to gain two sets of data.

(a) Give **one** variable that the student controlled in his investigation.

....

(1)

(b) Give **two** reasons for taking repeat readings in an investigation.

1 ....

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2 ....

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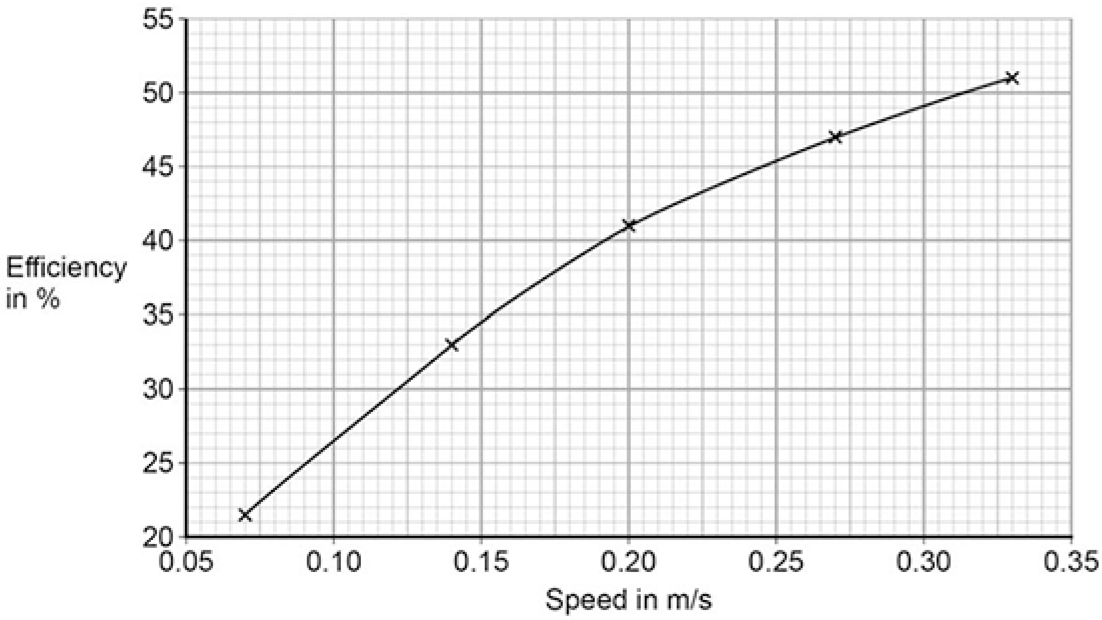
(2)

(c) **Figure 2** shows a graph of the student's results.

Figure 2



Give **two** conclusions that could be made from the data in **Figure 2**.

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....

(2)

(d) Give the main way that the motor is likely to waste energy.

....

....

(1)

(e) When the total power input to the motor was 5 W the motor could not lift the 2.5 N weight.

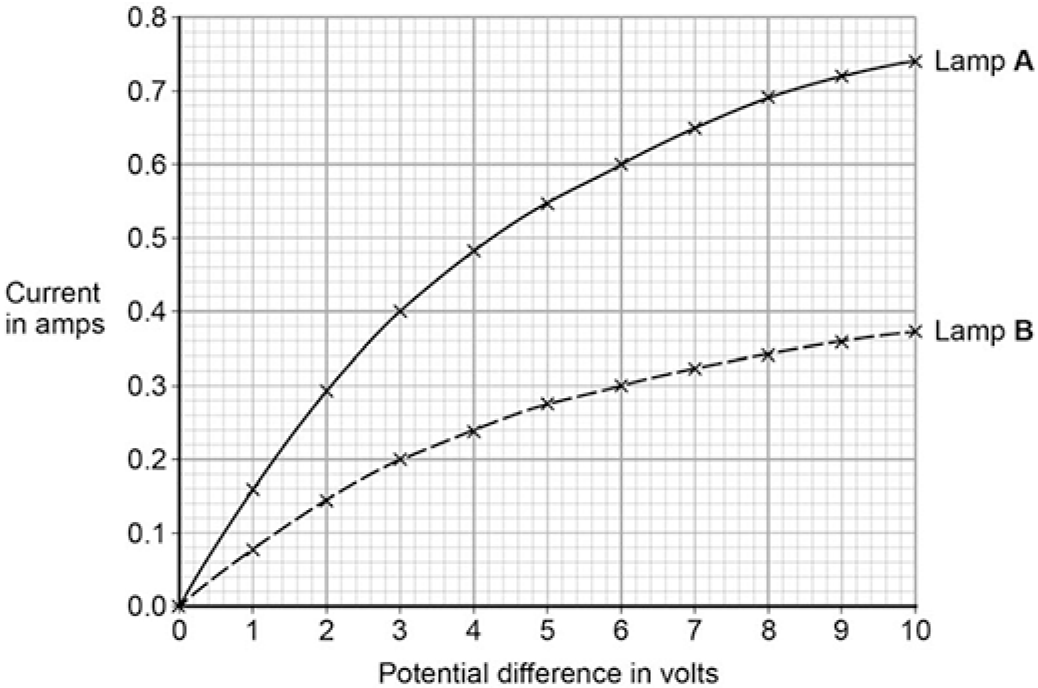
State the efficiency of the motor.

Efficiency = ... %

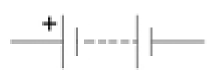
(1)
(Total 7 marks)

5 A student investigated how current varies with potential difference for two different lamps.

Her results are shown in the figure below.



(a) Complete the circuit diagram for the circuit that the student could have used to obtain the results shown in the figure above.



(3)

(b) Which lamp will be brighter at any potential difference?

Explain your answer.

Use the figure above to aid your explanation

....

....

....

....

(2)

(c) Lamp **B** has the higher resistance at any potential difference.

Explain how the figure above shows this.

....

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(2)

(d) Both lamps behave like ohmic conductors through a range of values of potential difference.

Use the figure above to determine the range for these lamps.

Explain your answer.

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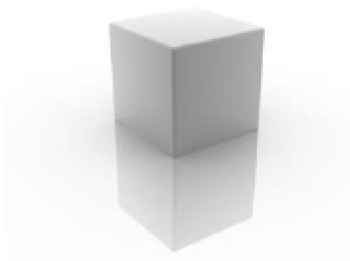
(3)
(Total 10 marks)

6 A student wants to calculate the density of the two objects shown in the figure below.



Metal cube

Small statue

Describe the methods that the student should use to calculate the densities of the two objects.

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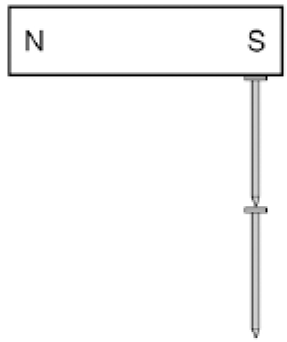
(Total 6 marks)

7 **Figure 1** shows two iron nails hanging from a bar magnet.

The iron nails which were unmagnetised are now magnetised.

Figure 1



(a) Complete the sentence.

Use a word from the box.

forced	**induced**	**permanent**

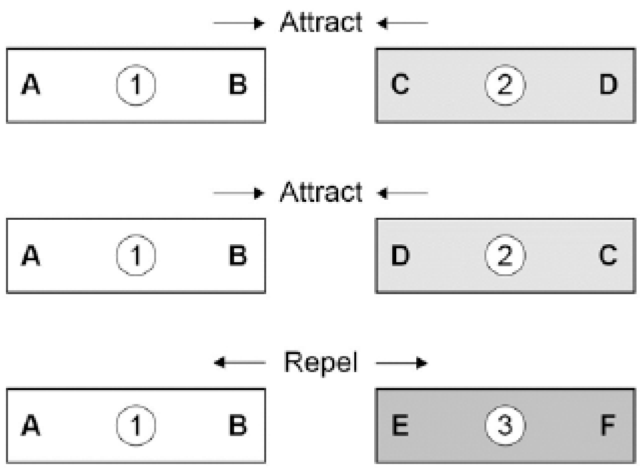
The iron nails have become .... magnets.

(1)

(b) Each of the three metal bars in **Figure 2** is either a bar magnet or a piece of unmagnetised iron.

The forces that act between the bars when different ends are placed close together are shown by the arrows.

Figure 2



Which **one** of the metal bars is a piece of unmagnetised iron?

Tick **one** box.

Bar 1 ☐

Bar 2 ☐

Bar 3 ☐

Give the reason for your answer.

....

....

(2)

(c) A student investigated the strength of different fridge magnets by putting small sheets of paper between each magnet and the fridge door.

The student measured the maximum number of sheets of paper that each magnet was able to hold in place.

Why was it important that each small sheet of paper had the same thickness?

....

....

....

(1)

(d) Before starting the investigation the student wrote the following hypothesis:

'The bigger the area of a fridge magnet the stronger the magnet will be.'

The student's results are given in the table below.

Fridge magnet	**Area of magnet in mm^2**	**Number of sheets of paper held**
A	40	20
B	110	16
C	250	6
D	340	8
E	1350	4

Give **one** reason why the results from the investigation **do not** support the student's hypothesis.

....

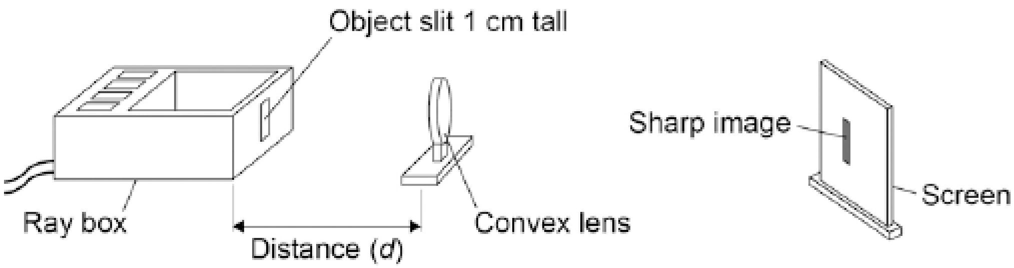
....

(1)
(Total 5 marks)

8 A student investigated how the magnification produced by a convex lens varies with the distance (d) between the object and the lens.

The student used the apparatus shown in **Figure 1**.

Figure 1



(a) The student measured the magnification produced by the lens by measuring the image height in centimetres.

Explain why the image height in centimetres was the same as the magnification.

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(2)

(b) The data recorded by the student is given in **Table 1**.

Table 1

Distance between the object and the lens in cm	**Magnification**
25	4.0
30	2.0
40	1.0
50	0.7
60	0.5

It would be difficult to obtain accurate magnification values for distances greater than 60 cm.

Suggest **one** change that could be made so that accurate magnification values could be obtained for distances greater than 60 cm.

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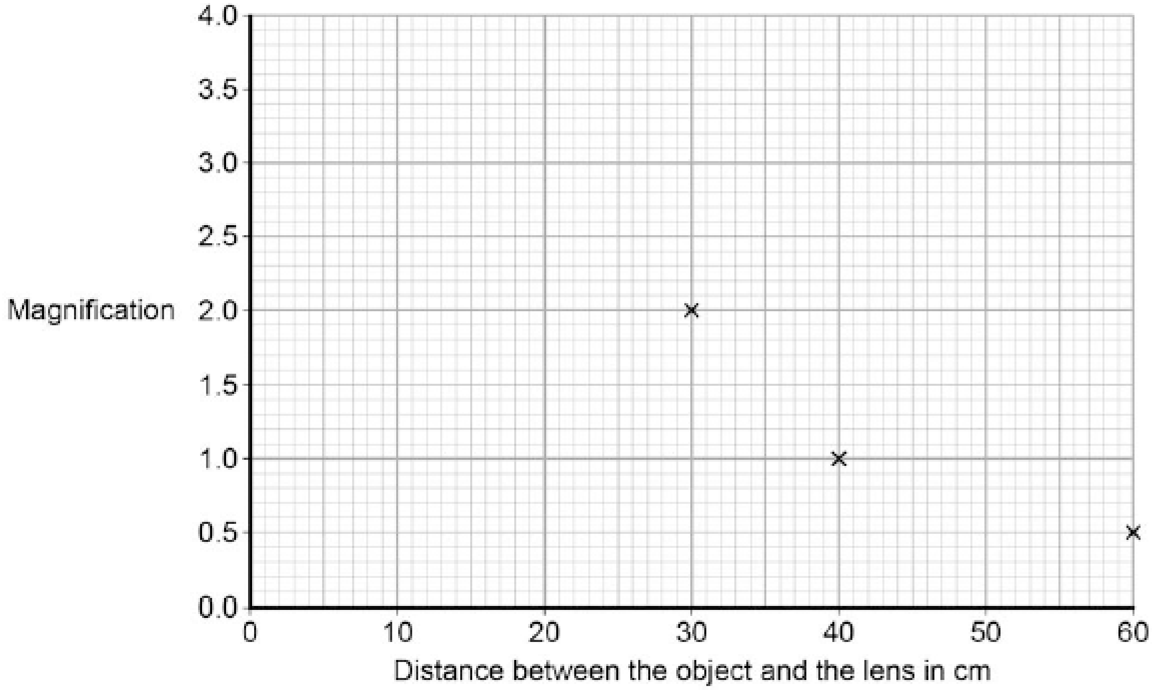
(1)

(c) The graph in **Figure 2** is incomplete.

Figure 2



Complete the graph in **Figure 2** by plotting the missing data and then drawing a line of best fit.

(2)

(d) How many times bigger is the image when the object is 35 cm from the lens compared to when the object is 55 cm from the lens?

....

....

....

(2)

(e) During the investigation the student also measured the distance between the lens and the image.

Table 2 gives both of the distances measured and the magnification.

Table 2

Distance between the lens and the image in cm	**Distance between the lens and the object in cm**	**Magnification**
100	25	4.0
60	30	2.0
40	40	1.0
33	50	0.7
30	60	0.5

Consider the data in **Table 2**.

Give a second way that the student could have determined the magnification of the object.

Justify your answer with a calculation.

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(2)
(Total 9 marks)

9 The data given in the table below was obtained from an investigation into the refraction of light at an air to glass boundary.

Angle of incidence	Angle of refraction
20°	13°
30°	19°
40°	25°
50°	30°

Describe an investigation a student could complete in order to obtain similar data to that given in the table above.

Your answer should consider any cause of inaccuracy in the data.

A labelled diagram may be drawn as part of your answer.

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(Total 6 marks)

10 The data given in the table below was obtained from an investigation into the refraction of light at an air to glass boundary.

Angle of incidence	**Angle of refraction**
20°	13°
30°	19°
40°	25°
50°	30°

(a) Describe an investigation a student could complete in order to obtain similar data to that given in the table above.

Your answer should consider any cause of inaccuracy in the data.

A labelled diagram may be drawn as part of your answer.

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(6)

(b) State the reason why light is refracted as it crosses from air into glass.

....

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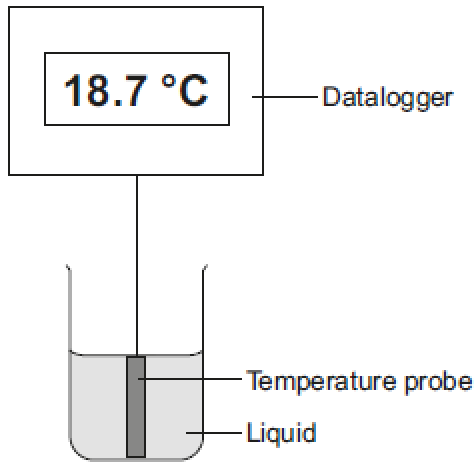
(1)
(Total 7 marks)

11 A student investigated the cooling effect of evaporation.

She used the equipment (datalogger and probe) shown in **Figure 1** to measure how the temperature of a liquid changed as the liquid evaporated.

Figure 1



(a) Which type of variable was the temperature in this investigation?

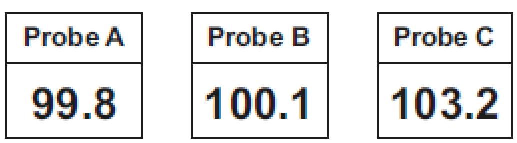
Tick (✓) **one** box.

	Tick (✓)
control	
dependent	
independent	

(1)

(b) Before the investigation started, the student checked the accuracy of three different temperature probes. The student put the probes in a beaker of boiling water that had a temperature of 100.0 °C.
The readings from the three temperature probes are shown in **Figure 2**.

Figure 2



Which **one** of the temperature probes, **A**, **B** or **C**, was **least** accurate?

Write the correct answer in the box.

☐

Give a reason for your answer.

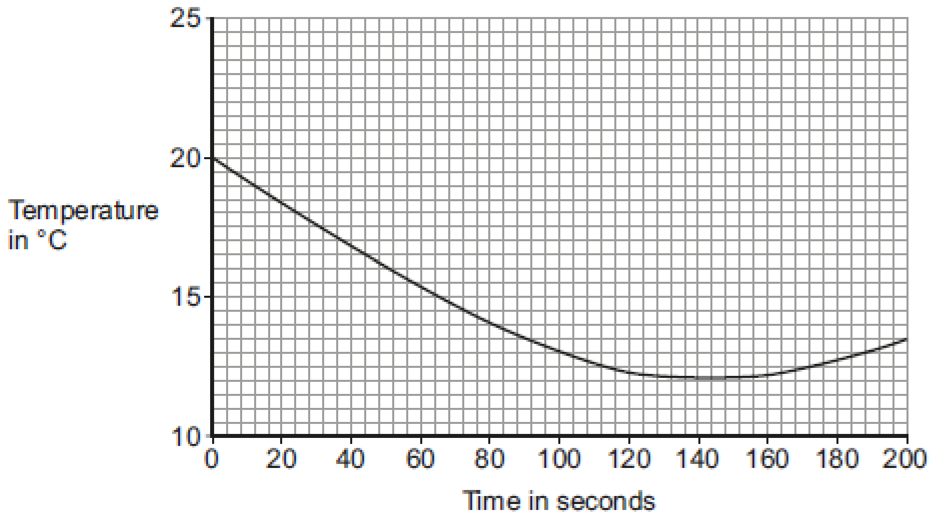
....

....

(2)

(c) **Figure 3** shows how the temperature recorded changed during the investigation.

Figure 3



(i) Use **Figure 3** to determine the lowest temperature recorded as the liquid evaporated.

Temperature = ... °C

(1)

(ii) Use **Figure 3** to determine how long it took for all the liquid to evaporate. Give a reason for your answer.

Time = ... seconds

Reason: ....

....

(2)

(iii) How would increasing the starting temperature of the liquid above 20 °C affect the rate of evaporation of the liquid?

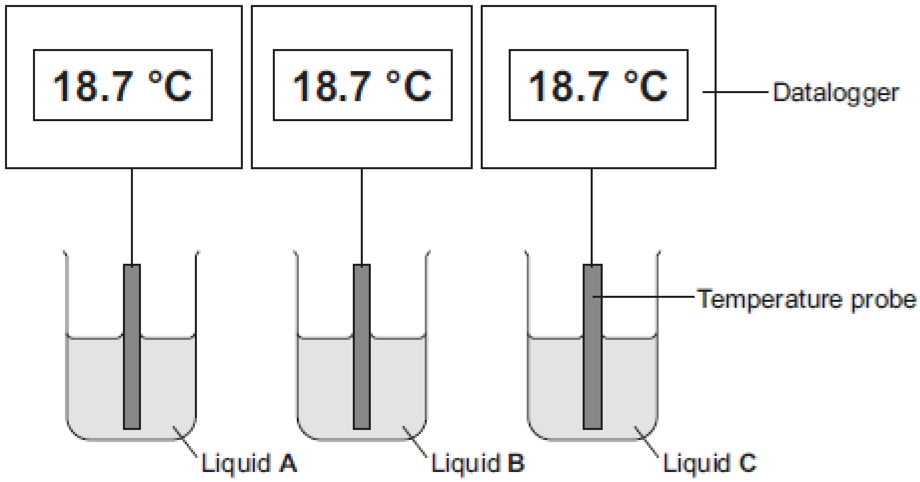
....

....

(1)
(Total 7 marks)

12 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.

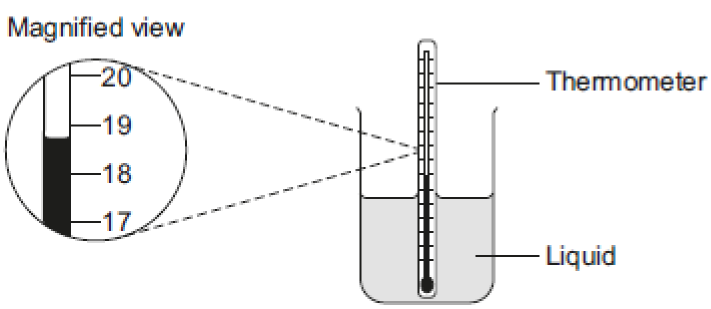
....

....

(1)

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

Figure 2



1. ....

....

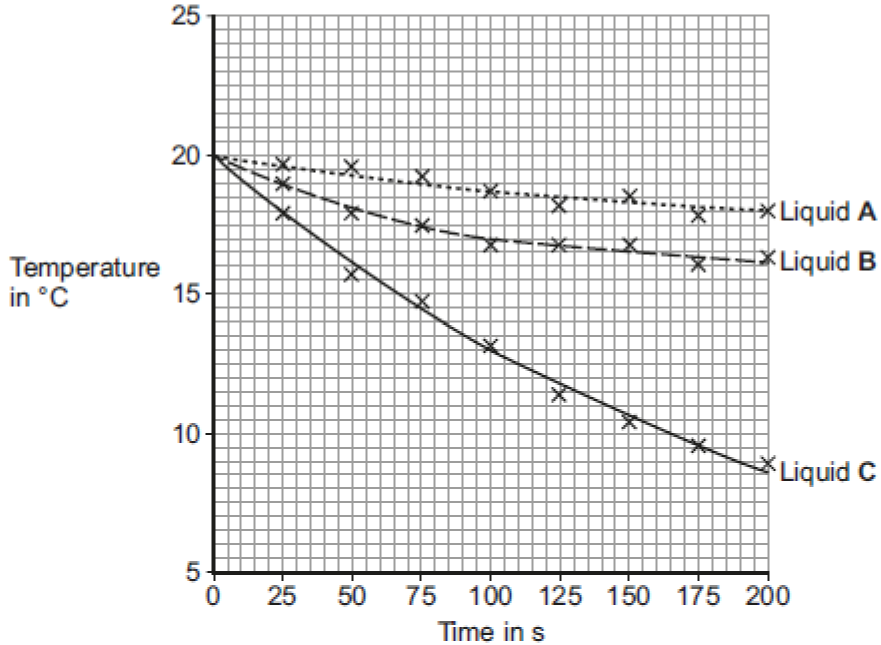
2. ....

....

(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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....

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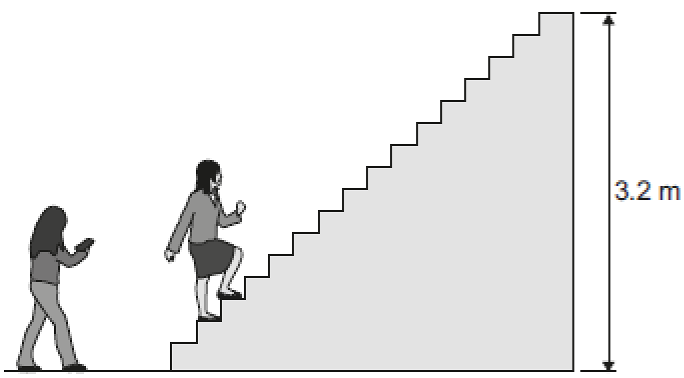
(3)
(Total 11 marks)

13 A student did an experiment to calculate her power.
The diagram below shows how she obtained the measurements needed.

The student first weighed herself and then ran up a flight of stairs. A second student timed how long it took her to go from the bottom to the top of the stairs. The height of the stairs was also measured.



(a) Complete the following sentence.

To run up the stairs the student must do work against

the force of ....

(1)

(b) The student did 2240 J of work going from the bottom of the stairs to the top of the stairs.

The student took 2.8 seconds to run up the stairs.

(i) Calculate the power the student developed when running up the stairs.

....

....

Power = ... W

(2)

(ii) How much gravitational potential energy did the student gain in going from the bottom to the top of the stairs?

Tick (✓) **one** box.

much more than 2240 J ☐

2240 J ☐

much less than 2240 J ☐

(1)

(c) Another four students did the same experiment.

The measurements taken and the calculated values for power are given in the table.

Student	**Weight in newtons**	**Time taken in seconds**	**Power in watts**
A	285	3.8	240
B	360	2.4	480
C	600	3.4	560
D	725	4.0	580

(i) To make a fair comparison of their powers the students kept **one** variable in the experiment constant.

What variable did the students keep constant?

....

(1)

(ii) From the data in the table a student wrote the following conclusion.

'The greater the weight of the student the greater the power developed.'

Suggest why this conclusion may **not** be true for a larger group of students.

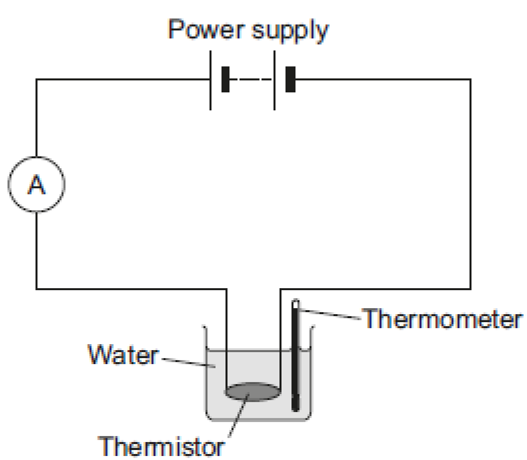
....

....

(1)
(Total 6 marks)

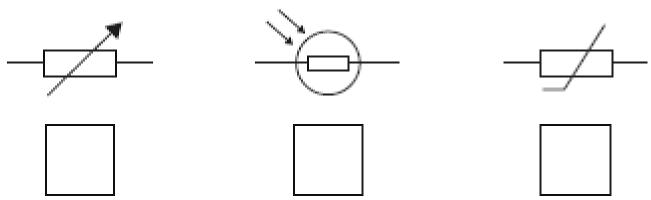
14 **Figure 1** shows the apparatus used to investigate how the current through a thermistor depends on the temperature of the thermistor.

Figure 1



(a) Which **one** of the following is the correct circuit symbol for a thermistor?

Tick (✓) **one** box.

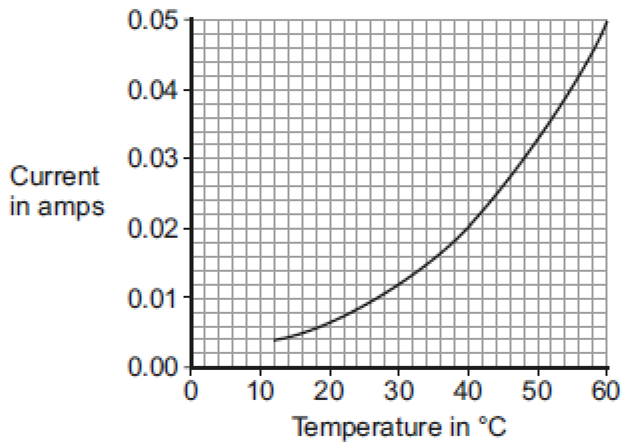


(1)

(b) To get a range of results, hot water at 60 °C was poured into the beaker.
The temperature of the water and current through the thermistor were then recorded as the water cooled.

The results of the investigation are shown in **Figure 2**.

Figure 2



(i) Suggest **one** way the investigation could have been changed to give a wider range of temperatures.

....

....

(1)

(ii) Describe how the current through the thermistor depends on the temperature of the thermistor.

....

....

(1)

(iii) Use **Figure 2** to determine the current through the thermistor at 40 °C.

Current at 40 °C = ... A

(1)

(iv) At 40 °C the thermistor has a resistance of 250 Ω.

Use your answer to part **(iii)** and the resistance of the thermistor to calculate the potential difference across the thermistor.

....

....

....

....

Potential difference = ... V

(2)

(v) The potential difference across the thermistor stays the same all through the investigation.

What conclusion can be made from the results in **Figure 2** about the resistance of the thermistor as the temperature of the thermistor **decreases?**

Tick (✓) **one** box.

the resistance increases ☐

the resistance does not change ☐

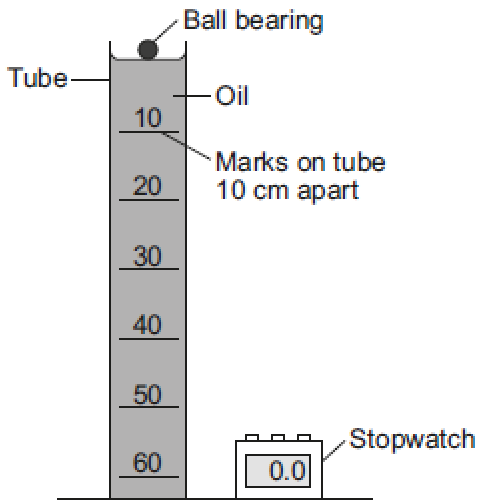
the resistance decreases ☐

(1)
(Total 7 marks)

15 A student investigated how the speed of a ball bearing changes as the ball bearing falls through a tube of oil.

Figure 1 shows the equipment the student used.

Figure 1



The student measured the time taken for the ball bearing to fall different distances.

Each distance was measured from the top of the oil.

(a) What is likely to have been the main source of error in this investigation?

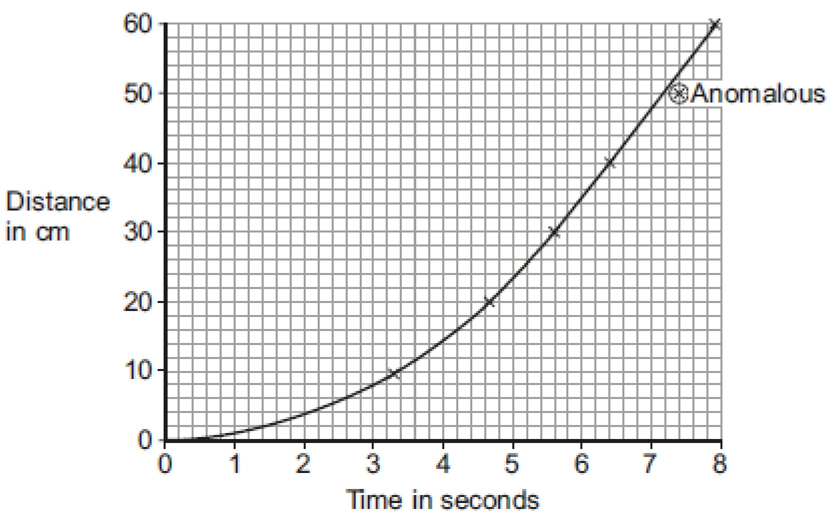
....

....

(1)

(b) **Figure 2** shows the student's results plotted as a graph.

Figure 2



(i) The student has identified one of the results as being anomalous.

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

after	**as**	**before**

The anomalous result was caused by the stopwatch being started

.... the ball bearing was released.

(1)

(ii) What can you conclude from the graph about the speed of the ball bearing during the first four seconds?

....

....

(1)

(iii) The graph shows that the ball bearing reached its terminal velocity.

Describe how the graph would be used to calculate the terminal velocity of the ball bearing.

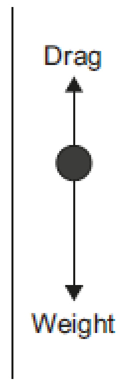
....

....

(1)

(iv) The directions of the two forces acting on the ball bearing as it falls through the oil are shown in **Figure 3**.

Figure 3



Explain, in terms of the forces shown in **Figure 3**, why the ball bearing reaches its terminal velocity.

....

....

....

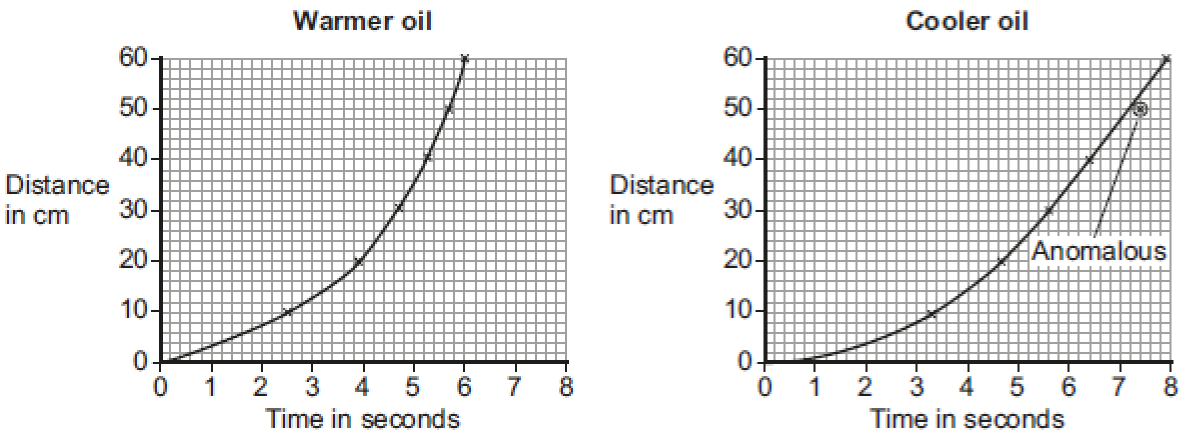
....

(2)

(c) The student repeated the investigation using warmer oil.

Figure 4 shows the set of results using the warmer oil **and** the set of results using the cooler oil.

Figure 4



Compare the two graphs in **Figure 4**.

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

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

After falling 40 cm, the drag force on the ball bearing in the warmer oil is

.... the drag force on the ball bearing in the cooler oil.

Explain the reason for your answer.

....

....

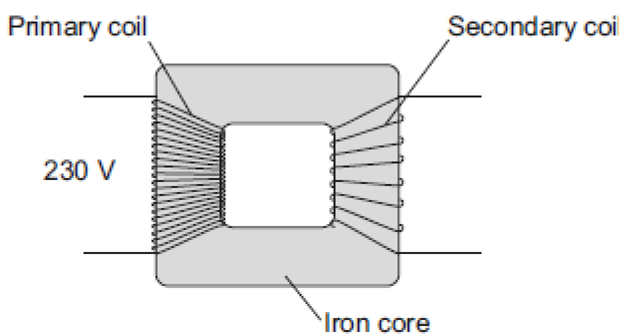
....

....

(3)
(Total 9 marks)

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

Figure 1



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

State what is produced in the iron core.

....

....

(2)

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

Calculate the number of turns on the primary coil.

....

....

....

....

Number of turns on the primary coil = ...

(2)

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

State why.

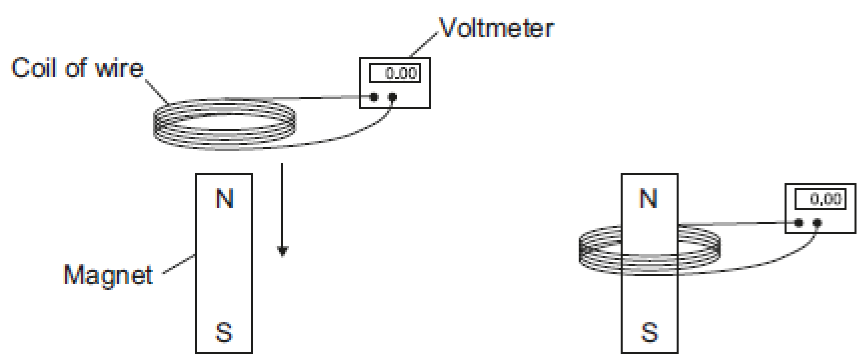
....

....

(1)

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

Figure 2



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

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

(i) State the resolution of the voltmeter.

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

Resolution ....

Reason ....

....

(2)

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

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

....

....

(1)

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

How do the results show that the investigation is reproducible?

....

....

(1)

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

....

(1)

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

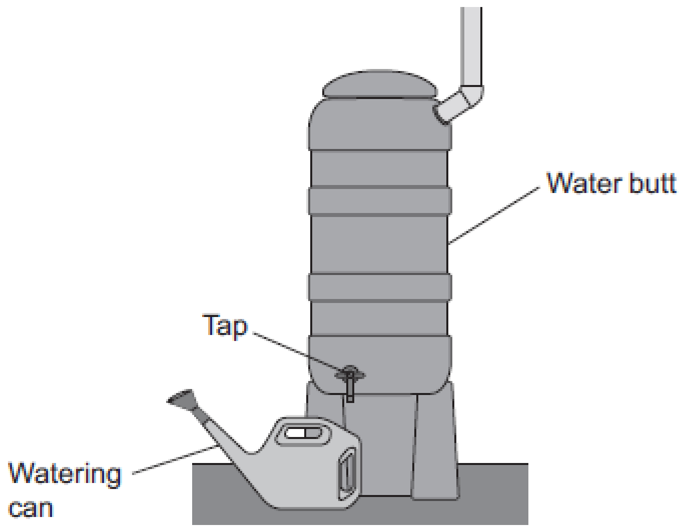
Suggest **one** advantage of having a transformer that can be used with many different devices.

....

....

(1)
(Total 11 marks)

17 The diagram shows a water butt used to collect rainwater.



A tap allows water to be collected from the water butt in a watering can.

(a) If the tap was placed higher up on the water butt, what difference would it make to the rate of flow of water from the tap?

Explain your answer.

....

....

....

....

(2)

(b) A hosepipe is now attached to the tap. The hosepipe takes water to where it is needed.

A gardener did an investigation to see how the rate of flow of water through a hosepipe, from a water butt, varies with the length of the hosepipe.

His results are shown in below table.

Length of hosepipe in metres	**Water collected in 10 seconds in cm^3**
2.0	500
3.0	500
4.0	500
5.0	500
10.0	250
15.0	170

(i) What conclusions can you make based on the results in the table above?

....

....

....

....

(2)

(ii) Suggest further readings that should be taken to improve the investigation.

Give reasons for your answers.

....

....

....

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....

....

(4)

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

You are provided with a water butt and lengths of hosepipe of different diameter.

Describe how you would investigate how the rate of flow of water through a hosepipe varies with the diameter of the hosepipe.

In your description you should include:

- any additional equipment that you would use
- any measurements you would make using the equipmentz
- any variables that need to be controlled and how this would be achieved.

....

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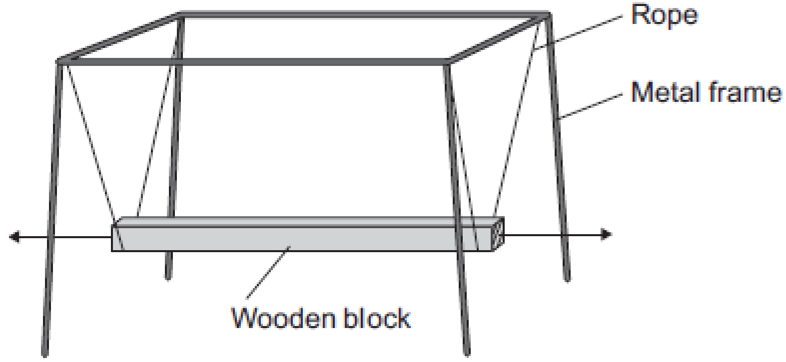
(6)
(Total 14 marks)

18 **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**.

....

....

....

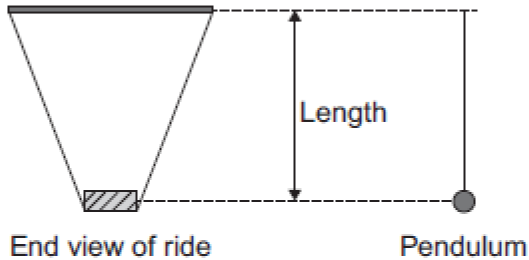
....

(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.

....

....

....

....

....

....

(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.

....

....

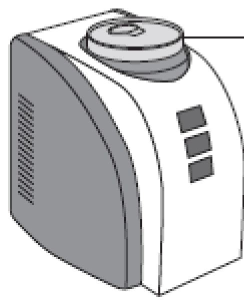
Force = ... N

(3)
(Total 12 marks)

19 A 'can-chiller' is used to make a can of drink colder.

Figure 1 shows a can-chiller.

Figure 1



(a) The can-chiller decreases the temperature of the liquid in the can by 15 °C.
The mass of liquid is 0.33 kg.
The specific heat capacity of the liquid is 4200 J / kg °C.

Calculate the energy transferred from the liquid as it cools.

....

....

....

Energy = ... J

(2)

(b) Complete the following sentence.

The specific heat capacity of a substance is the amount of energy required to

change the .... of one kilogram of the

substance by one degree Celsius.

(1)

(c) To calculate the specific heat capacity of a material, the mass of the material needs to be measured.

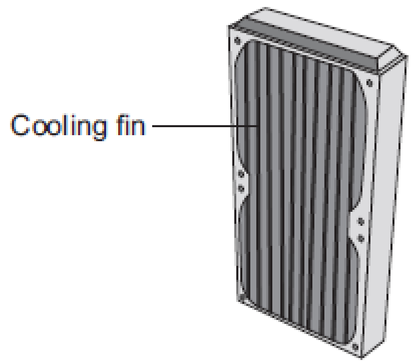
State the name of a measuring instrument used to measure mass.

....

(1)

(d) The back of the can-chiller has cooling fins, as shown in **Figure 2**.

Figure 2



The cooling fins increase the rate of energy transfer from the can-chiller to the surroundings.

Complete the following sentences.

The cooling fins are a .... colour because that makes them

good emitters of infrared radiation.

The large surface area of the cooling fins allows the air around the can-chiller

to gain energy quickly and rise, transferring energy by ....

(2)

(e) (i) The energy input to the can-chiller is the same as the energy output. This shows that energy is conserved.

Complete the following sentence.

Energy can be transferred usefully, stored or dissipated, but cannot be

.... or destroyed.

(1)

(ii) The temperature of the can of drink decreases while it is in the can-chiller.

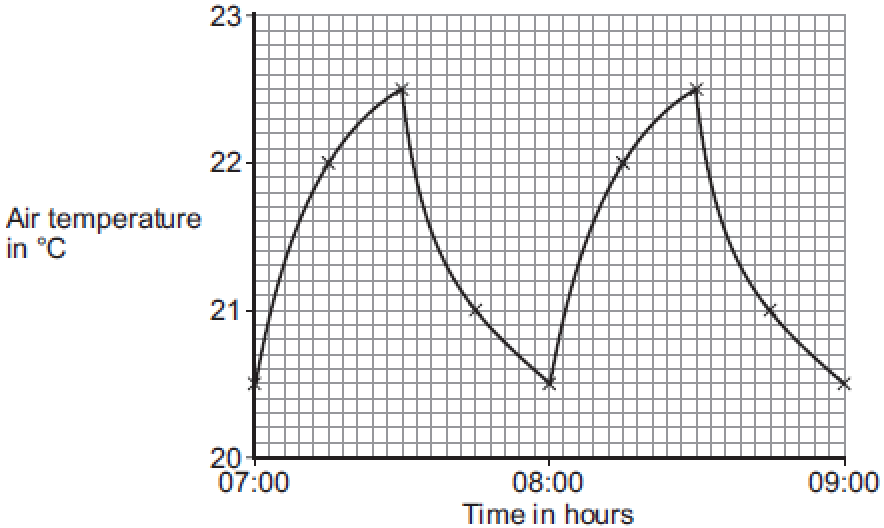
What happens to the temperature of the air around the cooling fins?

....

(1)
(Total 8 marks)

20 A householder monitored how the air temperature inside his house changed over a 2-hour period. The householder measured the temperature every 15 minutes.

THe graph shows how the temperature changed with time.



(a) (i) The householder used a digital thermometer to measure the temperature.

What would be an appropriate resolution for the digital thermometer?

Draw a ring around your answer.

0.5 °C **1 °C** **5 °C**

(1)

(ii) The householder's results are shown on the graph above.

Why would it **not** be appropriate to use the results to plot a bar chart?

....

....

(1)

(b) The householder's heating is controlled by a thermostat. The thermostat switches the heating on when the temperature decreases below a certain temperature.

(i) At what temperature does the thermostat switch the heating on?

.... °C

(1)

(ii) Use the graph to determine the number of minutes that the householder's heating was switched on between 07:00 and 09:00.

....

....

Time = ... minutes

(1)

(c) The householder read the following extract from a newspaper article about reducing energy use in the home.

> . . . decreasing the temperature setting on your thermostat by 1 °C will reduce your heating bill by 10% . . .

On Monday, the householder set his thermostat at 20.0 °C and recorded the energy, in kWh, used to heat his house.

On Tuesday, the householder set his thermostat at 19.0 °C and recorded the energy, in kWh, used to heat his house.

The table shows the results of the householder's investigation.

Thermostat setting in °C	**Energy in kWh**
20.0	8.0
19.0	7.2

(i) The outside temperature was the same on both days.

Give **one** reason why this was important.

....

....

(1)

(ii) Explain how the results shown in the table above support the extract from the newspaper article.

Justify your answer with a calculation.

....

....

....

....

(2)

(iii) The statement in the extract is **not** valid for all situations.
Suggest why.

....

....

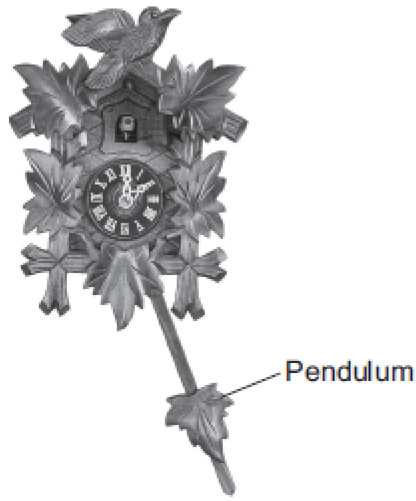
....

....

(2)
(Total 9 marks)

21 The clock shown in **Figure 1** uses a pendulum to keep time.

Figure 1



(a) The pendulum has a frequency of 0.80 Hz.

Calculate the periodic time of the pendulum.

....

....

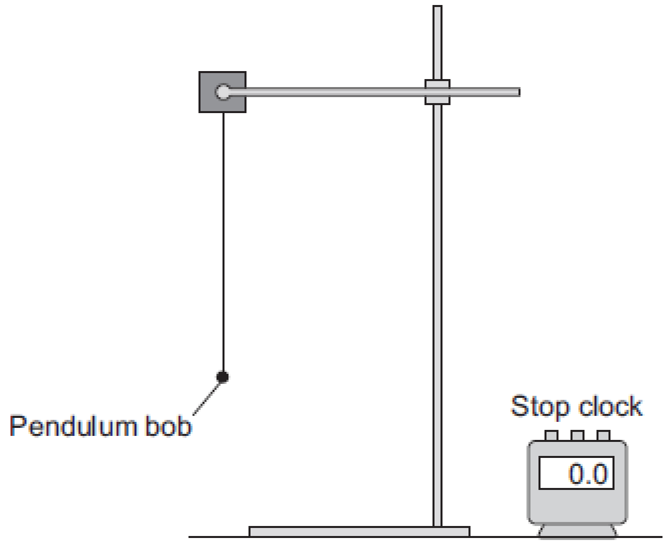
....

Periodic time = ... seconds

(2)

(b) A student investigated the factors affecting the oscillation of a pendulum. The student set up a pendulum as shown in **Figure 2**.

Figure 2



The student investigated how many complete oscillations the pendulum made for different lengths of the pendulum and different masses of the pendulum bob.

The results are shown in the table.

Length of the pendulum in millimetres	**Mass of the pendulum bob in grams**	**Number of complete oscillations made by the pendulum in 20 seconds**
200	100	22
200	200	22
400	100	15
400	200	15
600	50	13
600	100	13

(i) State **two** conclusions that the student should make from the results shown in the table.

1...

....

2...

....

(2)

(ii) The student wants to be more certain that her conclusions are correct.

Suggest **two** ways in which the investigation could be improved.

1. ....

....

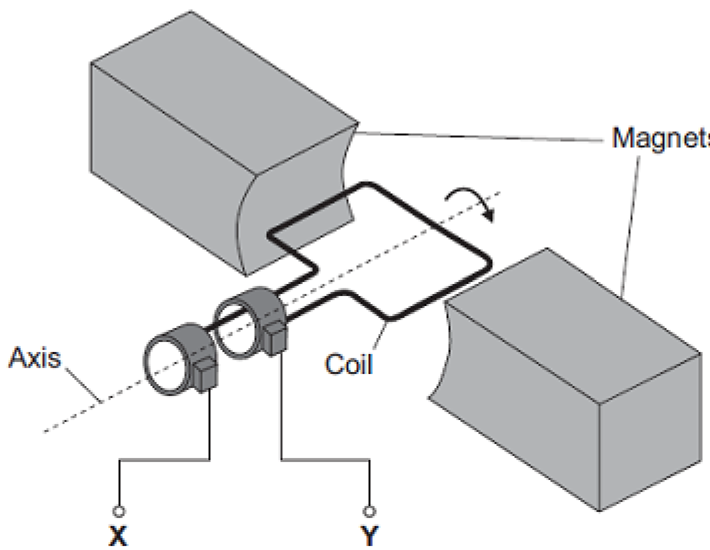
2. ....

....

(2)
(Total 6 marks)

22 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)

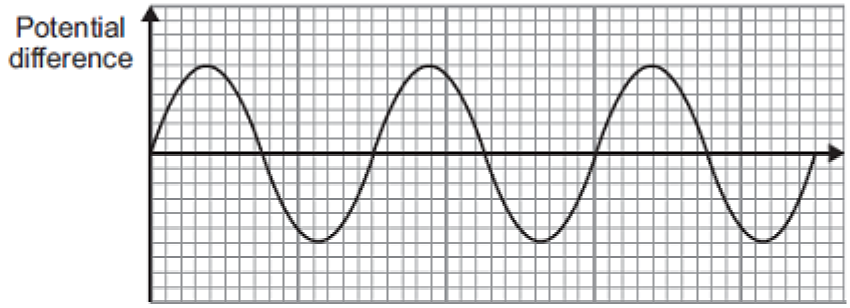
(iii) Name an instrument that could be used to measure the potential difference between **X** and **Y**.

....

(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)

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

These boxes are often used for jewellery.

Diagram 1

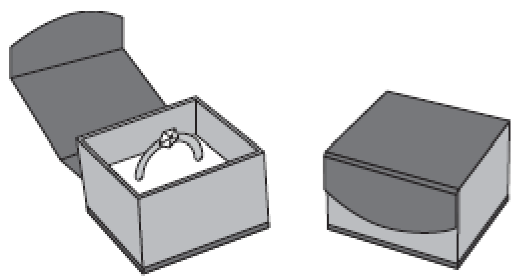
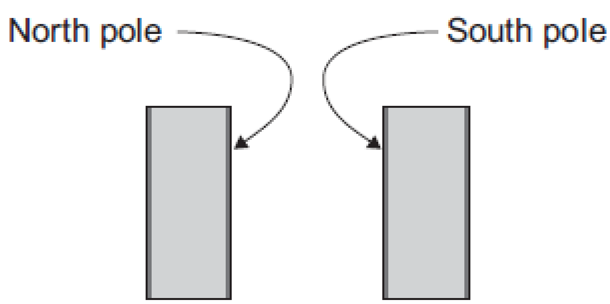


Diagram 2 shows the two magnets. The poles of the magnets are on the longer faces.

Diagram 2



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

(2)

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

Explain why.

....

....

....

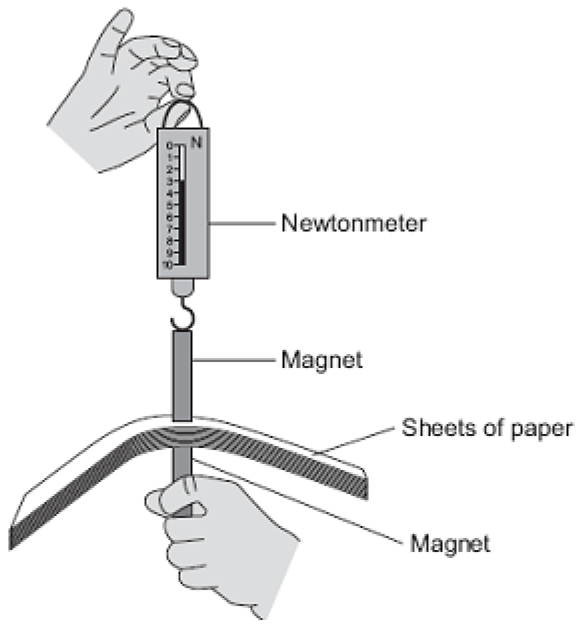
....

(2)

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

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

Diagram 3



She uses the following procedure:

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

The results are shown in the table.

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

(i) Describe the pattern of her results.

....

....

....

....

(2)

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

Why?

....

....

(1)

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

Suggest why.

....

....

....

....

(2)

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

....

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....

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....

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(3)

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

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

....

....

....

Separation of magnets = ... mm

(3)
(Total 15 marks)

24 All objects emit and absorb infrared radiation.

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

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

The best emitters of infrared radiation have

.... surfaces.

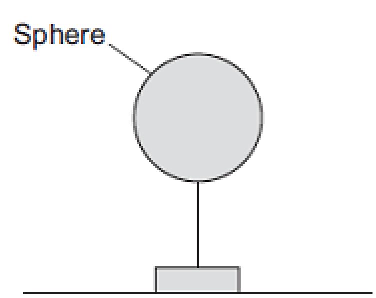
The worst emitters of infrared radiation have

.... surfaces.

(2)

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

Diagram 1



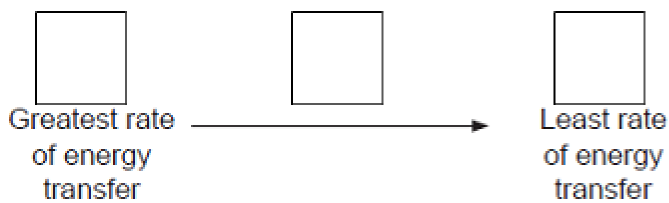
Energy is transferred from the sphere to the surroundings.

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

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

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

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



Give a reason for your answer.

....

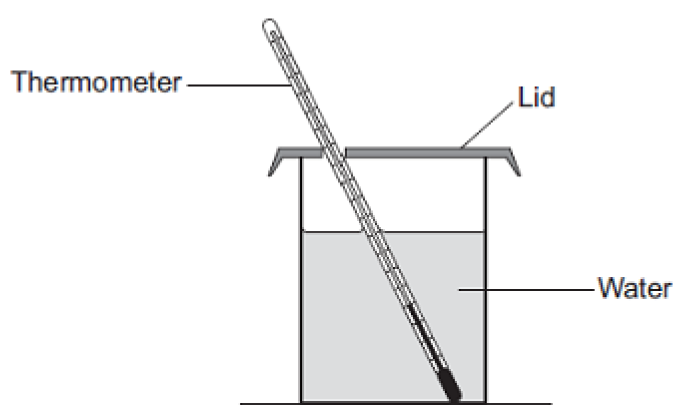
....

(2)

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

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

Diagram 2



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

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

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

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

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

Give a reason for your answer.

....

....

....

....

(2)

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

1 ....

....

2 ....

....

3 ....

....

(3)

(d) The photographs show two different foxes.

Fox A

Fox B

Which fox is better adapted to survive cold conditions?

Give reasons for your answer.

....

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....

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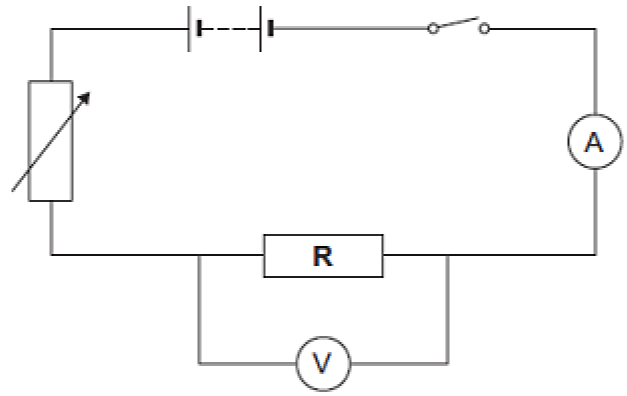
(3)
(Total 12 marks)

25 (a) A resistor is a component that is used in an electric circuit.



(i) Describe how a student would use the circuit to take the readings necessary to determine the resistance of resistor **R**.

....

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(6)

(ii) Explain why the student should open the switch after each reading.

....

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....

(2)

(iii) In an experiment using this circuit, an ammeter reading was 0.75 A.
The calculated value of the resistance of resistor **R** was 16 Ω.

What is the voltmeter reading?

....

....

Voltmeter reading = ... V

(2)

(iv) The student told his teacher that the resistance of resistor **R** was 16 Ω.

The teacher explained that the resistors used could only have one of the following values of resistance.

10 Ω **12 Ω** **15 Ω** **18 Ω** **22 Ω**

Suggest which of these resistors the student had used in his experiment.

Give a reason for your answer.

....

....

....

....

(2)

(b) The diagram shows a fuse.

Describe the action of the fuse in a circuit.

....

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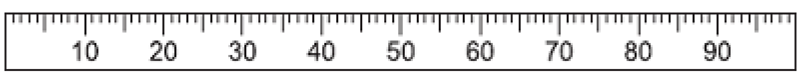
(3)
(Total 15 marks)

26 A student carries out an investigation using a metre rule as a pendulum.

(a) **Diagram 1** shows a metre rule.

Diagram 1



(i) Draw, on **Diagram 1**, an **X** to show the position of the centre of mass of the rule.

(1)

(ii) State what is meant by the 'centre of mass of an object'.

....

....

(1)

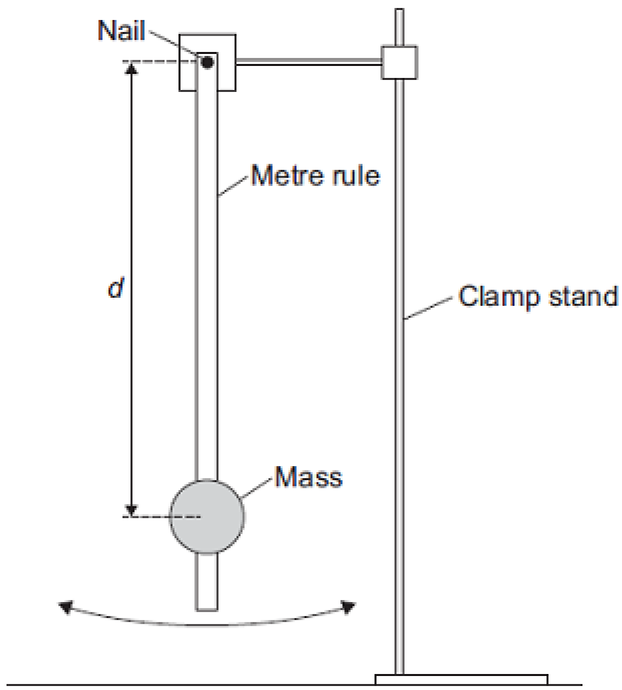
(b) The student taped a 100 g mass to a metre rule.

She set up the apparatus as shown in **Diagram 2**.

She suspended the metre rule from a nail through a hole close to one end, so she could use the metre rule as a pendulum.

The distance d is the distance between the nail and the 100 g mass.

Diagram 2



(i) Draw, on **Diagram 2**, a **Y** to show a possible position of the centre of mass of the pendulum.

(1)

(ii) The student carried out an investigation to find out how the time period of the pendulum varies with *d*.

Some of her results are shown in the table.

	Time for 10 swings in seconds				
***d* in cm**	**First test**	**Second test**	**Third test**	**Mean value**	**Mean time for 1 swing in seconds**
10.0	15.3	15.4	15.5	15.4	1.54
30.0	14.7	14.6	14.7	14.7	1.47
50.0	15.3	15.6	15.4	15.4	1.54
70.0	16.5	16.6	16.5		

Complete the table.

You may use the space below to show your working.

....

....

(3)

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

Describe how the student would carry out the investigation to get the results in the table in part (ii).

You should include:

- any other apparatus required
- how she should use the apparatus
- how she could make it a fair test
- a risk assessment
- how she could make her results as accurate as possible.

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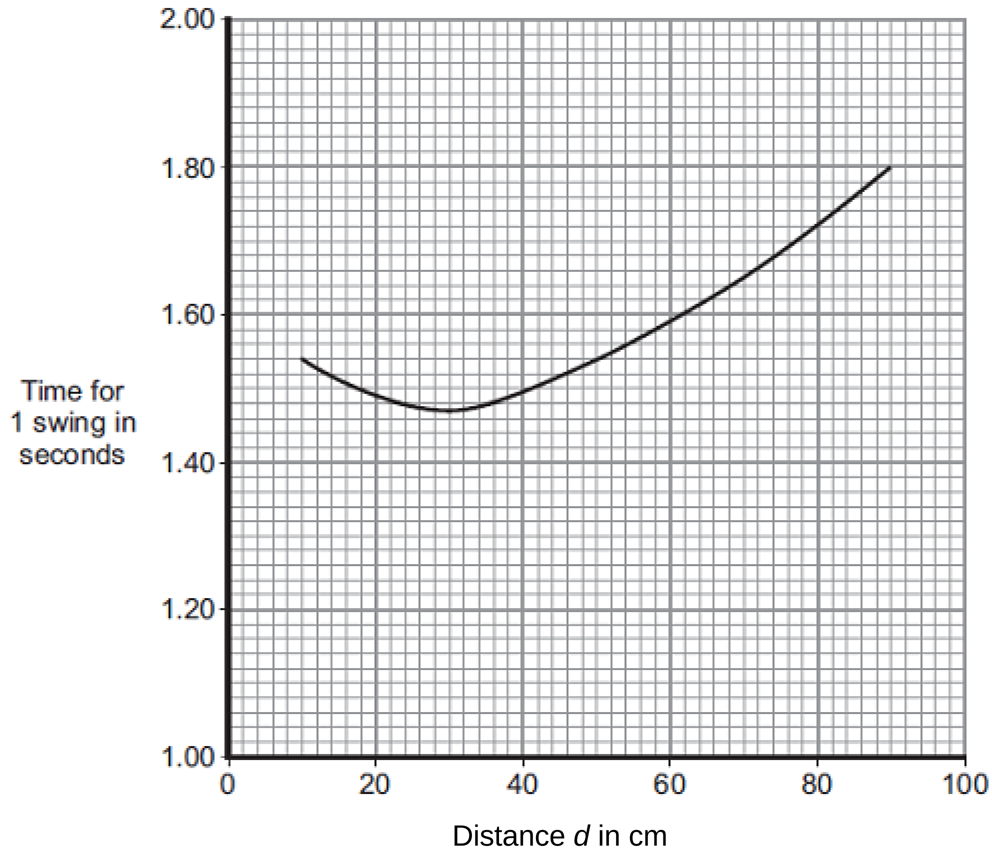
(6)

(c) A graph of the student's results is shown below.



(i) Describe the pattern shown by the graph.

....

....

....

....

(2)

(ii) The student thinks that the measurements of time for *d* = 10 cm might be anomalous, so she takes a fourth measurement.

Her four measurements are shown below.

15.3 s **15.4 s** **15.5 s** **15.3 s**

State whether you consider any of these measurements to be anomalous.

Justify your answer.

....

....

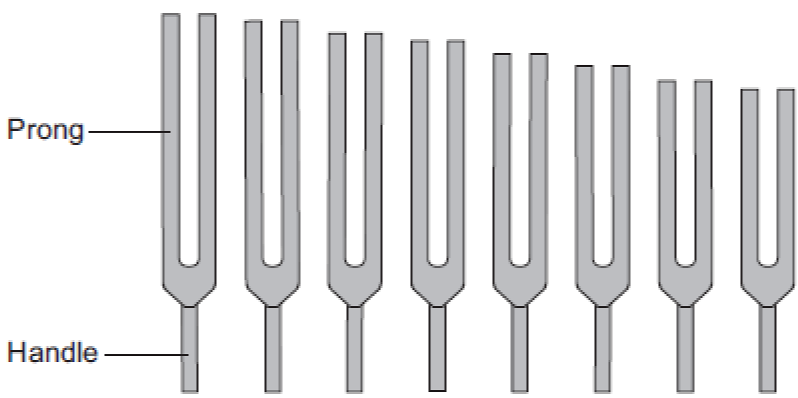
....

....

(2)
(Total 16 marks)

27 **Figure 1** shows a set of tuning forks.

Figure 1



A tuning fork has a handle and two prongs. It is made from metal.

When the prongs are struck on a hard object, the tuning fork makes a sound wave with a single frequency. The frequency depends on the length of the prongs.

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

direction	**loudness**	**pitch**	**speed**

The frequency of a sound wave determines its ....

The amplitude of a sound wave determines its ....

(2)

(b) Each tuning fork has its frequency engraved on it. A student measured the length of the prongs for each tuning fork.

Some of her data is shown in the table.

Frequency in hertz	**Length of prongs in cm**
320	9.5
384	8.7
480	7.8
512	7.5

(i) Describe the pattern shown in the table.

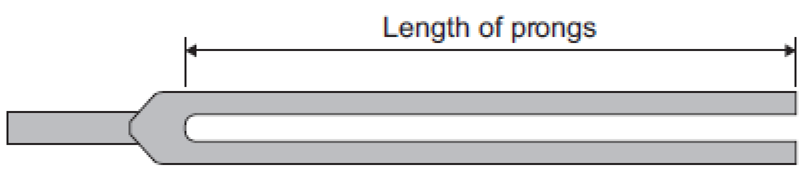
....

....

(1)

(ii) **Figure 2** shows a full-size drawing of a tuning fork.

Figure 2



Measure and record the length of the prongs.

Length of prongs = ... cm

(1)

Use the data in the table above to estimate the frequency of the tuning fork in **Figure 2**.

Explain your answer.

....

....

....

....

....

Estimated frequency = ... Hz

(3)

(c) Ultrasound waves are used in hospitals.

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

electronic	**hydraulic**	**radioactive**

Ultrasound waves can be produced by .... systems.

(1)

(ii) The frequency of an ultrasound wave used in a hospital is 2×10^6 Hz.

It is **not** possible to produce ultrasound waves of this frequency using a tuning fork.

Explain why.

....

....

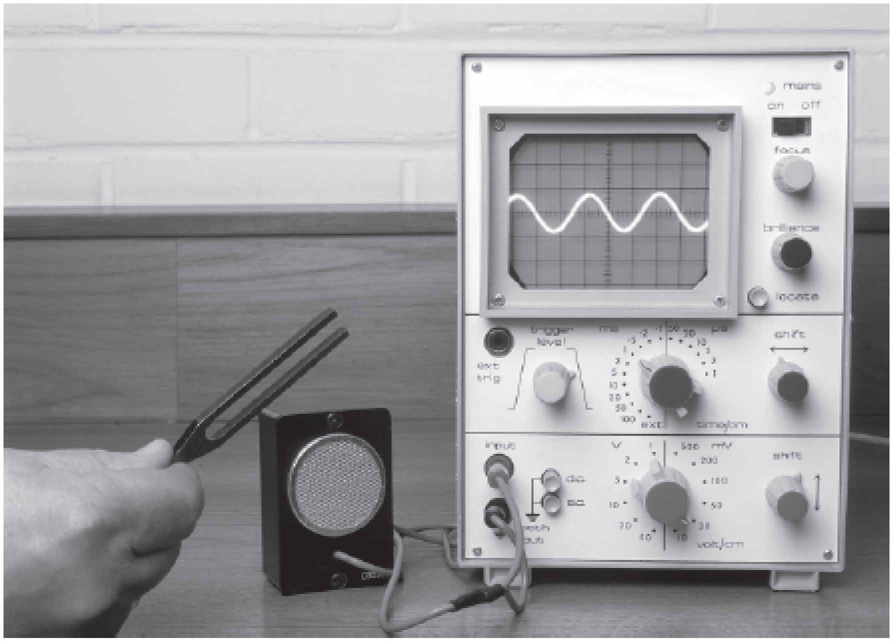
....

....

(2)

(d) **Figure 3** shows a tuning fork and a microphone. The microphone is connected to an oscilloscope.

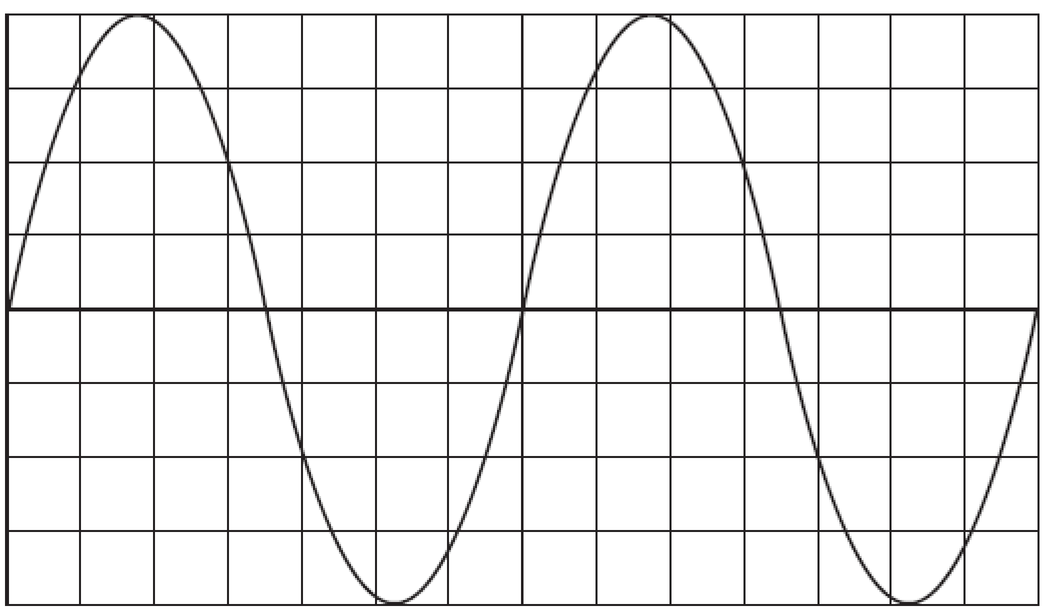
Figure 3



When the tuning fork is struck and then placed in front of the microphone, a trace appears on the oscilloscope screen.

Figure 4 shows part of the trace on the screen.

Figure 4



Each horizontal division in **Figure 4** represents a time of 0.0005 s.

What is the frequency of the tuning fork?

....

....

....

Frequency = ... Hz

(3)

(Total 13 marks)

28 If a fault develops in an electrical circuit, the current may become too great. The circuit needs to be protected by being disconnected.

A fuse or a circuit breaker may be used to protect the circuit.
One type of circuit breaker is a Residual Current Circuit Breaker (RCCB).

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

earth	**live**	**neutral**

A fuse is connected in the .... wire.

(1)

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

are bigger	**are cheaper**	**react faster**

RCCBs are sometimes preferred to fuses because they ....

(1)

(iii) RCCBs operate by detecting a difference in the current between two wires.

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

earth and live	**earth and neutral**	**live and neutral**

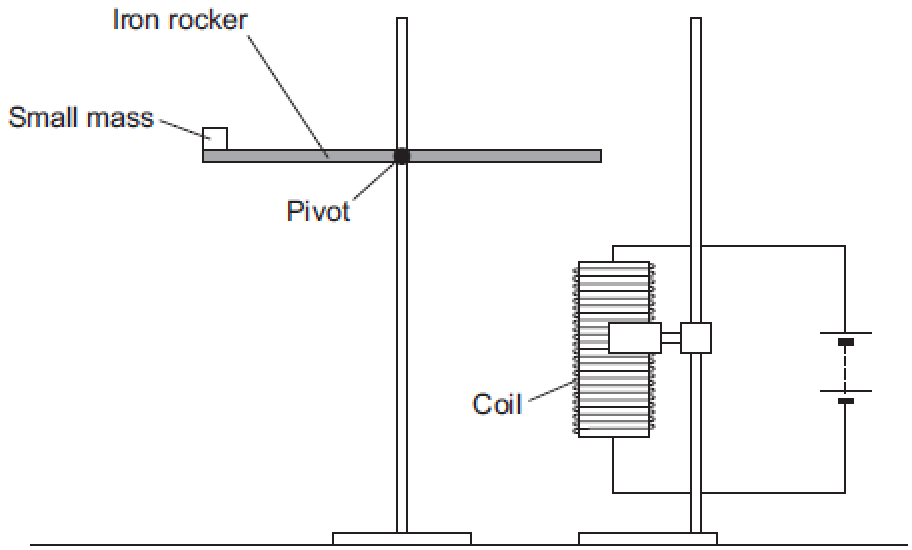
The two wires are the .... wires.

(1)

(b) An RCCB contains an iron rocker and a coil.

A student investigated how the force of attraction, between a coil and an iron rocker, varies with the current in the coil.

She supported a coil vertically and connected it in an electrical circuit, part of which is shown in the figure below .



She put a small mass on the end of the rocker and increased the current in the coil until the rocker balanced. She repeated the procedure for different masses.

Some of her results are shown in the table below.

Mass in grams	**Current needed for the rocker to balance in amps**
5	0.5
10	1.0
15	1.5
20	2.0

(i) State **two** extra components that must have been included in the circuit in the figure above to allow the data in the above table to be collected.

Give reasons for your answers.

....

....

....

....

....

....

....

....

(4)

(ii) A teacher said that the values of current were too high to be safe.

Suggest **two** changes that would allow lower values of current to be used in this investigation.

Change 1 ....

....

Change 2 ....

....

(2)
(Total 9 marks)

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

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

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

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

Suggest why.

....

....

(1)

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

....

....

....

....

(2)

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

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

....

....

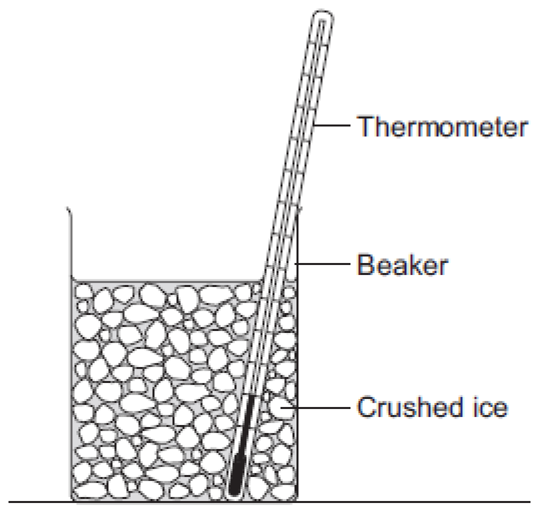
Energy = ... J

(2)

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

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

The figure below shows the equipment that she used.



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

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

....

....

(1)

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

Suggest **two** reasons why.

Tick (✓) **two** boxes.

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

(2)

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

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

Describe the pattern shown in the table.

....

....

(1)

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

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

Calculate the energy transferred in 2 minutes.

....

....

....

Energy transferred = ... J

(3)

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

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

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

- energy storage
- salt
- undersoil electrical heating.

....

....

....

....

....

....

....

....

....

....

....

....

Extra space ....

....

....

....

....

....

....

(6)
(Total 18 marks)

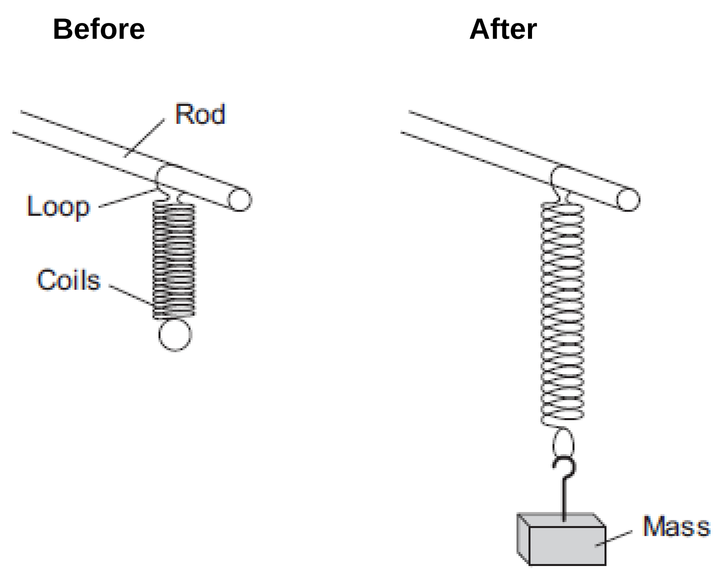
30 A student investigated the behaviour of springs. She had a box of identical springs.

(a) When a force acts on a spring, the shape of the spring changes.

The student suspended a spring from a rod by one of its loops. A force was applied to the spring by suspending a mass from it.

Figure 1 shows a spring before and after a mass had been suspended from it.

Figure 1



(i) State **two** ways in which the shape of the spring has changed.

1 ....

2 ....

(2)

(ii) No other masses were provided.

Explain how the student could test if the spring was behaving elastically.

....

....

....

....

(2)

(b) In a second investigation, a student took a set of measurements of force and extension.

Her results are shown in **Table 1** .

Table 1

Force in newtons	0.0	1.0	2.0	3.0	4.0	5.0	6.0
Extension in cm	0.0	4.0		12.0	16.0	22.0	31.0

(i) Add the missing value to **Table 1**.

Explain why you chose this value.

....

....

....

....

(3)

(ii) During this investigation the spring exceeded its limit of proportionality.

Suggest a value of force at which this happened.

Give a reason for your answer.

Force = ... N

Reason ....

....

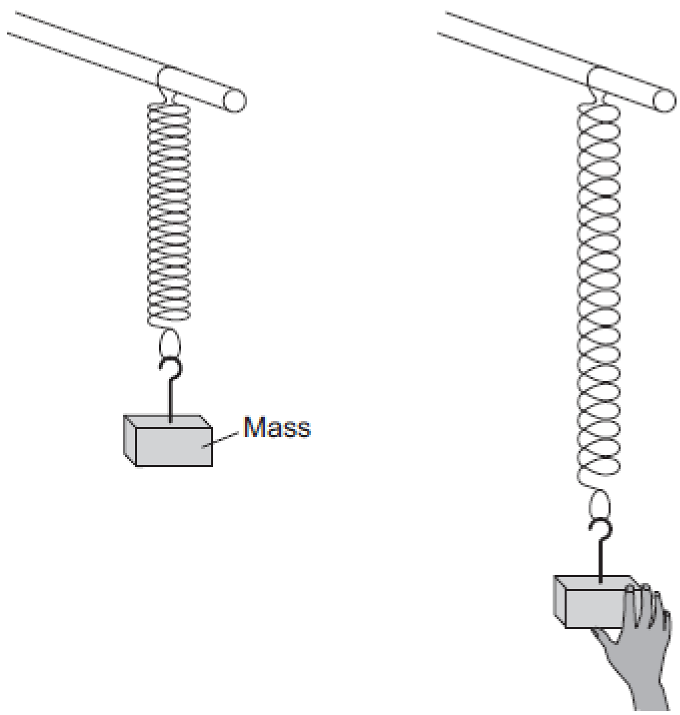
....

(2)

(c) In a third investigation the student:

- suspended a 100 g mass from a spring
- pulled the mass down as shown in **Figure 2**
- released the mass so that it oscillated up and down
- measured the time for 10 complete oscillations of the mass
- repeated for masses of 200 g, 300 g and 400 g.

Figure 2



Her results are shown in **Table 2**.

Table 2

	Time for 10 complete oscillations in seconds			
Mass in g	**Test 1**	**Test 2**	**Test 3**	**Mean**
100	4.34	5.20	4.32	4.6
200	5.93	5.99	5.86	5.9
300	7.01	7.12	7.08	7.1
400	8.23	8.22	8.25	8.2

(i) Before the mass is released, the spring stores energy.

What type of energy does the spring store?

Tick (✓) **one** box.

	Tick (✓)
Elastic potential energy	
Gravitational potential energy	
Kinetic energy	

(1)

(ii) The value of time for the 100 g mass in **Test 2** is anomalous.

Suggest **two** likely causes of this anomalous result.

Tick (✓) **two** boxes.

	Tick (✓)
Misread stopwatch	
Pulled the mass down too far	
Timed half oscillations, not complete oscillations	
Timed too few complete oscillations	
Timed too many complete oscillations	

(2)

(iii) Calculate the correct mean value of time for the 100 g mass in **Table 2**.

....

....

Mean value = ... s

(1)

(iv) Although the raw data in **Table 2** is given to 3 significant figures, the mean values are correctly given to 2 significant figures.

Suggest why.

....

....

....

....

(2)

(v) The student wanted to plot her results on a graph. She thought that four sets of results were not enough.

What extra equipment would she need to get more results?

....

....

....

....

(2)
(Total 17 marks)

31 Energy can be transferred through some materials by convection.

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

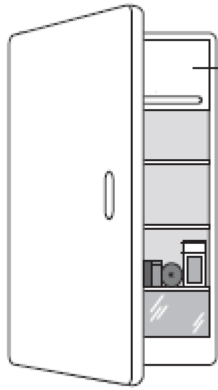
gas	**liquid**	**solid**

Energy **cannot** be transferred by convection through a ....

(1)

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

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



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

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

decreased	**unchanged**	**increased**

When the air near the freezer compartment is cooled, the energy of the air particles is ....

The spaces between the air particles are ....

The density of the air is ....

(3)

(c) The table below shows some information about three fridges, **A**, **B** and **C**.

The efficiency of each fridge is the same.

Fridge	**Volume in litres**	**Energy used in one year in kWh**
A	232	292
B	382	409
C	622	524

(i) Which fridge, **A**, **B** or **C**, would cost the least to use for 1 year? ☐

Give **one** reason for your answer.

....

....

(2)

(ii) A householder looks at the data in the table above.

What should she conclude about the pattern linking the volume of the fridge and the energy it uses in one year?

....

....

(1)

(iii) The householder could not be certain that her conclusion is correct for all fridges.

Suggest **one** reason why not.

....

....

(1)
(Total 8 marks)

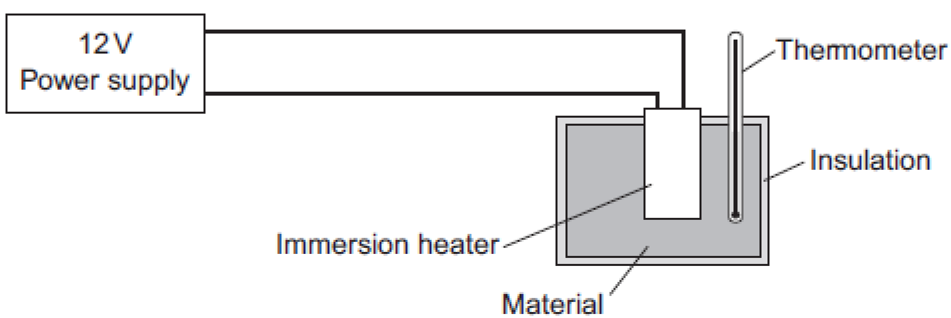
32 A student used the apparatus in **Figure 1** to compare the energy needed to heat blocks of different materials.

Each block had the same mass.

Each block had holes for the thermometer and the immersion heater.

Each block had a starting temperature of 20 °C.

Figure 1



The student measured the time taken to increase the temperature of each material by 5 °C.

(a) (i) State **two** variables the student controlled.

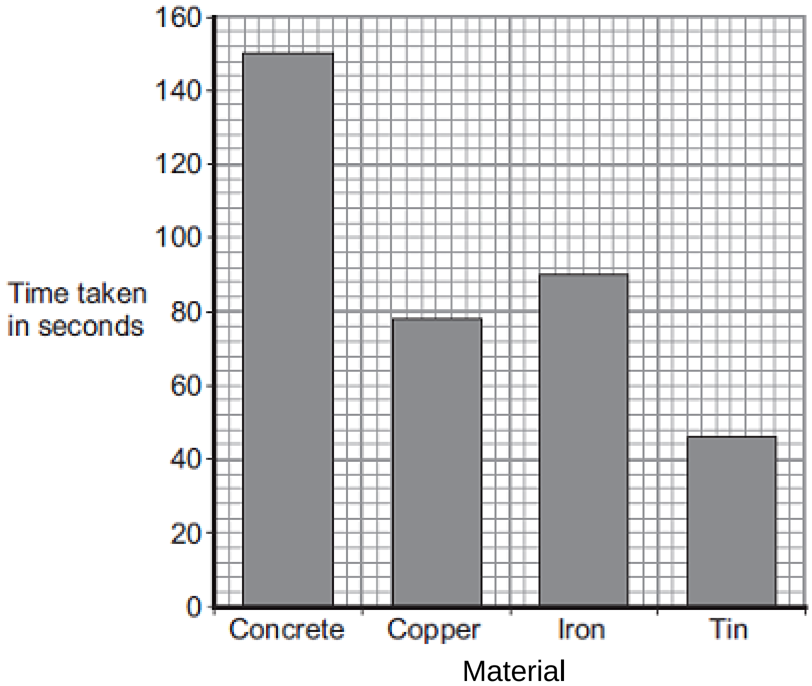
1 ....

2 ....

(2)

Figure 2 shows the student's results.

Figure 2



(ii) Why was a bar chart drawn rather than a line graph?

....

....

(1)

(iii) Which material was supplied with the most energy?

....

Give the reason for your answer.

....

....

(2)

(iv) The iron block had a mass of 2 kg.

Calculate the energy transferred by the heater to increase the temperature of the iron block by 5 °C.

The specific heat capacity of iron is 450 J / kg °C.

....

....

....

Energy transferred = ... J

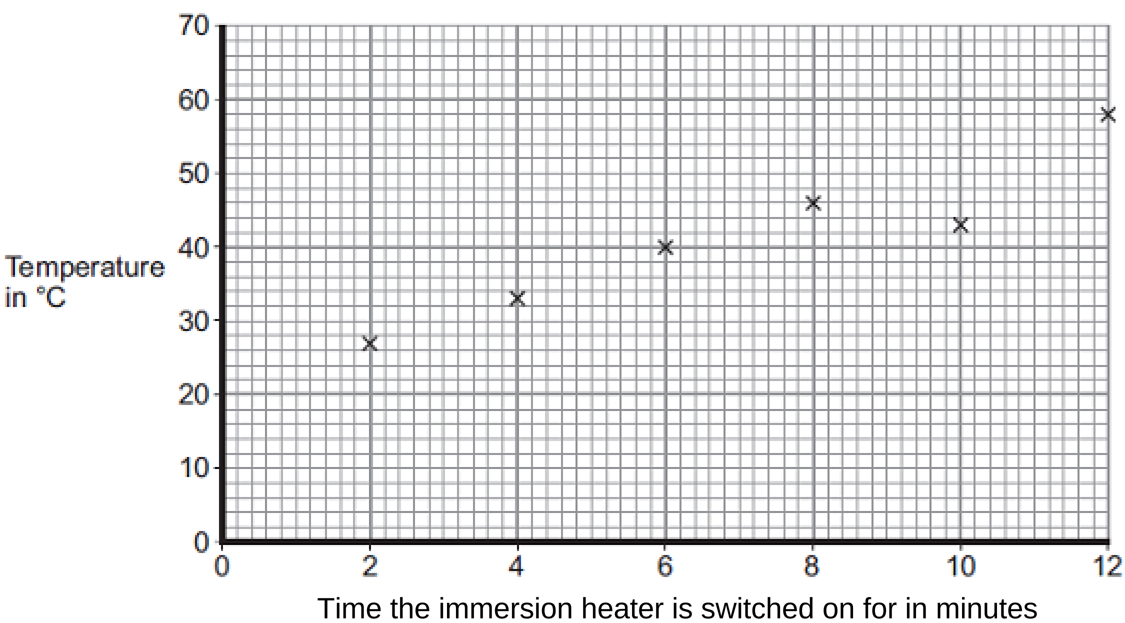
(2)

(b) The student used the same apparatus to heat a 1 kg block of aluminium.

He recorded the temperature of the block as it was heated from room temperature.

The results are shown in **Figure 3**.

Figure 3



(i) One of the student's results is anomalous.

Draw a ring around the anomalous result.

(1)

(ii) Draw the line of best fit for the points plotted in **Figure 3**.

(1)

(iii) What was the temperature of the room?

Temperature = ... °C

(1)

(iv) What was the interval of the time values used by the student?

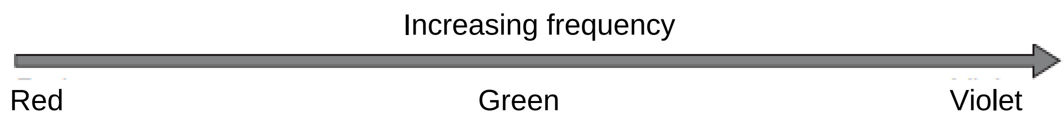
Interval = ... minutes

(1)
(Total 11 marks)

33 (a) The visible light spectrum has a range of frequencies.

Figure 1 shows that the frequency increases from red light to violet light.

Figure 1



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

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

As the frequency of the light waves increases, the wavelength

of the light waves .... and

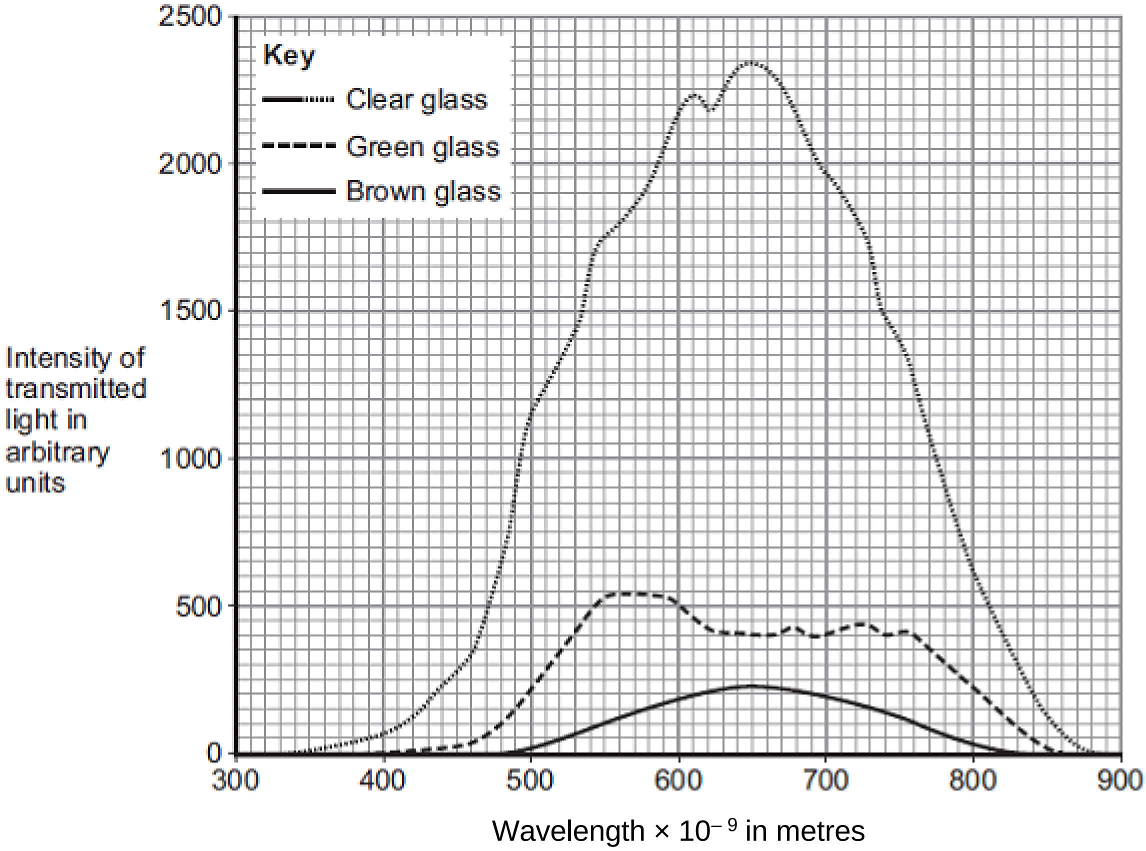
the energy of the light waves ....

(2)

(b) Bottled beer will spoil if the intensity of the light passing through the glass bottle into the beer is too high.

Figure 3 shows the intensity of the light that is transmitted through three different pieces of glass.

Figure 3



(i) The pieces of glass all had the same thickness.

Suggest why.

....

....

(1)

(ii) Bottles made of brown glass are suitable for storing beer.

Suggest why.

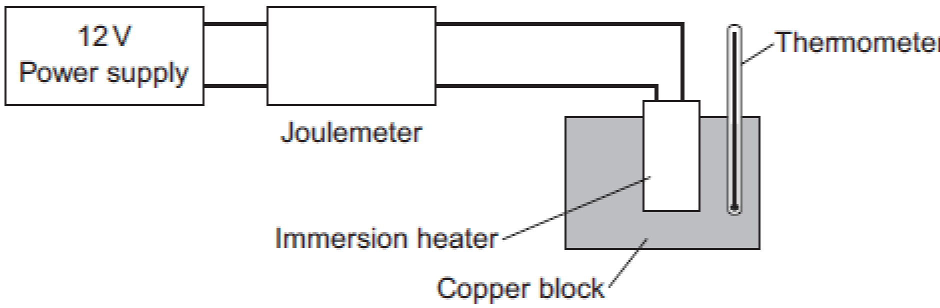
....

....

(1)
(Total 4 marks)

34 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.

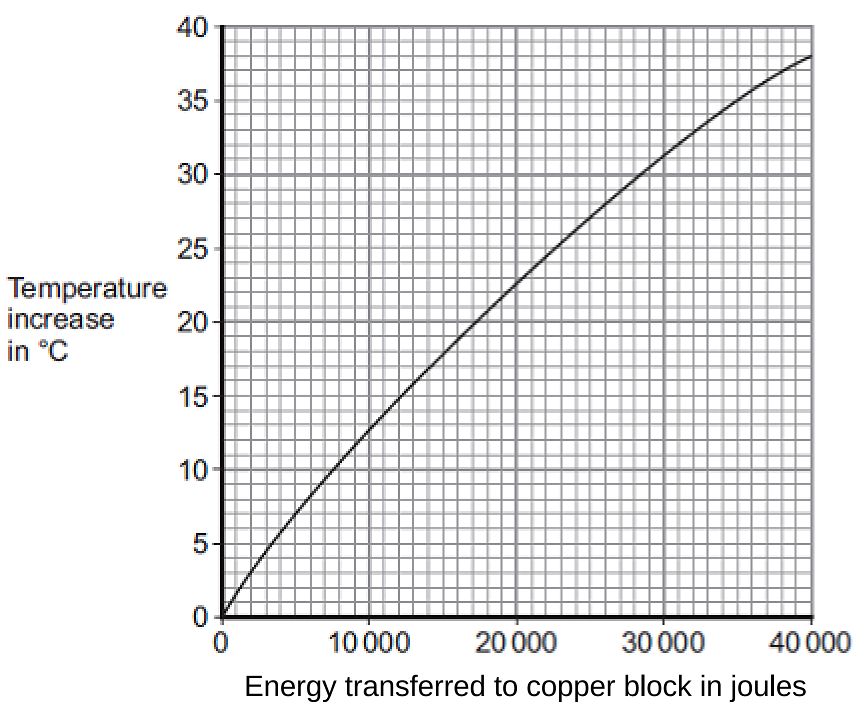
The energy transferred by the heater to the block was measured using the joulemeter.

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.

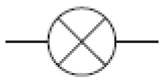
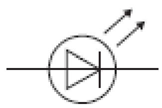
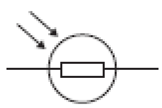
Suggest **one** reason why.

....

....

(1)
(Total 6 marks)

35 (a) Draw **one** line from each circuit symbol to its correct name.

Circuit symbol	**Name**
	Diode
	
	Light-dependent resistor (LDR)
	
	Lamp
	
	Light-emitting diode (LED)

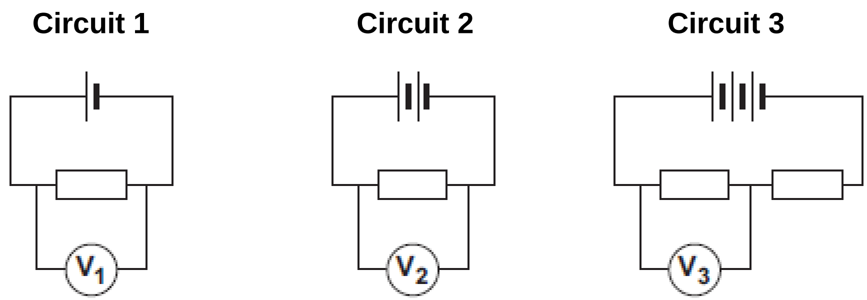
(3)

(b) **Figure 1** shows three circuits.

The resistors in the circuits are identical.

Each of the cells has a potential difference of 1.5 volts.

Figure 1



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

half	**twice**	**the same as**

The resistance of **circuit 1** is .... the resistance of **circuit 3**.

(1)

(ii) Calculate the reading on voltmeter $\mathbf{V_2}$.

....

Voltmeter reading $\mathbf{V_2}$ = ... V

(1)

(iii) Which voltmeter, $\mathbf{V_1}$, $\mathbf{V_2}$ or $\mathbf{V_3}$, will give the lowest reading?

Draw a ring around the correct answer.

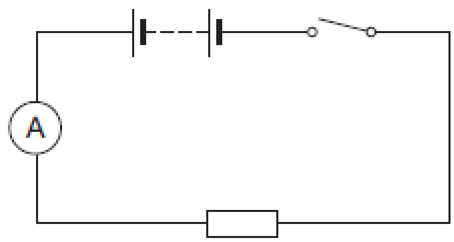
$\mathbf{V_1}$ $\mathbf{V_2}$ $\mathbf{V_3}$

(1)

(c) A student wanted to find out how the number of resistors affects the current in a series circuit.

Figure 2 shows the circuit used by the student.

Figure 2



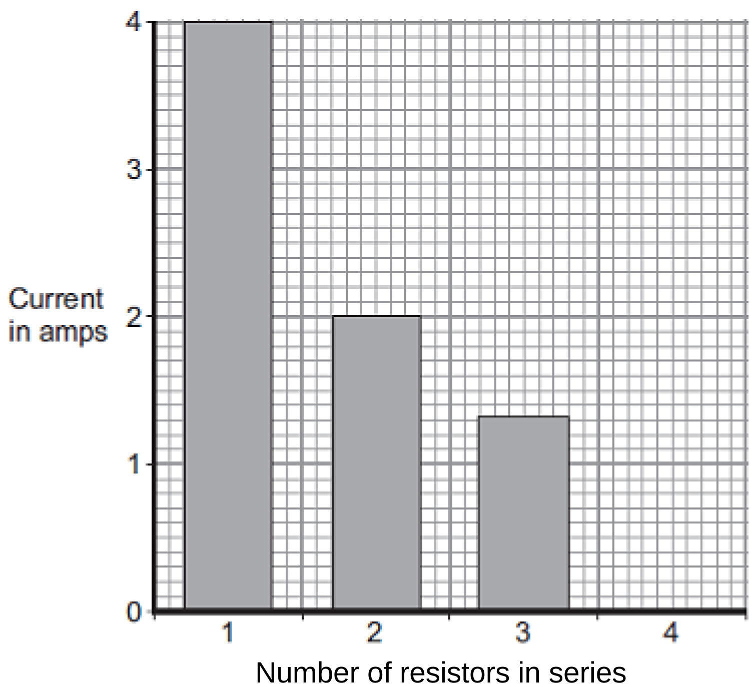
The student started with one resistor and then added more identical resistors to the circuit.

Each time a resistor was added, the student closed the switch and took the ammeter reading.

The student used a total of 4 resistors.

Figure 3 shows three of the results obtained by the student.

Figure 3



(i) To get valid results, the student kept one variable the same throughout the experiment.

Which variable did the student keep the same?

....

(1)

(ii) The bar chart in **Figure 3** is not complete. The result using 4 resistors is not shown.

Complete the bar chart to show the current in the circuit when 4 resistors were used.

(2)

(iii) What conclusion should the student make from the bar chart?

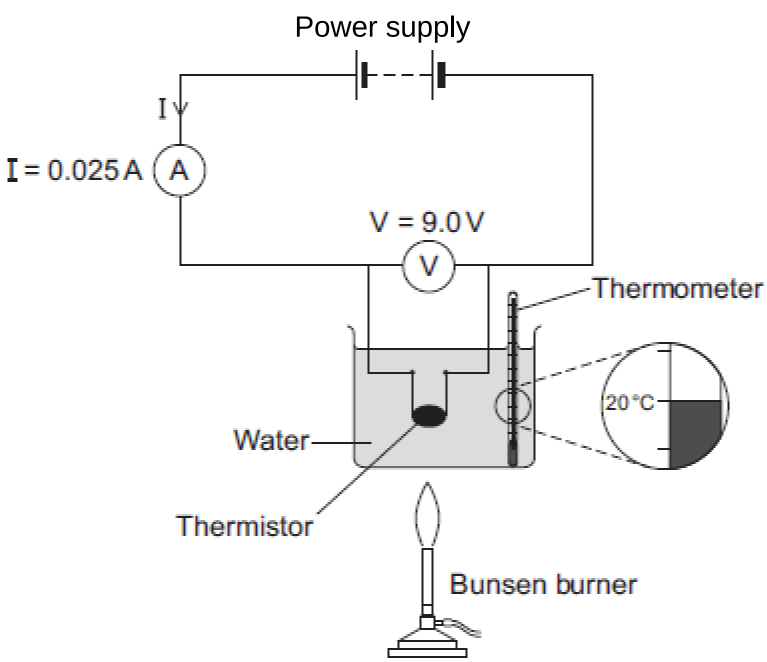
....

....

(1)
(Total 10 marks)

36 (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.

....

....

....

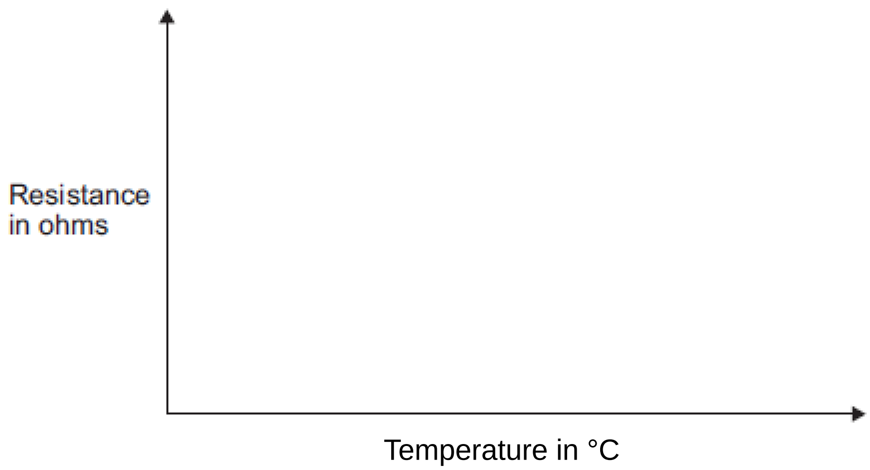
Resistance = ... ohms

(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.

....

....

....

....

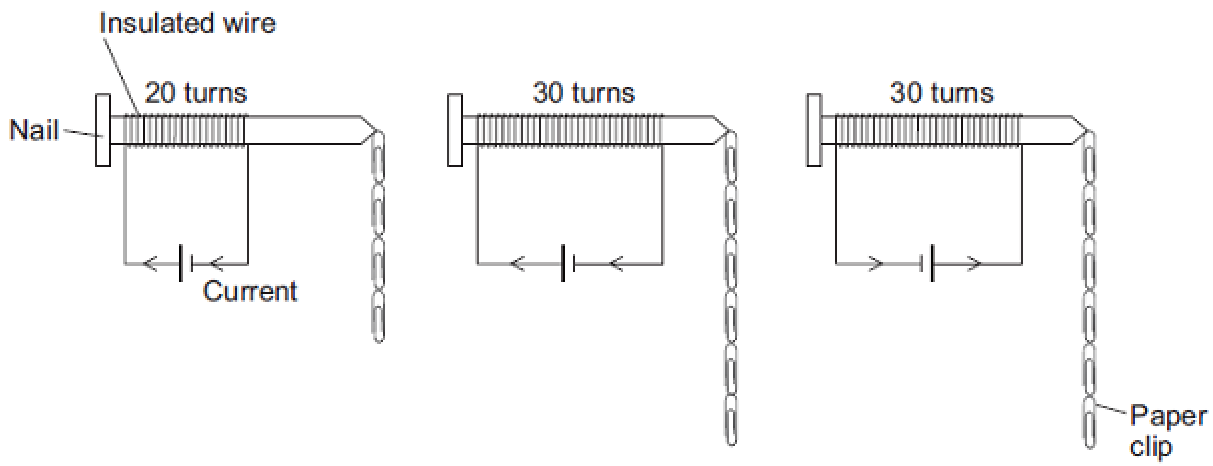
(2)
(Total 9 marks)

37 A student is investigating the strength of electromagnets.

Figure 1 shows three electromagnets.

The student hung a line of paper clips from each electromagnet.

Figure 1



Electromagnet **A** Electromagnet **B** Electromagnet **C**

No more paper clips can be hung from the bottom of each line of paper clips.

(a) (i) Complete the conclusion that the student should make from this investigation.

Increasing the number of turns of wire wrapped around the nail will ....

the strength of the electromagnet.

(1)

(ii) Which **two** pairs of electromagnets should be compared to make this conclusion?

Pair 1: Electromagnets .... and ....

Pair 2: Electromagnets .... and ....

(1)

(iii) Suggest **two** variables that the student should control in this investigation.

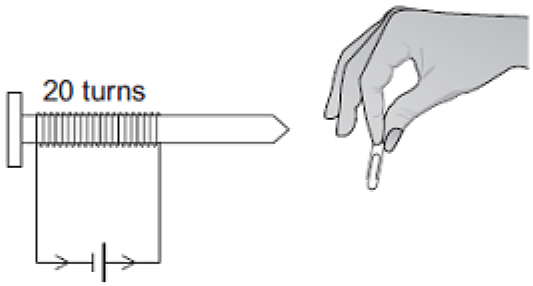
1 ....

2 ....

(2)

(b) The cell in electromagnet **A** is swapped around to make the current flow in the opposite direction. This is shown in **Figure 2**.

Figure 2



What is the maximum number of paper clips that can now be hung in a line from this electromagnet?

Draw a ring around the correct answer.

fewer than 4 **4** **more than 4**

Give **one** reason for your answer.

....

....

....

(2)

(c) Electromagnet **A** is changed to have only 10 turns of wire wrapped around the nail.

Suggest the maximum number of paper clips that could be hung in a line from the end of this electromagnet.

Maximum number of paper clips = ...

(1)
(Total 7 marks)

38 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.

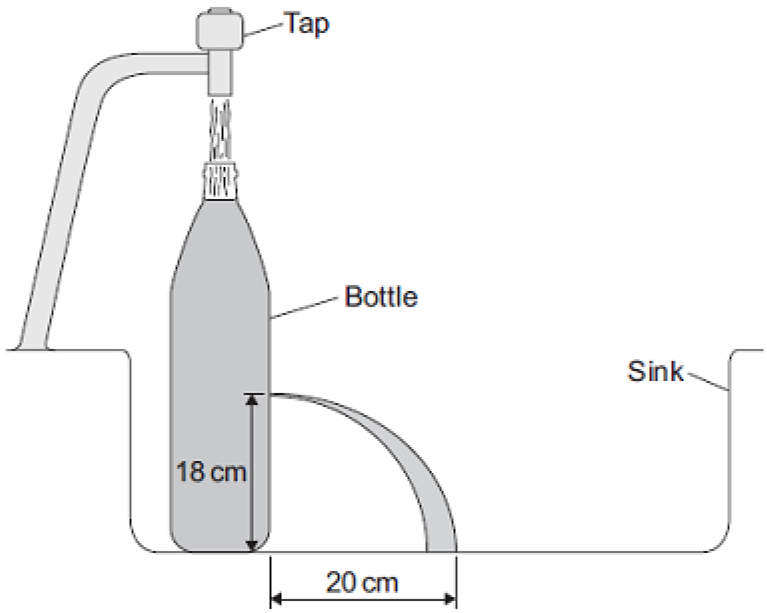
....

....

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.

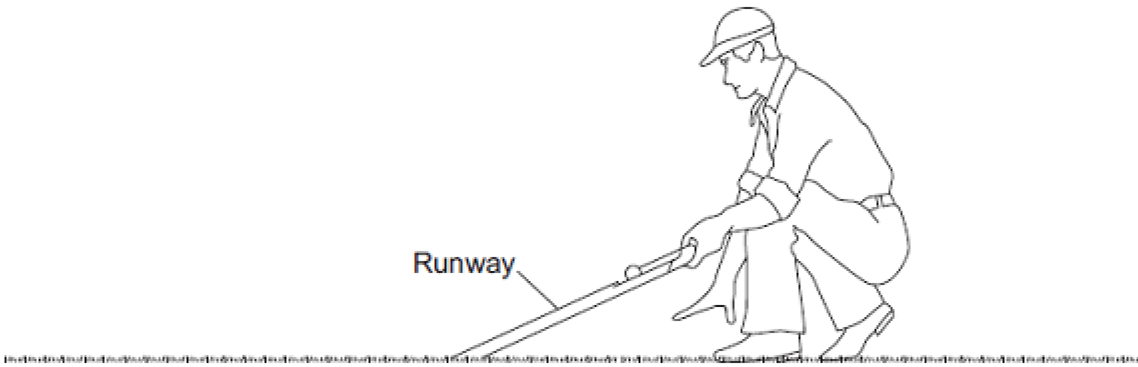
....

....

(1)
(Total 7 marks)

39 **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.

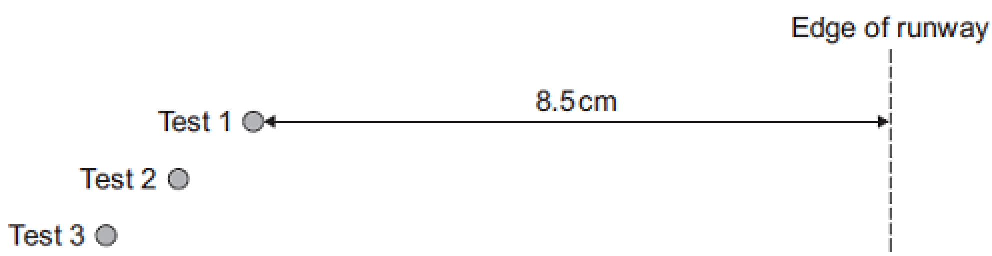
Figure 1



(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.

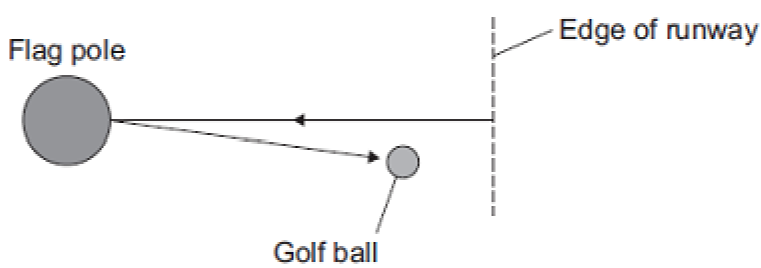
....

....

(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)

40 Electrical circuits have resistance.

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

When the resistance of a circuit increases, the current in the circuit

decreases.
increases.
stays the same.

(1)

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

a filament bulb	**an LED**	**an LDR**

An electrical component which has a resistance that increases as the

temperature increases is ....

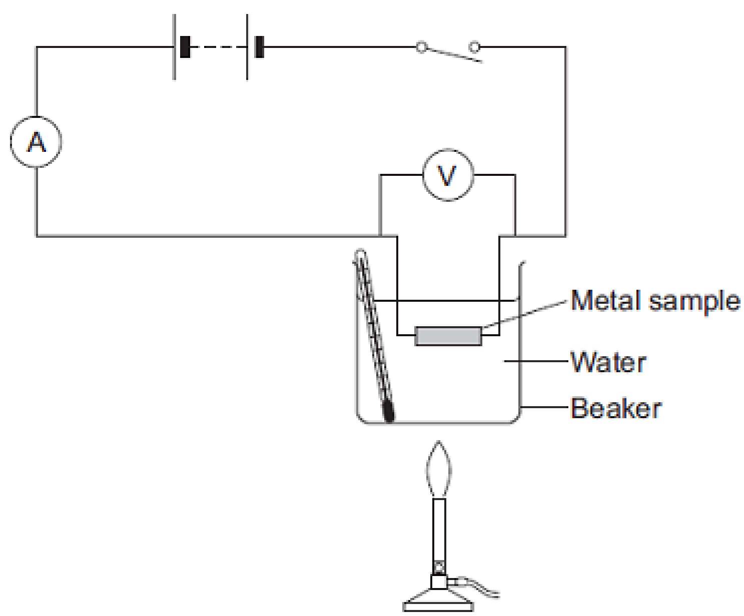
An electrical component which emits light only when a current flows through it

in the forward direction is ....

(2)

(c) When some metals are heated the resistance of the metal changes.

The equipment for investigating how the resistance of a metal changes when it is heated is shown in the diagram.



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

Describe an investigation a student could do to find how the resistance of a metal sample varies with temperature. The student uses the equipment shown.

Include in your answer:

- how the student should use the equipment
- the measurements the student should make
- how the student should use these measurements to determine the resistance
- how to make sure the results are valid.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

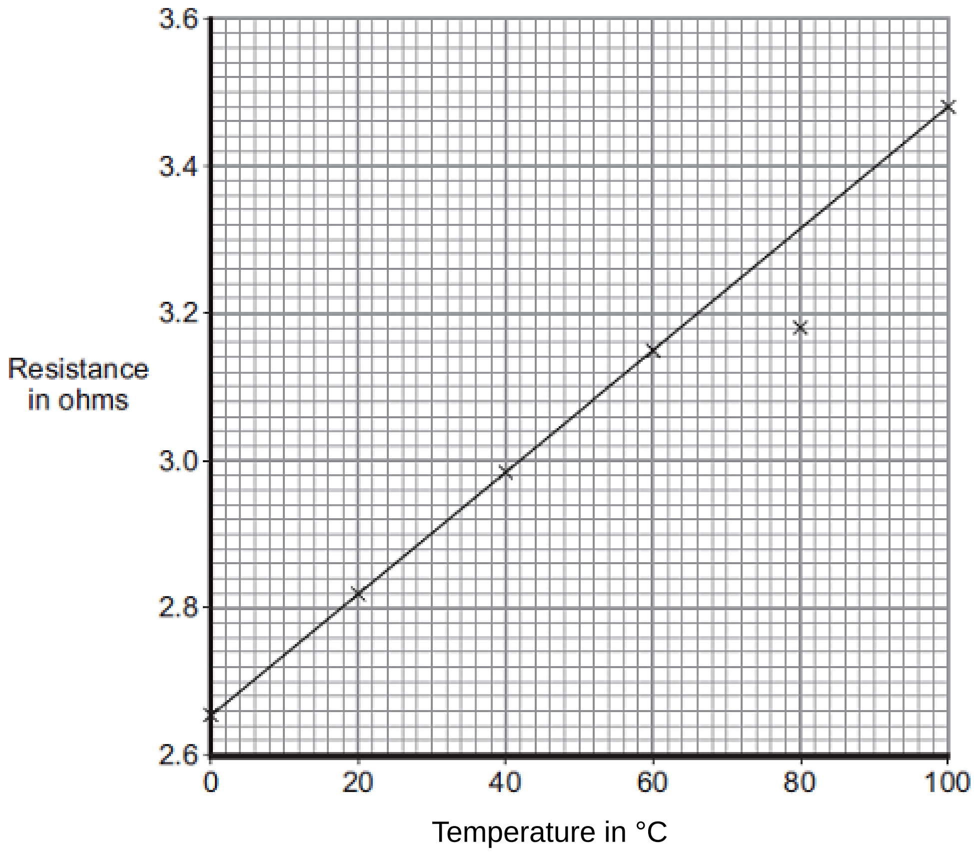
(6)

(d) The table shows some data for samples of four metals **P**, **Q**, **R** and **S**.

The metal samples all had the same cross-sectional area and were the same length.

Metal sample	Resistance at 0°C in ohms	Resistance at 100°C in ohms
P	4.05	5.67
Q	2.65	3.48
R	6.0	9.17
S	1.70	2.23

A graph of the results for one of the metal samples is shown.



(i) Which metal sample, **P**, **Q**, **R** or **S**, has the data shown in the graph? ☐

(1)

(ii) One of the results is anomalous. Circle this result on the graph.

(1)

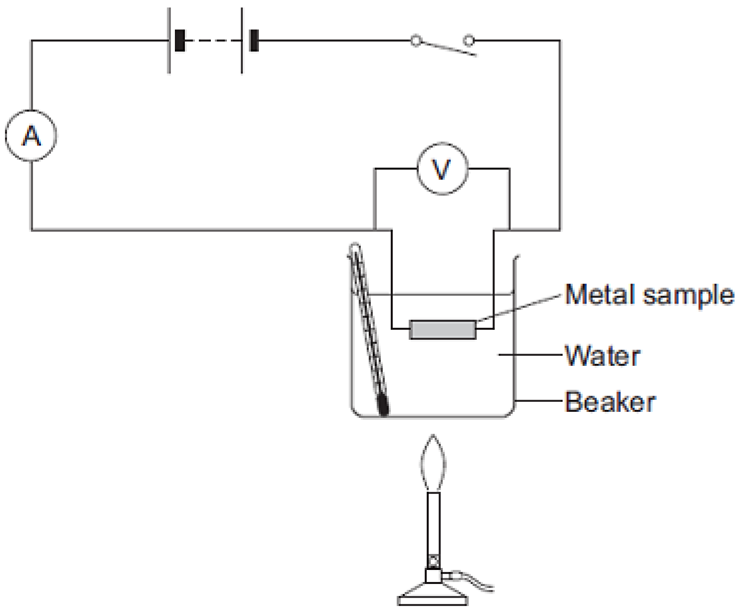
(iii) Suggest a reason for the anomalous result.

....

....

(1)

(iv) The same equipment used in the investigation could be used as a thermometer known as a 'resistance thermometer.'



Suggest **two** disadvantages of using this equipment as a thermometer compared to a liquid-in-glass thermometer.

1 ....

....

2 ....

....

(2)
(Total 14 marks)

Mark schemes

1 (a) battery, lamp and ammeter connected in series with variable resistor

1

voltmeter in parallel with (filament) lamp

1

(b) **Level 2 (3–4 marks):**
A detailed and coherent description of a plan covering all the major steps is provided. The steps are set out in a logical manner that could be followed by another person to obtain valid results.

Level 1 (1–2 marks):
Simple statements relating to relevant apparatus or steps are made but they may not be in a logical order. The plan would not allow another person to obtain valid results.

0 marks:
No relevant content

Indicative content

- ammeter used to measure current
- voltmeter used to measure potential difference
- resistance of variable resistor altered to change current in circuit **or** change potential difference (across filament lamp)
- resistance (of filament lamp) calculated **or** R=V / I statement
- resistance calculated for a large enough range of different currents that would allow a valid conclusion about the relationship to be made

4

(c) (as current increases) resistance increases (at an increasing rate)

1

(d) any value between 6.3 and 6.9 (Ω)

1

(e) **A**: Filament lamp

1

B: Resistor at constant temperature

1

C: Diode

1

[11]

2 (a) Alpha – two protons and two neutrons

1

Beta – electron from the nucleus

1

Gamma – electromagnetic radiation

1

(b) Gamma

Beta

Alpha

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

2

(c) any **two** from:

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

accept any other sensible and practical suggestion

2

(d) half-life = 80 s

1

counts / s after 200 s = 71

accept an answer of 70

1

(e) very small amount of radiation emitted

accept similar / same level as background radiation

1

[10]

3 (a) 0.1 (°C)

1

(b) power = energy transferred / time

allow P = E / t

1

allow E = P × t

(c) 1050 / 300

1

3.5 (W)

1

*accept 3.5 (W) with no working shown for **2** marks*

(d) 1050 = m × 4200 × 0.6

1

m = 1050 / (4200 × 0.6)

1

m = 0.417 (kg)

1

*accept 0.417 (kg) with no working shown for **3** marks*

(e) any **one** from:

- energy used to heat metal pan (as well as the water)
- energy transfer to the surroundings (through the insulation)
- angle of solar radiation will have changed during investigation
- intensity of solar radiation may have varied during investigation

1

[8]

4 (a) weight (lifted)

or

height (lifted)

1

(b) any **two** from:

- calculate a mean
- spot anomalies
- reduce the effect of random errors

2

(c) as speed increases, the efficiency increases

1

(but) graph tends towards a constant value

or

appears to reach a limit

accept efficiency cannot be greater than 100%

1

(d) heating the surroundings

1

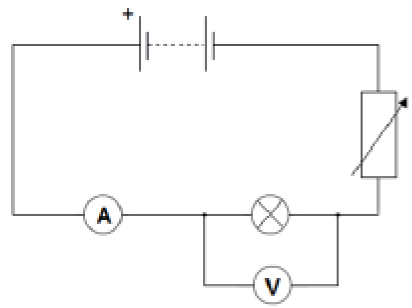
(e) 0 (%)

1

[7]

5

(a)



battery in series with bulb and ammeter

1

voltmeter in parallel with bulb

1

variable resistor

or

variable power pack

or

potentiometer

1

(b) A is brighter because it has a higher current (than lamp B at any p.d.)

1

(therefore A has a) higher power output (than bulb B)

accept higher energy output per second

1

(c) lower current (than lamp A) for the same potential difference

accept answer in terms of R = V / I

1

lower gradient (than lamp A)

1

(d) 0 – 2 Volts

allow a range from 0 V up to any value between 1 and 2 V.

1

(for an ohmic conductor) current is directly proportional to potential difference

allow lines (of best fit) are straight and pass through the origin

1

(so) resistance is constant

1

[10]

6

Level 3 (5–6 marks):
Clear and coherent description of both methods including equation needed to calculate density. Steps are logically ordered and could be followed by someone else to obtain valid results.

Level 2 (3–4 marks):
Clear description of one method to measure density **or** partial description of both methods. Steps may not be logically ordered.

Level 1 (1–2 marks):
Basic description of measurements needed with no indication of how to use them.

0 marks:
No relevant content.

Indicative content

For both:

- measure mass using a balance
- calculate density using $\rho = m / V$

Metal cube:

- measure length of cube's sides using a ruler
- calculate volume

Small statue:

- immerse in water
- measure volume / mass of water displaced
- volume of water displaced = volume of small statue

[6]

7

(a) induced

1

(b) bar 2

1

(the same end) of bar 1 attracts both ends of bar 2

or

only two magnets can repel so cannot be bar 1 or bar 3

1

(c) so the results for each magnet can be compared

or

so there is only one independent variable

fair test is insufficient

allow different thickness of paper would affect number of sheets each magnet could hold

accept it is a control variable

1

(d) because the magnet with the biggest area was not the strongest

accept any correct reason that confirms the hypothesis is wrong eg smallest magnet holds more sheets than the largest

1

[5]

8 (a) magnification = $\frac{\text{image height}}{\text{object height}}$

1

dividing by an object height of 1 cm gives the same (numerical) value

1

(b) accept anything practical that would work eg:

use a taller object

use a (travelling) microscope

attach a scale to the screen and use a magnifying glass

1

(c) both points plotted correctly

1

correct line of best fit drawn

a curve passing through all points (within ½ square), judge by eye

1

(d) values of 1.4 and 0.6 extracted from the graph

1

2.33 times bigger

accept any number between 2.3 and 2.5 inclusive

1

(e) by dividing the distance between the lens and the image by the distance between the lens and the object

1

at least one correct calculation and comparison eg 100÷25 = 4 which is the same as the measured magnification

1

[9]

9

Level 3 (5–6 marks):
A detailed and coherent plan covering all the major steps is provided. The steps in the method are logically ordered. The method would lead to the production of valid results.

A source of inaccuracy is provided.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

place a glass block on a piece of paper

draw around the glass block and then remove from the paper

draw a line at 90° to one side of the block (the normal)

use a protractor to measure and then draw a line at an angle of 20° to the normal

replace the glass block

using a ray box and slit point the ray of light down the drawn line

mark the ray of light emerging from the block

remove the block and draw in the refracted ray

measure the angle of refraction with a protractor

repeat the procedure for a range of values of the angle of incidence

possible source of inaccuracy

the width of the light ray

which makes it difficult to judge where the centre of the ray is

[6]

10 (a) **Level 3 (5–6 marks):**
A detailed and coherent plan covering all the major steps is provided. The steps in the method are logically ordered. The method would lead to the production of valid results.

A source of inaccuracy is provided.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

place a glass block on a piece of paper

draw around the glass block and then remove from the paper

draw a line at 90° to one side of the block (the normal)

use a protractor to measure and then draw a line at an angle of 20° to the normal

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remove the block and draw in the refracted ray

measure the angle of refraction with a protractor

repeat the procedure for a range of values of the angle of incidence

possible source of inaccuracy

the width of the light ray

which makes it difficult to judge where the centre of the ray is

6

(b) velocity / speed of the light decreases

allow velocity / speed of the light changes

1

[7]

11 (a) dependent

1

(b) (probe) C

allow 103.2

1

largest difference between reading and actual temperature

reason only scores if C chosen

accept larger

it is 3.2 greater is insufficient

comparing C with only one other probe is insufficient

1

(c) (i) 12(°C)

accept a value between 12.0 and 12.2 inclusive

1

(ii) 140 (seconds)

accept an answer between 130 and 150 inclusive

1

temperature starts to rise

only scores if time mark awarded

accept the temperature was lowest (at this time)

1

(iii) increase

accept faster (rate)

1

[7]

12 (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]

13 (a) gravity

accept weight for gravity

air resistance is insufficient

1

(b) (i) 800

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

$$P = \frac{2240}{2.8}$$

provided no subsequent step

2

(ii) 2240 J

1

(c) (i) (vertical) height

accept (height of) stairs

1

(ii) a fast / short time (for a lighter student) may give the greatest power

accept time is a factor

or

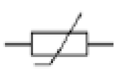
a slow / long time (for a heavy student) may give the least power

fitness is insufficient

1

[6]

14 (a) last box ticked



1

(b) (i) use hotter water (than 60 °C)

accept use boiling water

accept use water at any stated temperature above 60 °C

or

add ice cubes

accept add water at any stated temperature below 12 °C

use different temperatures is insufficient

1

(ii) the current increases as the temperature increases

1

(iii) 0.02 (A)

1

(iv) 5 (V)

or

their **(b)(iii)** × 250 correctly calculated

*allow **1** mark for correct substitution ie V = 0.02 × 250*

or

*V = their **(b)(iii)** × 250*

2

(v) the resistance increases

1

[7]

15 (a) starting / stopping the stopwatch

human error is insufficient

reaction time is insufficient

or

timing over the smaller distances

accept not timing accurately

do not accept references to measuring distance incorrectly

1

(b) (i) before

1

(ii) increasing

accept accelerating

it is not constant is insufficient

it is less than after four seconds is insufficient

it reaches a constant speed negates

1

(iii) calculate the gradient of the straight/steepest/constant section

accept gradient of any section after 5.5 seconds/30 cm

1

(iv) drag (force) increases (as the ball bearing gets faster)

accept frictional/upward force for drag

1

(until) drag (force) = weight

or

(until) resultant force is zero

accept upward force = downward force

accept till forces are balanced

1

(c) less than

1

ball bearing increases speed at a greater rate

accept it travels the same distance in less time

or

ball bearing has a greater acceleration

accept the ball bearing is going faster

or

terminal velocity has not been reached

1

so resultant force must be greater

or

as weight is the same (the drag must be less)

accept warmer oil has a lower density/viscosity for 1 mark if neither of the two reason marks score

1

[9]

16 (a) a magnetic field

accept electromagnetic field

heat is insufficient

1

that is alternating / changing

1

(b) 20

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

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

provided no subsequent step

2

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

allow energy / power is lost to the surroundings

allow energy / power is lost as heat / sound

power is lost is insufficient

1

(d) (i) 0.01 (V)

1

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

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

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

1

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

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

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

1

(iii) both sets of results show the same pattern

accept trend for pattern

results are similar is insufficient

results follow a pattern is insufficient

1

(iv) (electromagnetic) induction

accept it is induced

do not accept electric / magnetic induction

1

(e) any **one** from:

- more economical / cheaper for the consumer

  allow more convenient

- easier/cheaper to replace if broken/lost

  allow in case one gets lost

- since fewer transformers need to be made less resources are used

  allow fewer plug sockets are needed

  allow fewer transformers are needed

  environmentally friendly is insufficient

1

[11]

17 (a) rate of flow of water less

1

because pressure is less
or
because force acting is less
or
because height of water above tap is less

1

(b) (i) at short lengths water collected is the same

accept rate of flow for water collected

1

at longer lengths water collected decreases as the length of pipe increases

*if no other mark gained allow as the length increases the flow decreases for **1** mark*

1

(ii) **max 4 marks**

take more readings to calculate a mean (1)

take more readings is insufficient

to reduce effect of random errors (1)
or
take more readings between 5.0 m and 10.0 m (1)
see where the change occurs (1)
or
take more readings above 15.0 m (1)

accept take more readings at longer lengths

to see if trend continues (1)

*maximum of **2** marks for more readings and max **2** for reasons*

4

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

0 marks
No relevant content

Level 1 (1−2 marks)
There is a basic description of the measurement of time **or** volume **or** diameter of pipe

Level 2 (3−4 marks)
There is a description of the measurement of the time taken to collect a fixed volume **or** the volume collected in a fixed time
and a description of an additional control variable

Level 3 (5−6 marks)
There is a description of the measurement of the time taken to collect a fixed volume **or** the volume collected in a fixed time
and a description of an additional control variable
and a description of appropriate equipment

examples of the points made in the response
equipment
- tape measure or rule
- stopwatch
- container for collecting water
- measuring cylinder.

measurements
- diameter of hosepipe
- length of hosepipe
- volume of water collected
- time taken for collecting water
- repeat for different diameters.

control factors
- height of water in water butt (achieved by using a tap)
- length of hosepipe and how it is achieved by measuring and cutting.

6

[14]

18 (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]

19

(a) 20 790 (J)

*an answer of 21 000 (J) (2 s.f.) gains **2** marks*

*allow **1** mark for correct substitution:*
ie E = 0.33 × 4200 × 15 provided no subsequent step shown

2

(b) temperature

1

(c) (top pan) balance

accept scales

*do **not** accept a scale*
*do **not** accept weighing scales*
*do **not** accept newtonmeter*
*do **not** accept spring balance*

1

(d) dark / black / (dark) grey

1

convection

correct order only

1

(e) (i) created

accept made

1

(ii) increases

1

[8]

20

(a) (i) 0.5 °C

1

(ii) data is continuous
or
both variables are continuous
or
independent variable is continuous
or
time is continuous

accept results / measurements for data

accept data is not categoric

one variable is continuous is insufficient

air temperature is continuous is insufficient

1

(b) (i) 20.5 (°C)

1

(ii) 60 (minutes)

accept 1 hour

1

(c) (i) so a comparison can be made

or

outside temperature is a control variable

accept:

(outside) temperature would affect energy required (to maintain temperature of the house)

or

(outside) temperature would affect internal temperature (of the house)

or

heat loss will be faster on a cold day

outside temperature will affect the results is insufficient

fair test is insufficient

1

(ii) the cost is equal to the number of kWh × the cost per kWh

accept (heating) bill depends on (number of) kWh used

accept energy for kWh

1

calculation 0.8 / 8.0 = 0.1 or 10%

allow 7.2 / 8.0 = 0.9 or 90%

1

(iii) heating is on for more / less time (than anticipated)

1

because some days it is cooler / warmer (than anticipated)

accept other sensible suggestions

*an answer giving two sensible situations gains **2** marks*

possible examples:

- *some houses have different amounts of insulation*
- *there are different styles of house*

temperature (inside / outside) is always changing is insufficient

1

[9]

21 (a) 1.25

*accept 1.3 for **2** marks*

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

ie $\frac{1}{0.8}$

provided no subsequent step shown

2

(b) (i) increasing the length (of the pendulum) decreases the number of oscillations / swings made (in 20 seconds)

accept increasing the length (of the pendulum) increases the time (of 1 oscillation / swing)

accept increasing the length (of the pendulum) decreases the speed / frequency (of 1 oscillation / swing)

answers must refer to the effect of increasing / decreasing length

ignore references to time being proportional to length

1

changing the mass (of the pendulum bob) does not change the number of oscillations / swings made (in 20 seconds)

accept changing the mass does not change the time / speed / frequency / results

accept weight for mass

1

(ii) any **two** suitable improvements:

- measure (the number of swings) over a wider range of (pendulum) lengths
- measure (the number of swings) over a wider range of (bob) masses
- measure the number of swings made over a greater period of time
- repeat each measurement & calculate mean / average (number of oscillations in 20 seconds)

  accept repeat measurements & discard anomalous measurements

  repeat measurements is insufficient
- measure (the total number of swings &) the fraction of swings made
- start the swings at the same height.

  use a computer / datalogger to make measurement (of number of oscillations) is insufficient

  measuring time period is insufficient

  using a stop clock with greater resolution is insufficient

2

[6]

22 (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*

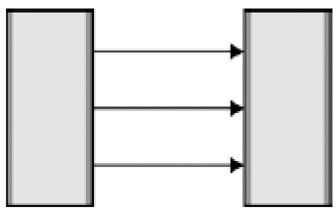
2

[8]

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

1

direction N to S



1

(ii) north poles repel

1

(so) box will not close

1

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

1

force levels off (after 50 sheets)

1

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

1

(iii) (top) magnet and newtonmeter separate before magnets separate

accept reverse argument

1

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

1

(iv) any **three** from:

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

3

(v) 3 (mm)

*30 × 0.1 ecf gains **2** marks*

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

3

[15]

24 (a) dark matt

1

light shiny

1

(b) B A C

1

biggest temperature difference (80 °C)

dependent on first mark

1

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

1

best absorber (of infrared radiation)

1

(ii) any **three** from:

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

3

(d) fox A

smaller ears

1

thicker fur

1

these minimise energy transfer

dependent on first 2 marks

1

[12]

25 (a) (i) any **six** from:

- switch on
- read both ammeter and voltmeter

  allow read the meters
- adjust variable resistor to change the current
- take further readings
- draw graph
- (of) V against I

  allow take mean
- R = V / I

  allow take the gradient of the graph

6

(ii) resistor would get hot if current left on

1

so its resistance would increase

1

(iii) 12 (V)

*0.75 × 16 gains **1** mark*

2

(iv) 15 (Ω)

1

16 is nearer to that value than any other

1

(b) if current is above 5 A / value of fuse

1

fuse melts

allow blows / breaks

*do **not** accept exploded*

1

breaks circuit

1

[15]

26 (a) (i) **X** placed at 50 cm mark

1

(ii) <u>point</u> at which mass of object may be (thought to be) concentrated

1

(b) (i) **Y** placed between the centre of the rule and the upper part of mass

1

(ii) 16.5

*allow for **1** mark*
(16.5 + 16.6 +16.5) / 3

2

1.65

value consistent with mean value given
only penalise significant figures once

1

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

0 marks
No relevant content

Level 1 (1 – 2 marks)
A description of a method which would provide results which may not be valid

Level 2 (3 – 4 marks)
A clear description of a method enabling some valid results to be obtained. A safety factor is mentioned

Level 3 (5 – 6 marks)
A clear and detailed description of experiment. A safety factor is mentioned. Uncertainty is mentioned

examples of the physics points made in the response:

additional apparatus

- stopwatch

use of apparatus

- measure from hole to centre of the mass
- pull rule to one side, release
- time for 10 swings and repeat
- divide mean by 10
- change position of mass and repeat

fair test

- keep other factors constant
- time to same point on swing

risk assessment

- injury from sharp nail
- stand topple over
- rule hit someone

accuracy

- take more than 4 values of *d*
- estimate position of centre of slotted mass
- small amplitudes
- discard anomalous results
- use of fiducial marker

6

(c) (i) initial reduction in *T* (reaching minimum value) as *d* increases

1

after 30 cm *T* increases for higher value of *d*

1

(ii) (no)

any **two** from:

- fourth reading is close to mean
- range of data 0.2 s / very small
- variation in data is expected

2

[16]

27 (a) pitch

1

loudness

1

(b) (i) as length (of prongs) decreases frequency / pitch increases

accept converse

accept negative correlation

ignore inversely proportional

1

(ii) 8.3 (cm)

accept 8.3 ± 0.1 cm

1

(iii) (8.3 cm is) between 7.8 (cm) and 8.7 (cm)

*ecf from part **(ii)***

1

(so *f* must be) between 384 (Hz) and 480 (Hz)

1

410 (Hz) ≤ *f* ≤ 450 (Hz)

*if only the estimated frequency given, accept for **1** mark an answer within the range*

1

(c) (i) electronic

1

(ii) frequency is (very) high

accept frequency above

*20 000 (Hz) **or** audible range*

1

so tuning fork ***or*** length of prongs would be very small (1.2 mm)

1

(d) 285.7 (Hz)

accept any correct rounding 286, 290, 300

*allow **2** marks for 285*

*allow **2** marks for correct substitution 0.0035 = 1 / f*

*allow **1** mark for T = 0.0035 s*

*allow **1** mark for an answer of 2000*

3

[13]

28 (a) (i) live

1

(ii) react faster

1

(iii) live and neutral

1

(b) (i) ammeter

1

to measure current

accept to measure amps

1

plus any **one** from:

- *variable resistor* (1)
  to vary current (1)
  accept variable power supply
  accept change or control
- *switch* (1)
  to stop apparatus getting hot / protect battery
  or
  to reset equipment (1)
- fuse (1)
  to break circuit if current is too big (1)

2

(ii) any **two** from:

- use smaller mass(es)
- move mass closer to pivot
- reduce gap between coil and rocker
- more turns (on coil) *coil / loop*
- iron core in coil

accept use smaller weight(s)

2

[9]

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

1

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

melt is insufficient

1

unit mass / 1kg

1

(ii) 5.1×10^6 (J)

accept 5×10^6

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

2

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

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

1

(ii) to distribute the salt throughout the ice

1

to keep all the ice at the same temperature

1

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

allow concentration for mass

accept negative correlation

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

1

(d) 60 000 (J)

accept 60 KJ

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

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

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

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

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

3

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

0 marks
No relevant content

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

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

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

examples of the points made in the response

extra information

energy storage

advantages:

- no fuel costs
- no environmental effects

disadvantages:

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

salt spreading

advantages:

- easily available
- cheap

disadvantages:

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

undersoil heating

advantages:

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

disadvantages:

- costly
- bad for environment

6 **[18]**

30 (a) (i) any **two** from:

- length of coils increased
- coils have tilted
- length of loop(s) increased
- increased gap between coils
- *spring has stretched / got longer*
- *spring has got thinner*

2

(ii) remove mass

accept remove force / weight

1

observe if the spring returns to its original length / shape *(then* it is behaving elastically)

1

(b) (i) 8.0 (cm)

1

extension is directly proportional to force *(up to 4 N)*

for every 1.0 N extension increases by 4.0 cm (up to 4 N)

evidence of processing figures eg 8.0 *cm* is half way between 4.0 *cm* and 12.0 *cm*

1

allow spring constant (k) goes from to $\frac{1}{4}$ to $\frac{5}{22}$

1

(ii) any value greater than 4.0 N and less than or equal to 5.0 N

1

the increase in extension is greater than 4 cm per 1.0 N (of force) added

dependent on first mark

1

(c) (i) elastic potential energy

1

(ii) misread stopwatch

1

timed too many complete oscillations

1

(iii) 4.3 (s)

accept 4.33 (s)

1

(iv) stopwatch reads to 0.01 s

1

reaction time is about 0.2 s
or
reaction time is less precise than stopwatch

1

(v) use more masses

1

smaller masses eg 50 g

not exceeding limit of proportionality

1

[17]

31 (a) solid

1

(b) decreased

correct order only

1

decreased

1

increased

1

(c) (i) A

reason only scores if A chosen

1

uses least / less energy (in 1 year)

a comparison is required

accept uses least power

accept uses least kWh

1

(ii) greater the volume the greater the energy it uses (in 1 year)

1

(iii) a very small number sampled

accept only tested 3

accept insufficient evidence / data

allow not all fridges have the same efficiency ***or*** *a correct description implying different efficiencies*

only tested each fridge once is insufficient

there are lots of different makes is insufficient

1

[8]

32 (a) (i) any **two** from:

- mass (of block)

  accept weight for mass
- starting temperature
- final / increase in temperature

  temperature is insufficient
- voltage / p.d.

  same power supply insufficient
- power (supplied to each block)
- type / thickness of insulation

  same insulation insufficient

2

(ii) one of variables is categoric

or

(type of) material is categoric

accept the data is categoric

accept a description of categoric

*do **not** accept temp rise is categoric*

1

(iii) concrete

reason only scores if concrete chosen

1

(heater on for) longest / longer time

a long time or quoting a time is insufficient

*do **not** accept it is the highest bar*

1

(iv) 4500 (J)

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

2 × 450 × 5 provided no subsequent step shown

2

(b) (i) point at 10 minutes identified

1

(ii) line through all points except anomalous

line must go from at least first to last point

1

(iii) 20 (°C)

if 20°C is given, award the mark.

If an answer other than 20°C is given, look at the graph. If the graph shows a correct extrapolation of the candidate's best-fit line and the intercept value has been correctly stated, allow 1 mark.

1

(iv) 2 (minutes)

1

[11]

33 (a) decreases

correct order only

1

increases

1

(b) (i) intensity (of transmitted light) depends on thickness

or

to enable a valid comparison

or

it is a control variable

accept absorption depends on thickness

it would affect the results is insufficient

fair test is insufficient

1

(ii) transmits the least light

or

absorbs the most light

accept very little light is transmitted

*do **not** accept transmits none of the light*

*do **not** accept absorbs all of the light*

any reference to heat negates this mark

1

[4]

34 (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

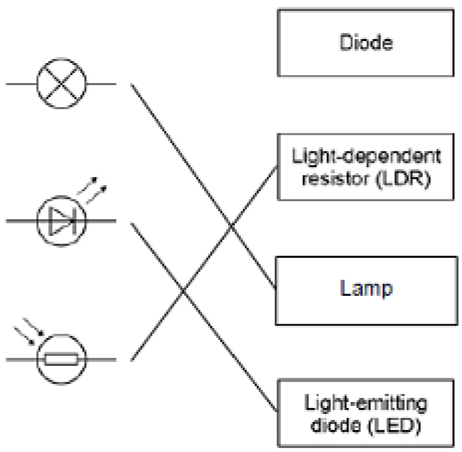
accept there is no insulation (on the copper block)

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

1

[6]

35 (a)



*allow **1** mark for each correct line if more than one line is drawn from any symbol then all of those lines are wrong*

3

(b) (i) half

1

(ii) 3(V)

1

(iii) V_1

1

(c) (i) potential difference / voltage of the power supply

accept the power supply

accept the voltage / volts

accept number of cells / batteries

accept (same) cells / batteries

do not accept same ammeter / switch / wires

1

(ii) bar drawn – height 1.(00)A

ignore width of bar

*allow **1** mark for bar shorter than 3rd bar*

2

(iii) as the number of resistors increases the current decreases

1

[10]

36 (a) (i)

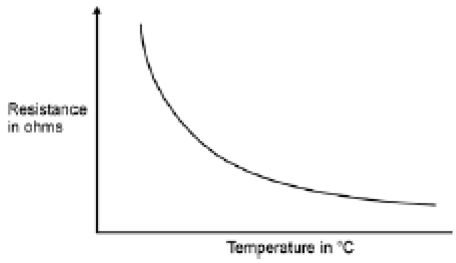
1

(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]

37 (a) (i) increase

1

(ii) A and B
and
B and C

both required for the mark

either order

1

(iii) any **two** from:

- size of nail
  or
  nail material
  allow (same) nail
- current
  allow (same) cell
  allow p.d.
  same amount of electricity is insufficient
- (size of) paper clip
- length of wire
  accept type / thickness of wire

2

(b) 4

1

B picks up the same number as C, so this electromagnet would pick up the same number as A
or
direction of current does not affect the strength of the electromagnet

allow it has got the same number of turns as A

1

(c) 2

allow 1 or 3

1

[7]

38 (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]

39 (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]

40 (a) decreases

1

(b) a filament bulb

allow bulb

1

an LED

1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response.

0 marks
No relevant content.

Level 1 (1−2 marks)
There is a basic description of the method. This is incomplete and would not lead to any useful results.

Level 2 (3−4 marks)
There is a description of the method which is almost complete with a few minor omissions and would lead to some results.

Level 3 (5−6 marks)
There is a detailed description of the method which would lead to valid results.
To gain full marks an answer including graph, or another appropriate representation of results, must be given.

examples of the physics points made in the response:

- read V and I
- read temperature
- apply heat

  allow hot water to cool
- read V and I at least one other temperature
- determine R from V / I
- range of temperatures above 50 °C

extra detail:

- use thermometer to read temperature at regular intervals of temperature
- remove source of heat and stir before taking readings
- details of attaining 0 °C or 100 °C
- last reading taken while boiling
- graph of R against T
- at least 3 different temperatures

6

(d) (i) Q

1

(ii) (80, 3.18)

1

(iii) any **one** from:

- measurement of V too small
- measurement of I too big
- incorrect calculation of R
- thermometer misread

  allow misread meter

  ignore any references to an error that is systematic

1

(iv) any **two** from:

- not portable

  allow requires a lot of equipment allow takes time to set up
- needs an electrical supply
- cannot be read directly

  accept it is more difficult to read compared to liquid-in-glass

2

[14]

Examiner reports

11

(a) Just over a third of students scored this mark. The most common incorrect answer was control.

(b) Almost three quarters of students scored the mark for choosing probe C, a lot of students found it difficult to articulate their ideas to explain their choice. A common incorrect answer was that C was an anomaly, or was inaccurate because it was above 100^{0}C and the temperature should have been going down, not up. Just over a third of students scored both marks.

(c) (i) Just over half of students scored this mark. Some students incorrectly read the scale and were outside the tolerance; others misunderstood the graph and stated 20 °C or 13.5 °C.

(ii) A quarter of students scored only 1 mark by stating the correct time, but a fifth of students scored both marks.

(iii) Half of students scored this mark, most incorrect responses stated the opposite effect, that rate of evaporation would be lower.

12

(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.

13

(a) The majority of the students scored this mark.

(b) (i) This was well answered by the majority of the students. Those who attempted it and failed to score a mark usually multiplied the numbers rather than dividing.

(ii) The vast majority of the students thought that the g.p.e. gained would be 'much more' or 'much less' than 2240J and so did not score the mark.

(c) (i) About half of the students scored this mark, with most referring to the number, size or height of the stairs.

(ii) Very few of the students scored this mark. Few appreciated that the power developed depends upon both weight and time taken. Some students hinted at this by referring to fitness or muscle development but a clear statement referring to time taken was needed. Those few who referred to the pattern sometimes failed to gain a mark by referring to heavy students running up in a short time. This would have given them a high power output which fits the pattern of the four students in the question.

14

(a) Under half of the students could identify the circuit symbol for a thermistor.

(b) (i) About a quarter of the students scored this mark. The main errors were either the students realising that different temperatures would increase the range but not stating that the additional temperatures should be outside the range shown on the graph line, or, more regrettably, responding in terms which indicated that they thought the component was some type of immersion heater and that more current inputted would increase the range.

(ii) This question produced surprisingly few correct answers with many students being unable to identify the positive correlation between the temperature change and the current. A significant number of the students did not attempt this question.

(iii) Most students were able to use the graph to give the correct current.

(iv) Again many students did not attempt this question. Of those that did over a half scored both marks by using their answer from [b][iii] to correctly multiply the current by the resistance to find the potential difference across the thermistor. However, many of the students either multiplied or divided a combination of the figures available, ie. the current, temperature and resistance.

(v) Less than half of the students scored this mark.

15 **Foundation**

(a) Many students were distracted by the markings on the tube and answered in terms of the marks not being the stated distance apart or by the fact that each individual centimetre was not marked. Other common errors were the weight of the ball bearing or the opacity of the oil. Too many students were happy with a one word answer such as 'stopwatch'. To score the mark the students needed to state what it was about the use of the stopwatch that led to an error being made.

(b) (i) The majority of the students gave an incorrect answer, 'after' being the most popular choice.

(ii) Many of the students answered this in terms of describing how the distance varied with time during the first 4 seconds. Only about one third of the students scored the mark.

(iii) A substantial number of students did not attempt this question. Virtually none of the students who did attempt the question gave a correct answer. The most common error was not identifying that the terminal velocity was shown by the straight part of the graph. Even the very few who mentioned gradient or steepness failed to identify which part of the graph had to be used. The most common answer was simply to quote distance/time.

(iv) A small number of students received partial credit for this question, mostly through realising that the force of drag would become equal to the force due to the weight. However few articulated that the drag would increase. As in previous papers, there is still a common misconception that when forces on a moving object become balanced, the object become stationary.

(c) Many of the students did pick the correct answer from the three options but made no attempt at an explanation. Of those who did try it was pleasing to see that the majority had recognised that the ball bearing took less time to fall a particular distance in the warmer oil and this meant there was less drag. It was rare to see any reference to resultant force or to the weight of the ball being constant.

Higher

(a) This was answered well with about half of the students understanding that the error would be in the timing. Some students misunderstood the experimental set-up and thought the tube had been labelled incorrectly and should have had 10 at the bottom and 60 at the top like a measuring cylinder.

(b) (i) About half of the students scored this mark.

(ii) Most of the students' answers used phrases that were implied variations of the wording on the mark scheme. The most common being 'it is getting faster'. A significant minority did not read the question about 'during the first four seconds' and mentioned constant speed/terminal velocity. Many students said, as the distance increased, so did the time so the response was not sufficiently unambiguous to score the mark.

(iii) Very few students scored this mark. Many students had the right idea but missed gaining the mark by writing either 'work out the gradient', or 'use the straight line part', but not putting both ideas together. Most students who used specific values were working out average velocity, from (0,0) choosing coordinates after the velocity had become constant, but not appreciating that it needed change in y/change in x, all on the constant gradient section.

(iv) Around one fifth of the students scored both marks with a further two fifths scoring one mark. Many of the students did understand the idea of upward force balancing downward force although the phrase 'resultant force = 0' was rarely seen. Drag = weight was the most common answer with a wide variety of phrases describing 'balance'. The idea that the drag force increases was seen less often. Too many students were unspecific about how the weight and the drag force become equal. Unfortunately many students were confused about resultant force and said that ‘the resultant force was equal’ when they meant that the resultant force was 0 (the forces were balanced).

(c) Very few of the students scored 3 marks, although nearly two thirds of the students scored 2 marks, not always having accessed the mark for ‘less than’. Answers 'equal to' were rare and usually failed to score any further marks. The most usual reasons were 'ball going faster' and about travelling the same distance in less time. Few students gained the mark for recognising that the weight was the same or that the resultant force must be greater, although the former was the more frequent of the two. Quite a few answers described the weight changing. A few students mentioned the viscosity of the oil. There was still the misconception that a particle expanding was the reason for decreasing density. Some students mistakenly thought that the line of the ball in warmer oil had become straight towards the end.

16 **Foundation**

(a) Less than a quarter of students realised that a magnetic field was produced, whereas other students thought that a current or p.d. was produced in the iron core. It was not common for students to gain the mark for realising that the magnetic field produced would be changing.

(b) This calculation was handled well by students, with just under three quarters gaining both marks.

(c) Many students confused the loss of power with it being a step-down transformer. The most common way of students gaining the mark was for noting that energy is transferred by heating. Just under one fifth of students answered correctly.

(d) (i) Few students were able to correctly identify the resolution, although many more students were along the right lines, with an answer of 2 decimal places occurring regularly. The reason for this being appropriate was less well answered with many students answering how they knew that this was the resolution, rather than answering the question of why this was a suitable resolution for this experiment. Just under a fifth of students gained marks on this question.

(ii) Just under one tenth of students correctly stated why the results were different.

(iii) Slightly more than a tenth of students answered this question correctly. Many students thought that a lack of anomalous results made the experiment reproducible, or just the fact that two students had carried out the experiment made it reproducible. Many students just quoted numbers given in the table.

(iv) Induction was clearly something which students struggled with, and the question was only attempted by about two thirds of students. Only a few students knew the name of the process.

(e) Just over half of students were able to suggest an advantage of the transformer. It was not uncommon for those who got the question wrong to have just repeated the stem of the question.

Higher

(a) Approximately two thirds of students realised that a magnetic field was produced, whereas other students thought that a current or p.d. was produced in the iron core. Only about a quarter of students realised that the magnetic field produced would be changing.

(b) This calculation was handled well by students, with the vast majority gaining both marks.

(c) Many students confused the loss of power with it being a step-down transformer. The most common way of students gaining the mark was for noting that energy is transferred by heating. Just under four tenths of students answered correctly.

(d) (i) Many students struggled to identify the correct resolution, although some were along the right lines, with answers of 2 decimal places or 0.00 occurring regularly. The reason for it being appropriate was less well done with many students answering how they knew that this was the resolution, rather than answering the question of why this was a suitable resolution for this experiment. Less than half of students gained marks on this question.

(ii) About a third of students answered this question correctly. Many students stated that part of the equipment being used was different, despite the stem of the question clearly stating that the two students used exactly the same equipment.

(iii) Just over a third of students answered this question correctly. Many students thought that similar results made it reproducible, rather than there being a similar pattern in results.

(iv) Fewer than half the students stated the correct process.

(e) Over two thirds of students suggested a correct advantage. Unrewarded responses frequently just repeated the stem of the question.

17 (a) Three-fifths of students scored both marks here, with a further fifth scoring one mark. The most common misunderstanding noted was that pressure was the same in all directions in water and so the height of the tap made no difference to flow rate.

Some students thought that the higher the tap, the greater the gravitational PE and so the faster the water would flow into the bucket.

A small minority suggested that pressure higher up the water butt was greater.
Most realised the correct answer to this and expressed it clearly, some referred to slower flow as opposed to rate of flow. A significant number of students expressed the reverse argument here that at depth there was more pressure.

A link (positive correlation) between distance to travel and rate of flow was a common incorrect answer, sometimes linked with speed = distance over time and possibly referring to some sort of idea about acceleration under gravity.

(b) (i) Most students gained at least one mark on this section and nearly half scored both marks; only a very few scored no marks at all. The common mistake was to only look at the two end values and therefore talk about the flow rate or water collected as decreasing as the pipe gets longer without mentioning the initial section where the amount stays constant. Some students only referred to one section of the results, for instance by saying that ‘from 10 m the rate of flow decreases’ but not including reference to before 10 m.

Some students only quoted figures from the table, without recognising any relationships.

(ii) More than half of the students scored two or more marks but very few scored all four.

The reason for finding the mean was often incorrectly stated as to find anomalies rather than to reduce the effects of random errors.

Other reasons for not gaining marks included describing extensions to the experiment such as changing the diameter of the pipes, or for describing control measures that should be used in the experiment.

(c) The QWC question was well answered by students with most achieving Level 3 and gaining five or six marks for identifying the variables, suggesting suitable controls, and describing the equipment they would use in a clear, logical plan of the experimental procedure required. Where students did not gain marks it was usually by not including in the description the requirements bullet-pointed in the question. Some students did not include the additional equipment needed, in particular a stopwatch / timer and something in which to measure the volume of liquid collected, such as a large measuring cylinder. Sometimes descriptions of equipment used were vague but recognisable and did get the idea across of how the water could be collected and measured. Students who scored low marks did not include a control either of the length of the hosepipe or the initial amount of water in the butt. Some students did not say that they were measuring the water collected in a fixed time, or timing how long it took to collect a fixed volume.

18 (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.

19

(a) The majority of students made the correct substitution and calculated the correct answer. The most common mistakes were dividing one of the quantities or using only two of the three quantities.

(b) Just over half the students inserted the word ‘temperature’ in order to correctly complete the definition of specific heat capacity. The most common mistake was to insert the word ‘mass’.

(c) Very few answers were seen mentioning ‘balance’ or ‘top pan balance’; of the correct answers, ‘scales’ was the most common response, although only one quarter of students gained the mark.

A number of students confused mass and weight and consequently gave answers such as spring balance, weighing scales or newtonmeter.

There were many offerings of all kinds of laboratory equipment such as rulers and measuring cylinders, and a significant number made no attempt to provide an answer.

(d) Given that the diagram showed cooling fins that were a dark grey a surprisingly large number of students wrote the opposite for the first space e.g. light / shiny. The words ‘matt’ or ‘dull’ were often given without stating any colour, which was insufficient.

The second marking point saw fairly equal numbers of conduction, convection and radiation. There are a significantly large number of students who confuse the methods of energy transfer.

(e) (i) Only about a quarter of students supplied the correct answer of ‘created’ or ‘made’. Many answers offered synonyms for ‘destroyed’.

(ii) Many students thought that the temperature of the air around the cooling fins decreases, possibly showing a fundamental misconception regarding energy transfer, or it may have been that students thought ‘cooling fins’ cooled the air. Almost half of students answered the question correctly. Some of the weaker students stated that the air became cooler because the can was cooling the air.

20

(a) (i) Most students opted for the incorrect answer of 1 °C. The correct answer of 0.5 °C was chosen by just over a quarter of students.

(ii) This question was poorly answered. Very few students suggested that the data was continuous: most answered in terms of clarity or accuracy of the presentation of the data. Many thought that it was not appropriate to draw a bar chart as bar charts 'were not accurate'.

It is surprising that a similar question on an ISA paper will usually elicit the correct response; yet students seem unable to transfer this knowledge to a question on a written paper.

(b) (i) Over half of students correctly identified the temperature at which the heating was switched on.

(ii) Students found this question more difficult than (i), only a third of students could determine the number of minutes for which the heating was switched on.

(c) (i) The idea of a 'fair test' was by far the most common response, but gained no credit.

Most correct answers were written in terms of the outside temperature affecting the inside temperature. The idea of a control variable was rarely seen. One fifth of students scored the mark on this question.

Some students confused the terms 'heat' and 'temperature' which meant their answers were too vague for credit to be given.

Many students didn't show the calculation of the 10%. A number of students incorrectly stated that the amount was close to 10% but not quite or just repeated the article wording and the 2 values without justifying them. Few students gained the first marking point linking the bill to the amount of energy used. One fifth of students scored 1 mark for this question. Very few scored both marks.

(iii) Many students struggled with this question, only a quarter of students gained 1 mark.

Few students made any reference to the fact that the heating may need to be on for a different length of time in a different situation. Most marks were gained for recognising that there could be different outside temperatures on different days.

A significant number of students answered using sensible suggestions mainly amount of insulation, size of house. If two sensible situations were given 2 marks were awarded.

Those failing to gain credit often answered in terms of temperature but gave insufficient explanations. There seemed to be a common misconception that a thermostat was a kind of heater.

21 (a) This question was answered well, with nearly all of the students scoring both marks.

(b) (i) About half of the students scored both marks, with more than a third of the students scoring one mark. The most common reason for this was students who correctly wrote that mass did not affect the frequency of the pendulum, but then went on to write that length did affect the frequency of the pendulum without specifying how.

(ii) Just under a quarter of the students scored both marks with a further third of the students scoring one mark. It was quite common to see students repeating the experiment and expecting to gain marks for this without including the idea of averaging or checking for anomalies.

27 (a) Nearly all students knew that frequency determines the pitch of a sound and that amplitude determines the loudness of a sound.

(b) (i) Nearly all students correctly described the trend shown in the table of length of tuning fork prong and frequency.

(ii) Nearly all students correctly measured the length of a tuning fork prong.

(iii) Over half of the students were able to correctly estimate the frequency of the tuning fork measured in part (i) from a table listing prong lengths and frequency. Some students mistakenly assumed a relationship of direct proportionality between prong length and frequency.

(c) (i) Nearly all students knew that ultrasound waves were produced by electronic systems.

(ii) Less than half of the students could explain that ultrasound waves could not be produced by a tuning fork because the very high frequency would require an extremely small fork according to the evidence given. Many wrote that ‘tuning forks can only produce frequencies within the human audible range’ so scored neither mark.

(d) Just under half of the students scored full marks for correctly determining a frequency from a trace on an oscilloscope screen. Many calculated frequency from 1 / 0.0005 instead of from 1 / (7 × 0.0005).

28 (a) (i) Well over three-quarters of students knew that a fuse is connected in the live wire of a circuit.

(ii) Nearly all students knew that RCCBs are sometimes preferred to fuses because they react faster.

(iii) Two-thirds of students knew that RCCBs operate by detecting a difference in the current between the live wire and the neutral wire.

(b) (i) Students were required to name two of the extra components that were to be included in the circuit in the figure to obtain the results shown in the table 4. Just under half of the students scored two marks for suggesting an ammeter to measure current. A further third of students scored another two marks usually for a variable resistor to vary current. Some students mentioned a balance to determine the mass of the masses, but this is not a circuit component.

(ii) About a third of students scored full marks for two changes that would allow smaller currents to be used in the investigation. Another third of students were only able to give one correct change to the investigation.

29 (a) Three-quarters of students knew why an energy storage system would work if the road surface was black. Many answers stated that ‘black surfaces absorb heat’ rather than ‘absorb heat well’.

(b) (i) A quarter of students gave a correct definition of specific latent heat of fusion. However, many incorrect responses referred to melting rather than a change from solid to liquid.

(ii) Nearly all students correctly calculated the amount of energy required to melt the ice.

(c) (i) Two-thirds of students correctly stated that the variable to be controlled was mass of ice. The remainder stated that the mass of salt had to be controlled.

(ii) Two-thirds of students correctly ticked two boxes with suggestions as to why the student stirred the crushed ice.

(iii) Nearly all students could correctly describe the pattern of how mass of salt added to some crushed ice affected the melting point of the ice.

(d) Just under half of students scored full marks for a calculation of energy transferred given values of power and time in non-SI units. Conversion from: kW to W; and minutes to seconds, was required. The spread of marks demonstrated this, with a third of students dropping one mark.

(e) The Quality of Communication question brought together the elements of the entire question and asked for advantages and disadvantages of using energy storage, salt and undersoil heating for keeping a road free from ice in the winter. Most students used the available space and many used additional pages.

Three-quarters of students scored four marks or more. Some excellent work was seen, but many students wasted time by repeating much of what was in the question. Also they ended a very good account with an unnecessary summary. Some very well written work only addressed either an advantage or a disadvantage of each system.

30 (a) (i) Over three-quarters of students correctly described two ways in which a spring changed shape when a mass was suspended from it. Some stated the same thing twice with ‘got longer’ and ‘extended’ or ‘bigger distance between the loops’.

(ii) Nearly three-quarters of students correctly described how the spring could be tested to see if it behaved elastically.

(b) (i) Nearly all students were able to score at least two out of three marks for completing **Table 1** with a value of extension and explaining their value.

(ii) Just less than half of the students correctly suggested a value of force at which the spring exceeded its limit of proportionality and gave a reason.

(c) (i) Nearly all students knew that the type of energy stored in the loaded spring was elastic potential energy.

(ii) Less than a third of students gave the correct two reasons out of five stating why a value in **Table 2** was anomalous.

(iii) Over four-fifths of students calculated the correct mean value of time in **Table 2** leaving out the anomalous value.

(iv) Hardly any students scored a mark where they were asked why raw values of time were given to three significant figures and mean values given to two significant figures. Instead of referring to the precision of a stopwatch and comparing this with human reaction time, they thought that it was something to do with making the plotting of a graph easier.

(v) Just under three-quarters of students correctly suggested that extra masses would be needed to get more results, but relatively few stated that that they should be smaller masses eg 50 g. Many of those who scored both marks also correctly referred to the value of force beyond which the spring may no longer behave elastically.

31 (a) Two thirds of the students could identify that convection cannot take place in a solid.

(b) A small proportion of the students correctly identified the changes in energy, spacing and density of air when it is cooled.

(c) (i) The majority of students were able to identify fridge A as costing the least to use and also stated it uses less energy. Students would benefit from remembering to use words which imply that a comparison with the fridges which were not chosen.

(ii) Just under a half of the students correctly stated that as the volume of the fridge increased the energy used in one year also increased. A common incorrect response was to state that the volume in litres was always less than the energy used in kWh, a little like comparing apples to oranges.

(iii) A small proportion of students appreciated that three fridges is too small a sample from which to draw conclusions for all other fridges.

32 (a) (i) About one third of the students correctly chose two control variables, a further quarter were able to identify one control variable. A common reason for not gaining marks was not being specific with their answers, e.g. simply saying 'temperature' rather than 'starting temperature'.

When a control variable is asked for, credit is not normally given for saying that the same equipment should be used, e.g. 'use the same thermometer each time'.

(ii) A low proportion of students appreciated that bar graphs are used when one of the sets of data is categoric. Most simply referred to the ease of comparing results or the ease of drawing bar graphs.

(iii) About half of the students identified that concrete needed the most energy to increase its temperature by 5°C. The majority of these recognised this was because the heater had been on for longer. Students were expected to compare the time for heating concrete with the times for the other materials and not simply state that the bar was higher or that it took a long time.

(iv) Three quarters of the students could correctly substitute into the appropriate equation and calculate the correct energy transfer.

(b) (i) Four fifths of the students correctly identified the anomalous result as the one after 10 minutes.

(ii) Many students did not appreciate that when a line of best fit is required any anomalous results are ignored. A line of best fit should have as many points below the line as above the line. Just over a half of students drew an acceptable line of best fit.

(iii) A third of the students appreciated that the block was at room temperature when the heater was switched on and were able to extrapolate their line of best fit back to the temperature axis and correctly record the intercept. Common incorrect responses were the lowest and highest plotted temperatures plotted on the graph.

(iv) About three fifths of the students knew that the interval is the time between each reading.

33 (a) About a third of the students correctly identified the change in the wavelength and energy of a light wave when its frequency is increased.

(b) (i) The majority of students failed to go further than stating the thickness was kept constant to make the test fair. A low proportion of students were able to state that the intensity of transmitted light depended on the thickness of glass and therefore needed to be controlled.

(ii) Many students were distracted by the fact that brown colours are good absorbers of thermal energy. About two fifths of the students correctly stated that brown glass had the smallest intensity of transmitted light.

34

(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.

35

(a) This was well answered with three fifths of the students scoring all three marks. There seemed no real pattern to the errors that were made.

(b) (i) Just over three fifths of the students scored this mark.

(ii) Only just over half of the students were able to correctly add the potential differences of the two cells. Many of the incorrect answers resulted from the students multiplying the potential differences together.

(iii) Nearly three fifths of the students scored this mark.

(c) (i) Only about a third of the students scored this mark. Many students failed to realise that the bar graph indicated both the number of resistors and current had changed and gave either of these quantities as the answer. Using the same ammeter was another common incorrect answer. A minority of students stated that the control variable does not change without actually identifying a control variable.

(ii) A majority of the students could see the pattern of reducing current and scored one mark for drawing a bar of reduced height. About a fifth of the students were able to score the second mark by accurately drawing this bar at the value of 1.0 amps.

(iii) Over four fifths of the students were able to express an answer in terms of ‘as the number of resistors increases, the current decreases’. Common errors were to have the two functions both increasing or both decreasing. Other unacceptable answers were that the number of resistors changed or affected the current without writing in which direction the change would be.

36 (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.

37 (a) (i) The vast majority of students correctly completed the conclusion.

(ii) A third of the students correctly identified the two pairs of electromagnets.

(iii) Most students were able to identify at least one of the variables that needed to be kept the same. However, some quoted the dependent variables, others gave vague responses of power / electricity rather than p.d. or current.

(b) Half of the students scored both marks for identifying the number of paperclips and a correct reason.

(c) Almost every student scored the mark.

38 (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.

39 (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.

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(a) Nearly all students knew that when the resistance of a circuit increases the current in it decreases.

(b) Nearly three-quarters of the students recognised the description of a filament bulb and a LED.

(c) The Quality of Communication question was a description of an experiment where the change in resistance of metal with temperature was investigated.

Many students wasted time, and used a substantial fraction of the answer lines, describing the electrical circuit provided. Just under half of the students scored four marks out of six for an adequate account that could be repeated to give sufficient data.

Students who scored more than four marks often included a graph of resistance against temperature or some detail such as removing the Bunsen burner and stirring the water before taking readings.

Those who scored three marks or less often did not state how resistance could be calculated from the meter readings, or did not state that the meters had to be read at all but that ‘resistance had to be recorded’ at each temperature.

(d) (i) Almost all students could relate a range of resistance values in a table to those represented on a graph.

(ii) Almost all students were able to circle an anomalous value on the graph.

(iii) Surprisingly, less than half the students were able to suggest a reason for the anomalous results such as misreading the thermometer or meters or incorrectly calculating resistance.

(iv) About a third of students were able to suggest a disadvantage of a resistance thermometer compared to a liquid-in-glass thermometer. About one tenth could suggest two, including the need for an electrical supply and that temperature could not be read directly.