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CONTENTS

Chapter 1: Forces and Motion
Question ---------- 3
Answer ---------- 77
Chapter 2: Electricity
Question ---------- 136
Answer ---------- 214
Chapter 3: Waves
Question ---------- 265
Answer ---------- 347
Chapter 4: Energy Resources and Transfers
Question ---------- 409
Answer ---------- 471
Chapter 5: Solids, Liquids and Gasses
Question ---------- 509
Answer ---------- 576
Chapter 6: Magnetism and Electromagnetism
Question ---------- 624
Answer ---------- 658
Chapter 7: Radioactivity and Particles
Question ---------- 677
Answer ---------- 733
Chapter 8: Astrophysics
Question ---------- 773
Answer ---------- 793

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Chapter 1: Forces and Motion Question

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1 A man uses a wheelbarrow to carry some logs along a flat path, as shown.



©http://commons.wikimedia.org/wiki/file:wheelbarrow_%28PSF%29.png

(a) He pushes with a horizontal force of 140 N and the wheelbarrow moves 39 m.

(i) State the relationship between work done, force and distance moved.

(1)

(ii) Calculate the work done moving the wheelbarrow.

(2)

work done = ... J

(iii) State how much energy is transferred to the wheelbarrow.

(1)

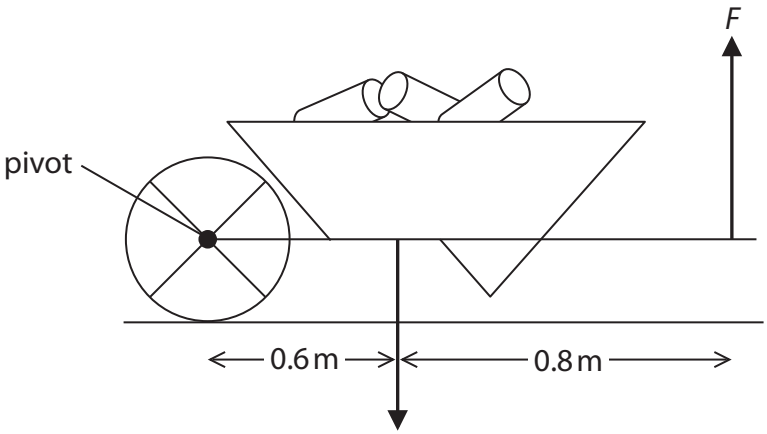
energy transferred = ... J

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(b) The man stops and holds the wheelbarrow horizontally, as shown.



The man exerts a total upward force of *F* N.

The weight of the loaded wheelbarrow is 470 N.

(i) Mark X on the diagram to indicate the centre of gravity of the loaded wheelbarrow.

(1)

(ii) State the equation linking moment, force and perpendicular distance from the pivot.

(1)

(iii) Calculate the force *F*.

(4)

force *F* = ... N

(Total for Question 1 = 10 marks)

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2 The photograph shows a hammer just before it hits a nail.



(a) The mass of the hammer is 0.50 kg.

When it hits the nail, the hammer is travelling downwards with a velocity of 3.1 m/s.

(i) State the relationship between momentum, mass and velocity.

(1)

(ii) Calculate the momentum of the hammer.

(2)

momentum = ... kg m/s

(iii) The hammer stops quickly when it hits the nail.

The momentum of the hammer reduces to zero in 0.070 s.

Calculate the amount of force that causes this to happen.

(2)

force = ... N

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(b) As it enters the wood, the nail exerts a force on the wood.

At the same time, the wood exerts a force on the nail.

Explain how these two forces are related.

(2)

(c) Both ends of the nail exert pressure when the nail goes into the wood.



Explain why the nail exerts more pressure on the wood than it does on the hammer.

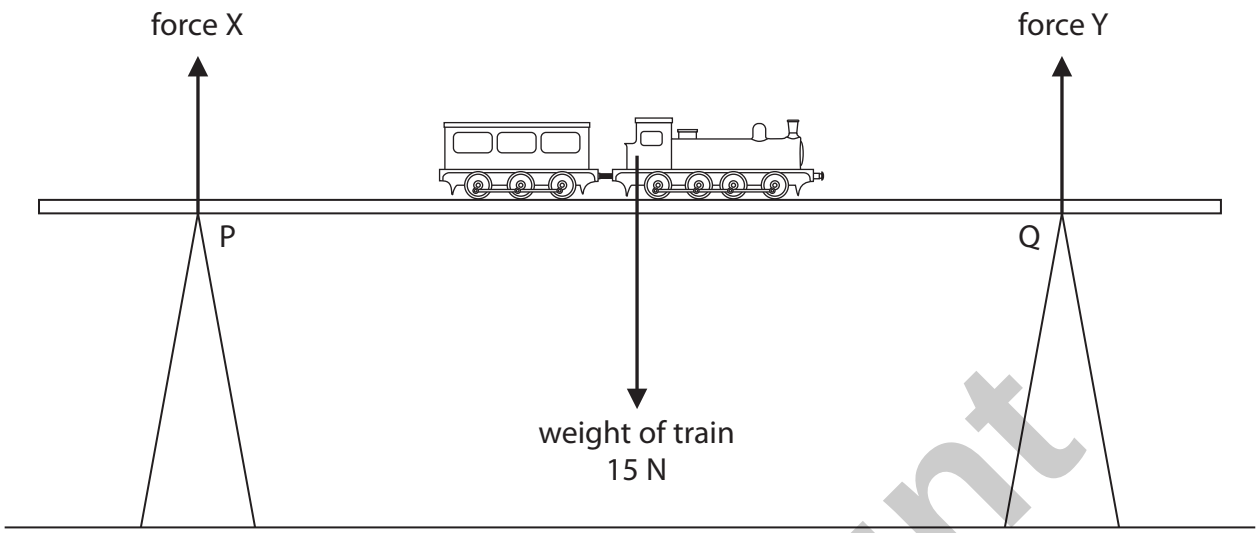
(2)

(Total for Question 2 = 9 marks)

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3 A toy train is placed on the middle of a bridge on a model railway.



The weight of the train acts through its centre of gravity.

Ignore the weight of the bridge.

(a) Which row of the table shows the correct values for forces X and Y?

(1)

	force X	force Y
☒ **A**	7.5 N	7.5 N
☒ **B**	0 N	0 N
☒ **C**	0 N	15 N
☒ **D**	15 N	0 N

(b) Describe how force X changes if the train moves from P to Q.

(2)

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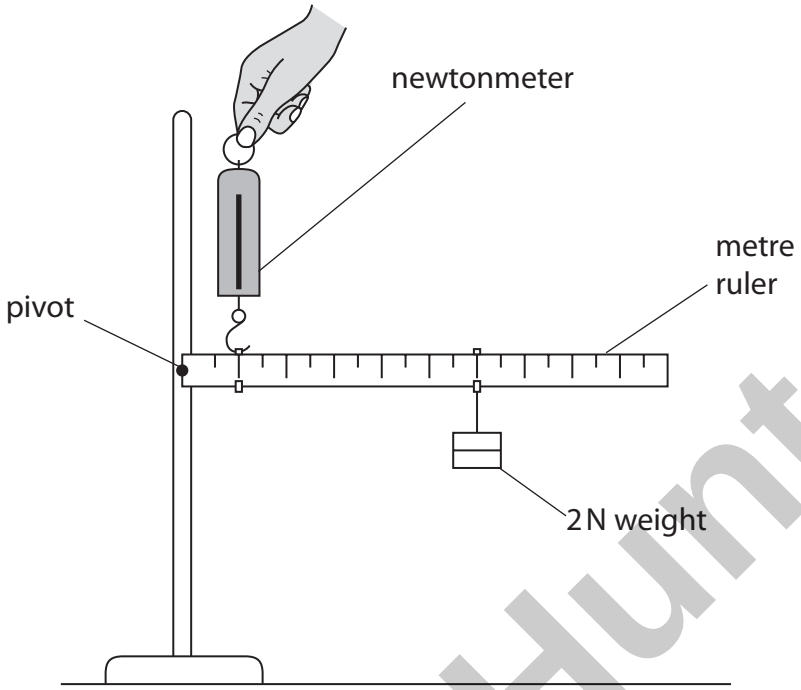
(Total for Question 3 = 3 marks)

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4 The diagram shows the apparatus used to investigate moments.



The 2 N weight is placed 60 cm from the pivot.

The newtonmeter is placed 10 cm from the pivot.

(a) (i) State the equation linking moment, force and perpendicular distance from the pivot.

(1)

(ii) Calculate the reading on the newtonmeter.

Ignore the weight of the ruler.

(3)

reading = ... N

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(b) The metre rule is replaced by an iron bar.

The iron bar is 1 m long and has a weight of 10 N.

The newtonmeter and the 2 N weight stay in their original position.

Explain how this change affects the reading on the newtonmeter.

(3)

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(Total for Question 4 = 7 marks)

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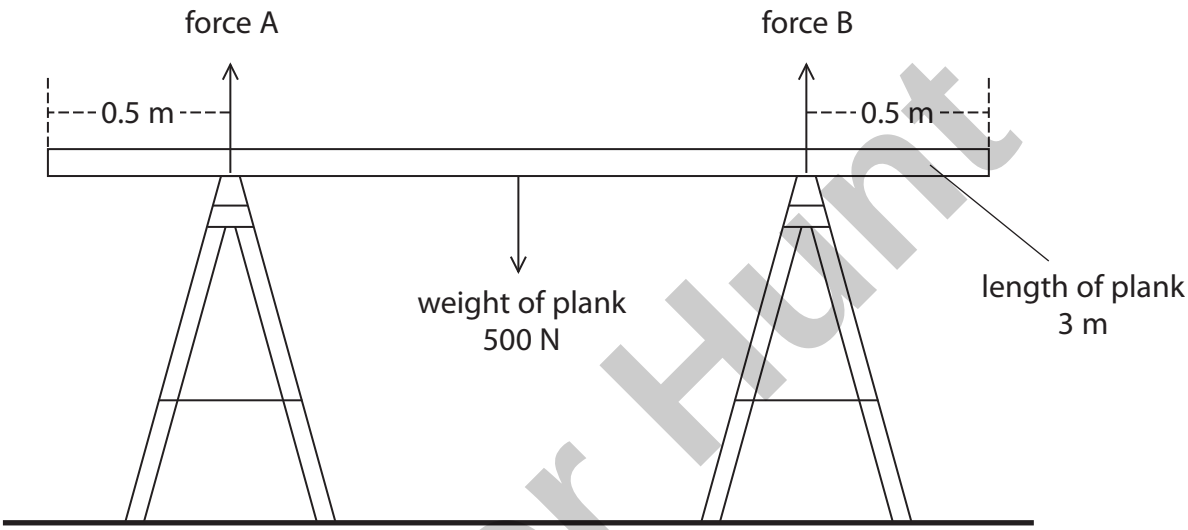
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5 (a) Which of these is a unit for the moment of a force?

(1)

- ☒ **A** N
- ☒ **B** N m
- ☒ **C** N/m
- ☒ **D** N/m^2

(b) A painter sets up a uniform plank so he can paint a wall.



The plank is 3 m long and weighs 500 N.

(i) Use the principle of moments to show that the upward force A is 250 N.

(4)

(ii) State the value of force B.

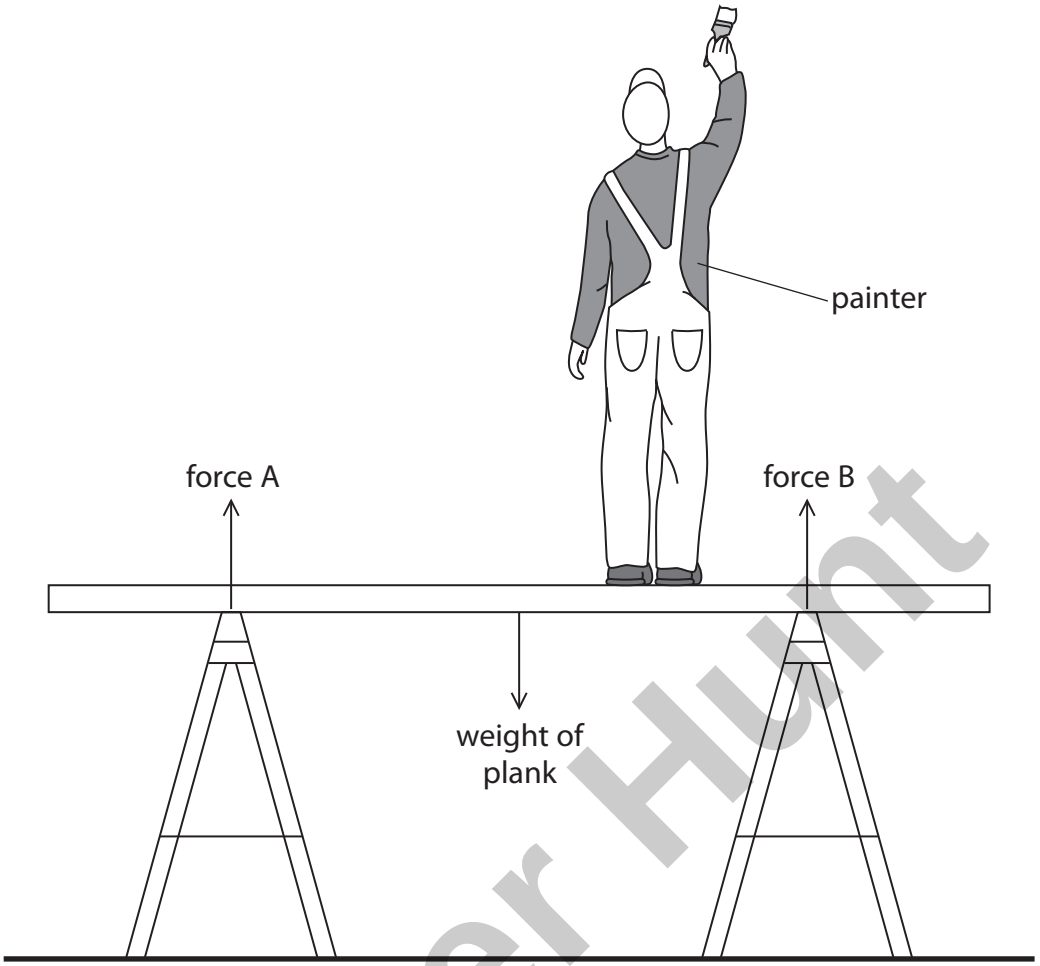
(1)

force B = ...N

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(c) The painter stands on the plank as shown.



(i) Draw an arrow on the diagram to show the weight of the painter.

(1)

(ii) Describe the changes in forces A and B when the painter stands on the plank.

(2)

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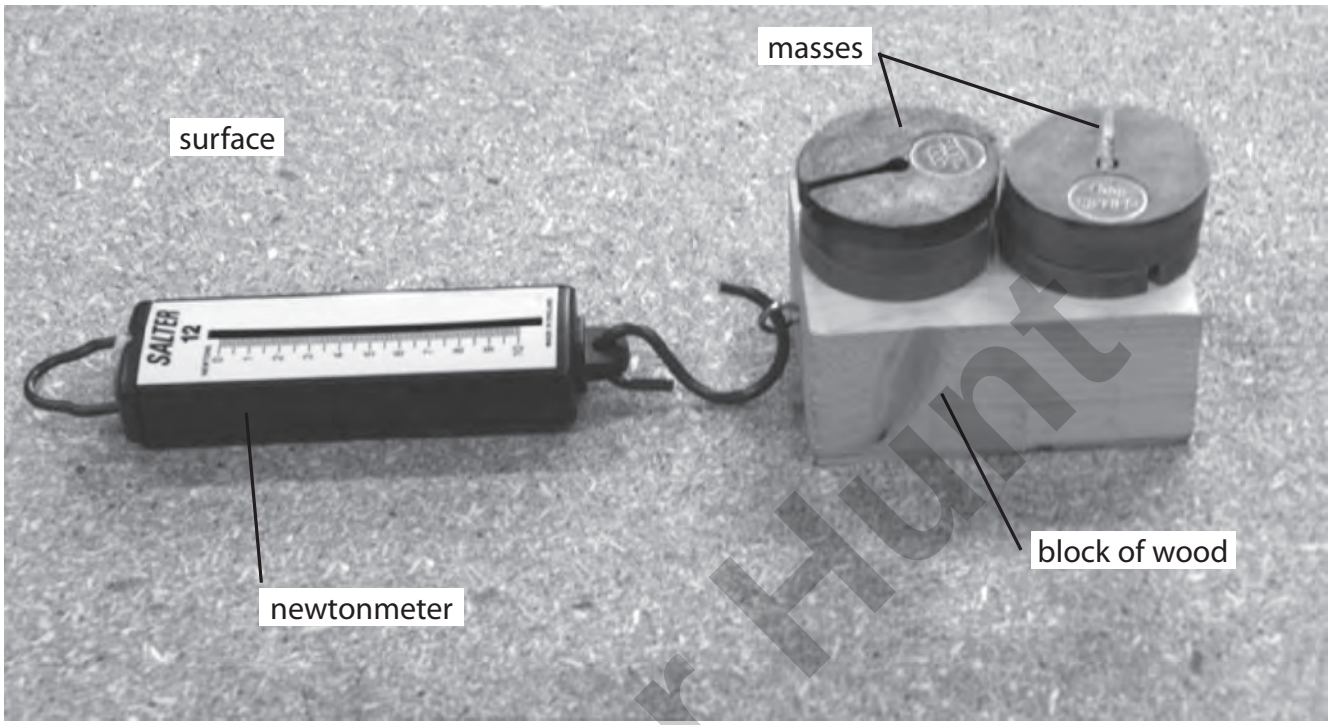
(Total for Question 5 = 9 marks)

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6 A student investigates friction between a block of wood and different types of surface.

(a) The student uses the equipment shown in photograph A to measure the force needed to move the block of wood.



Photograph A

(i) Suggest why the student places masses on the block.

(1)

.....

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(ii) Explain why he keeps the masses constant during the experiment.

(1)

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(b) The student investigates five different types of surface.

The table shows his results.

	Force in N		
Type of surface	**1st reading**	**2nd reading**	**Average**
chipboard	3.0	3.0	3.0
wood	2.5	2.5	2.5
coarse sandpaper	4.7	4.3	
fine sandpaper	5.6	5.8	5.7
ice	0.5	0.5	0.5

(i) Give an example of a non-continuous variable in this investigation.

(1)

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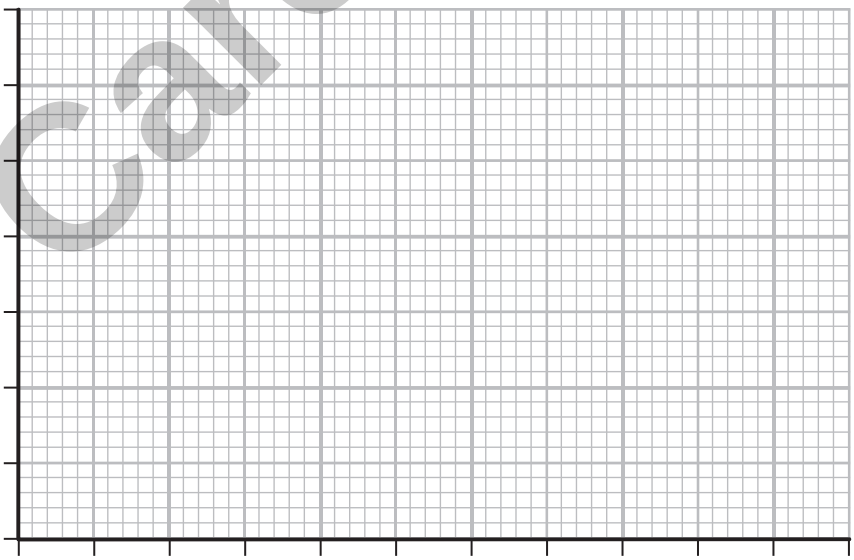
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(ii) Complete the table by inserting the missing average.

(1)

(iii) Display the average force results for this investigation on the grid.

(4)



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(c) The student compares his results with others in the class.

He finds that they have different values for the forces.

Suggest why.

(2)

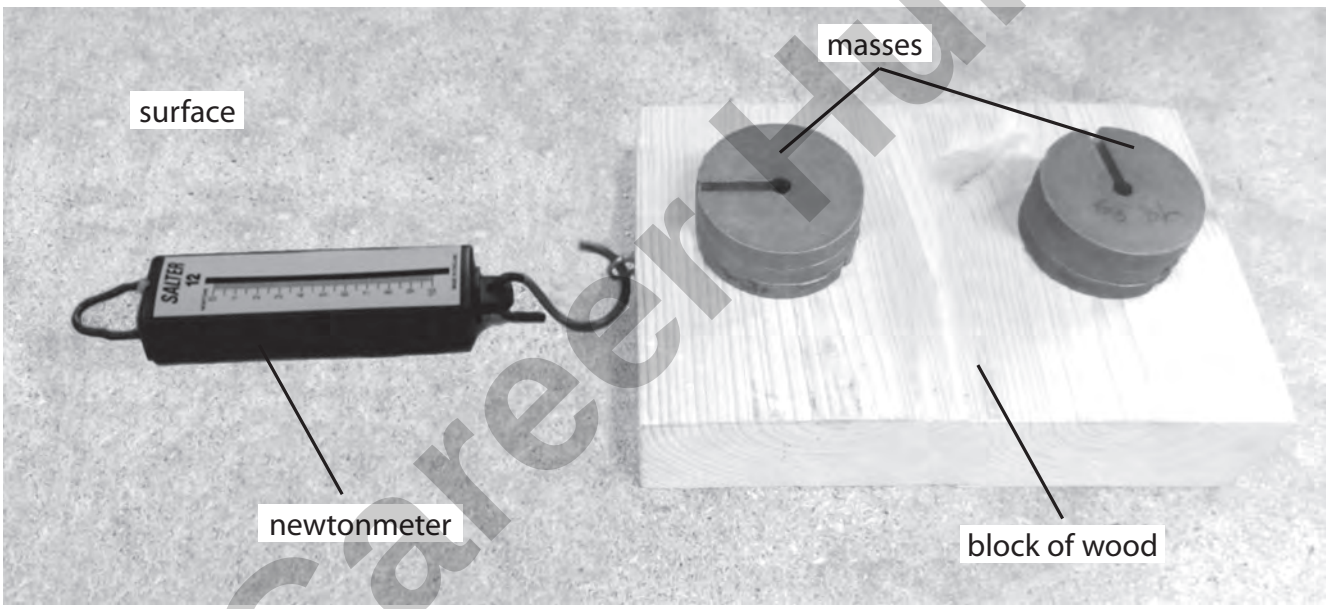
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(d) The student repeats the investigation using another block of wood as shown in photograph B.



Photograph B

This block of wood has the same mass but a different area of contact.

Explain how this change affects the pressure on the surface.

(2)

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(e) Suggest two ways in which the student could reduce friction between the two surfaces.

(2)

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2 .....

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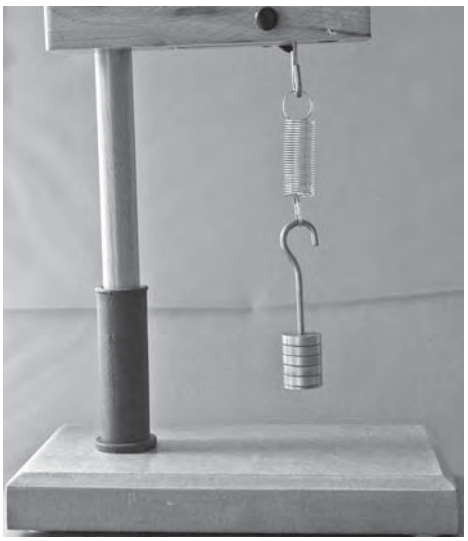
(Total for Question 6 = 14 marks)

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7 A student investigates whether a spring obeys Hooke's law.

She uses the apparatus shown in the photograph.



(a) Which additional measuring instrument does the student need for the investigation?

(1)

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(b) Explain how the student can investigate whether the spring obeys Hooke's law.

(5)

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8 An underground train enters a station.



© Tom Page

(a) The mass of the train and its passengers is 250 000 kg.

The total kinetic energy is 18 MJ.

(i) State the relationship between kinetic energy (KE), mass and velocity.

(1)

(ii) Calculate the velocity of the train as it enters the station.

(3)

velocity = ... m/s

(iii) The driver applies the brakes to stop the train.

State what happens to the kinetic energy of the train.

(1)

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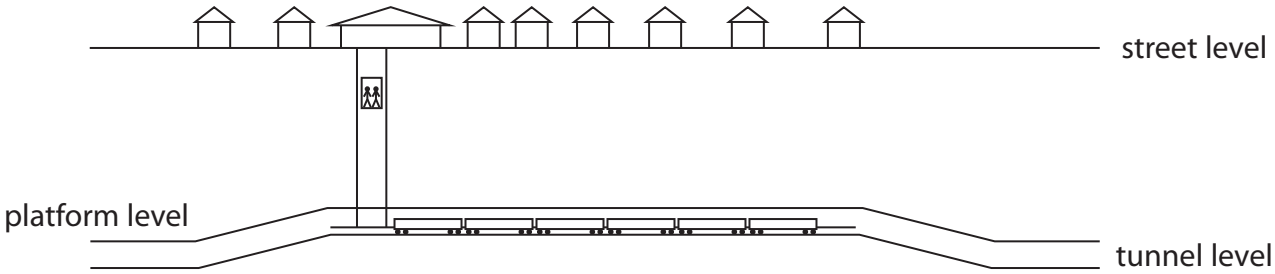
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(b) The diagram shows a section through the station.



(i) The passengers who use the station are carried from platform level to street level in a lift.

Explain why these passengers gain gravitational potential energy in the lift, even when they are below ground.

(2)

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(ii) The tunnel is designed so that the trains go up a slope as they enter the station and go down a slope as they leave.

The driver uses brakes to stop the train in the station and a motor to make the train move away.

Explain how the sloping parts of the tunnel affect the amount of work that needs to be done on the train by the brakes and by the motor.

(4)

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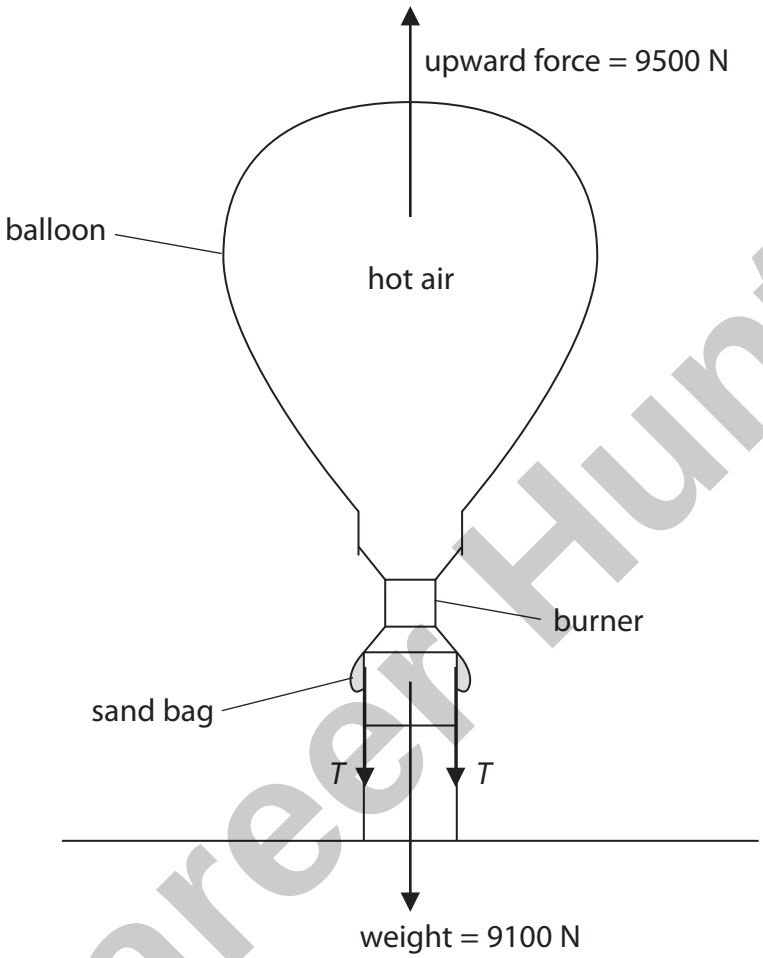
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9 A hot-air balloon is tied to the ground by two ropes.

The diagram shows the forces acting on the balloon.

The tension *T* in each rope is 200 N.



The ropes are untied and the balloon starts to move upwards.

(a) State the value of the force acting downwards on the balloon immediately after the ropes are untied and before the balloon starts moving.

(1)

force downwards = ... N

(b) (i) State the relationship between unbalanced force, mass and acceleration.

(1)

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(ii) The balloon has a total mass of 910 kg.

The initial unbalanced force on the balloon is 400 N upwards.

Calculate the initial acceleration.

(2)

initial acceleration = ... m/s^2

(c) Explain how the upward acceleration of the balloon changes during the first few seconds of its flight.

(3)

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(d) While the balloon is still accelerating, the pilot controls the balloon by pouring some sand from the bags.

Explain how this affects the upward acceleration of the balloon.

(2)

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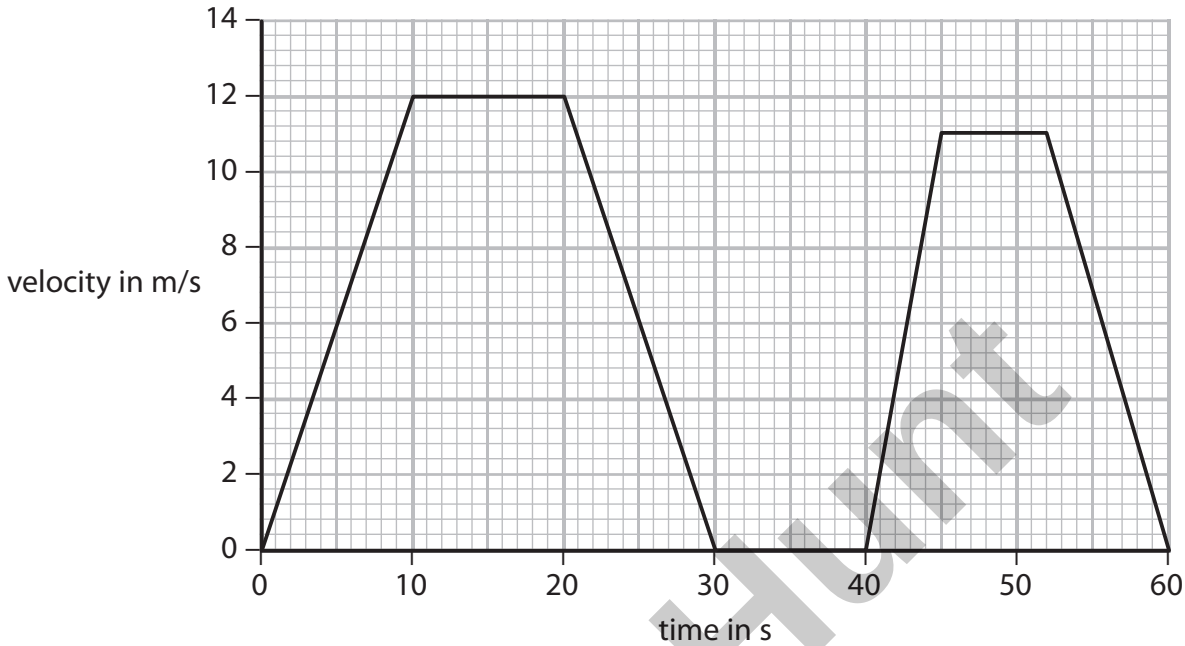
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10 A bus travels along a straight road.

The graph shows how the velocity of the bus changes during a short journey.



(a) (i) State the velocity of the bus after 25 s.

(1)

velocity = ... m/s

(ii) How long is the bus stationary during its journey?

(1)

time = ... s

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(b) (i) State the equation linking acceleration, change in velocity and time taken.

(1)

(ii) Calculate the acceleration of the bus during the first 10 seconds.

Give the unit.

(3)

acceleration = ... unit .....

(c) (i) State the equation linking average speed, distance moved and time taken.

(1)

(ii) The bus moves a total distance of 390 m during the journey.

Calculate the average speed of the bus.

(2)

average speed = ... m/s

(d) The bus travels further in the first 30 seconds of its journey than it does during the last 30 seconds.

Explain how the graph shows this.

(2)

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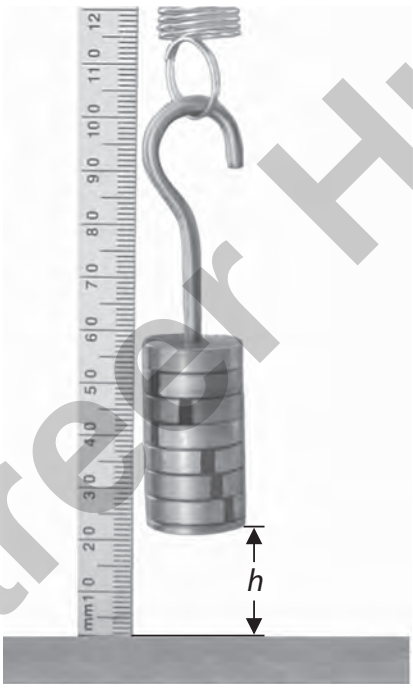
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11 A student uses this apparatus to investigate forces stretching a spring.



She uses a ruler to measure the vertical distance *h* between the bottom of the mass hanger and the base of the stand.



(a) Suggest two ways that the student can measure distance *h* more accurately.

(2)

1 .....

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2 .....

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(b) The student continues her investigation by loading the spring with different masses.

The table shows her results.

Mass in g	Force in N	Distance *h* in cm
20	0.2	4.6
40	0.4	3.9
60	0.6	3.1
80	0.8	2.3
100	1.0	1.6
120	1.2	0.9

(i) Name the dependent variable in this investigation.

(1)

.....

(ii) Explain how the force values in the table are calculated.

(2)

.....

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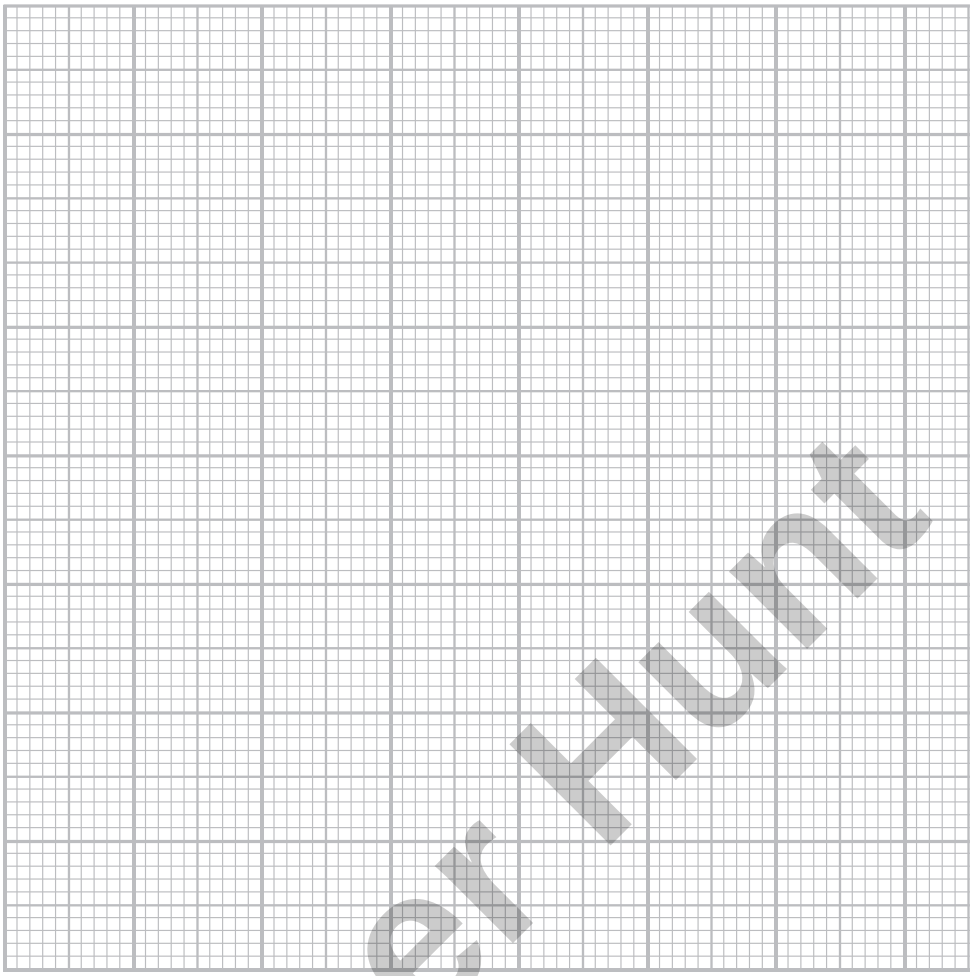
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(iii) Plot a graph of distance *h* against force, and draw the line of best fit.

(5)



(iv) Use your graph to find the force for which *h* is zero.

(2)

force = ... N

(v) Explain whether the spring obeys Hooke's law.

(2)

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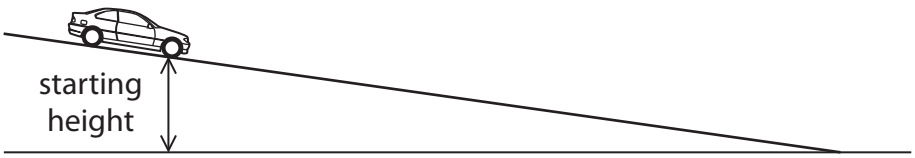
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12 A student investigates the speed of different toy cars as they roll down a slope.



(a) The student makes this prediction.

'The more weight a toy car has the faster it will roll down the slope.'

(i) What is the independent variable in the student's prediction?

(1)

.....

(ii) What is the dependent variable in the student's prediction?

(1)

.....

(b) State two factors that the student should keep constant in his investigation.

(2)

1 .....

.....

2 .....

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(c) Put ticks (✓) in the boxes to show which pieces of apparatus the student needs for his investigation.

One has been done for you.

(2)

battery	
joulemeter	
micrometer	
newtonmeter	
ruler	✓
stopwatch	
thermometer	

(d) Describe what the student should do to test his prediction that the more weight the toy car has, the faster it will roll down the slope.

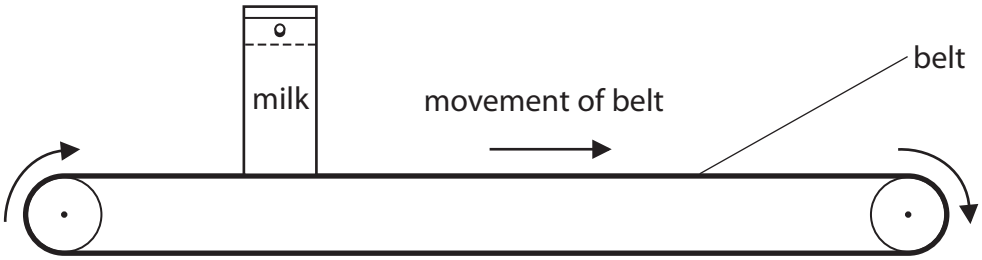
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13 Supermarkets use conveyer belts to move shopping at the till.

The diagram shows a carton of milk being pulled along by a horizontal conveyer belt.



The horizontal force on the carton from the belt is 1.7 N.

The carton moves a distance of 0.46 m.

(a) (i) State the equation linking work done, force and distance.

(1)

(ii) Calculate the work done moving the carton.

(2)

Work done = ... J

(iii) State how much energy is transferred to the carton.

(1)

Energy transferred = ... J

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(b) The belt stops suddenly and the carton falls over.



(i) How does this affect the kinetic energy of the carton?

(1)

.....

.....

(ii) Why does falling over reduce the gravitational potential energy of the carton?

(1)

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14 (a) Which of these is a vector quantity?

(1)

☒ **A** density

☒ **B** force

☒ **C** mass

☒ **D** speed

(b) Which of these is a scalar quantity?

(1)

☒ **A** acceleration

☒ **B** energy

☒ **C** momentum

☒ **D** velocity

(c) When a book from a low shelf is placed on a higher shelf, the book gains

(1)

☒ **A** gravitational potential energy

☒ **B** mass

☒ **C** weight

☒ **D** work

(d) When an object falls at terminal velocity

(1)

☒ **A** it accelerates at 10 m/s^2

☒ **B** it has no weight

☒ **C** the resultant vertical force is downwards

☒ **D** the vertical forces on it are balanced

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15 A student investigates the stretching of rubber bands.

She stretches four rubber bands as shown in the photograph.



She applies a force of 5.0 N and measures the length of the rubber bands.

She repeats the experiment with different numbers of rubber bands, using a force of 5.0 N each time.

The table shows her results.

Number of rubber bands	Stretched length in cm
1	43.2
2	28.0
3	21.5
4	
5	17.6
6	17.0

(a) (i) Estimate the length of the four rubber bands shown in the photograph and use your value to complete the table.

(1)

(ii) Suggest two reasons why your estimate may not be accurate.

(2)

1 .....

.....

2 .....

.....

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(b) Suggest how the student made this investigation a fair test.

(1)

.....

.....

(c) (i) The number of rubber bands is a series of whole numbers.

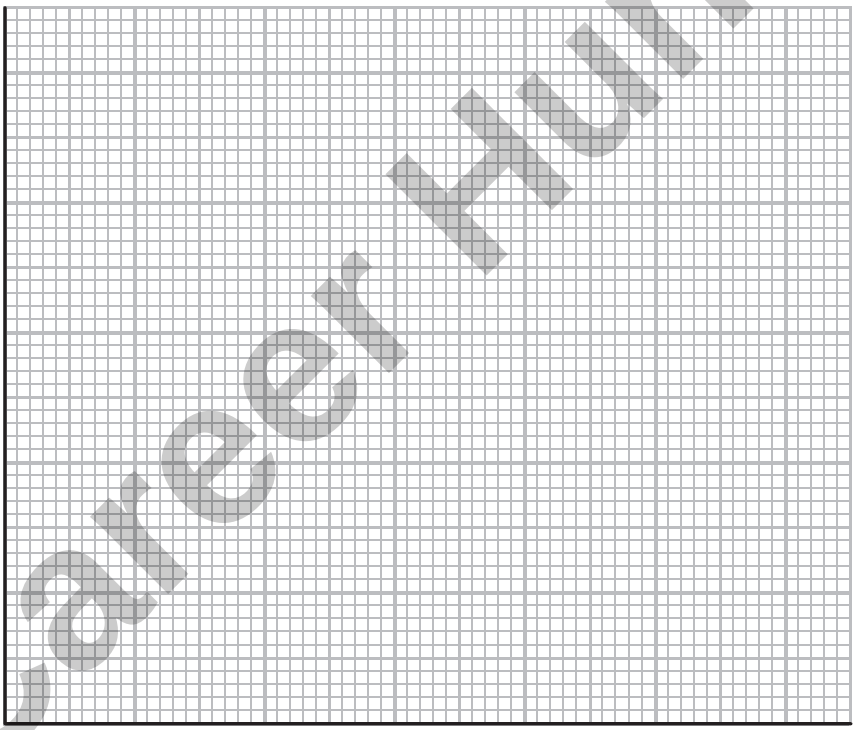
State the name of this type of variable.

(1)

.....

(ii) Display the results of the student's investigation on the grid.

(4)



(iii) Describe the relationship between the number of rubber bands and the stretched length.

(2)

.....

.....

.....

.....

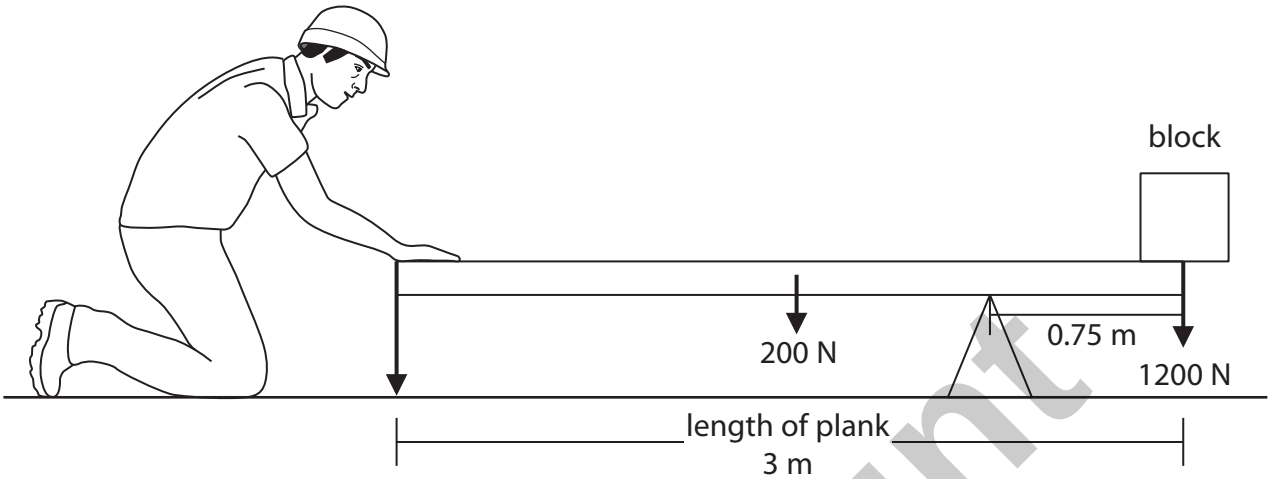
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16 A man uses a uniform plank to lift a block.

He holds the plank horizontal.



The arrows on the diagram represent three forces on the plank.

(a) Complete the table to identify the missing force.

(1)

Force	Name of force
F	force of man pushing down on the plank
1200 N	weight of block
200 N	

(b) (i) State the equation linking moment, force and perpendicular distance from the pivot.

(1)

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(ii) Calculate the clockwise moment of the block about the pivot.

(2)

moment = ... Nm

(c) Calculate the force of the man pushing down on the plank.

(4)

force = ... N

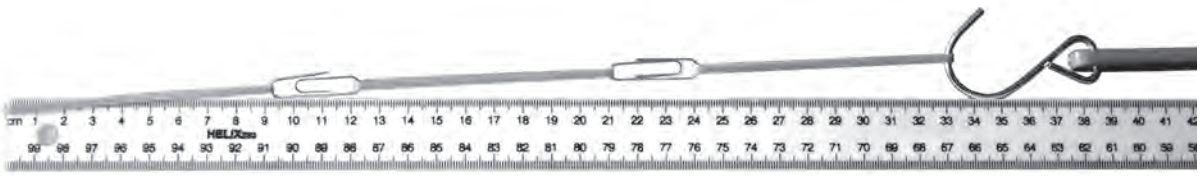
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17 A student makes chains of elastic bands by joining them together with paperclips.

He uses a newtonmeter to stretch each chain along a metre rule, as shown in photograph **A**.



Photograph A

For each chain, he records

- the number of elastic bands
- the length when the tension is 2 N
- the length when the tension is 1 N

Then he calculates the difference in length for each chain.

(a) (i) Complete the table by calculating the missing value.

(1)

Number of elastic bands	Length in cm		Difference in length in cm
	When tension 2 N	When tension 1 N	
1	8.1	7.5	0.6
2	20.2	18.2	2.0
3	31.7	29.3	2.4
4	43.7	40.3	3.4
5	56.3	51.6	4.7
6	67.6	62.5	

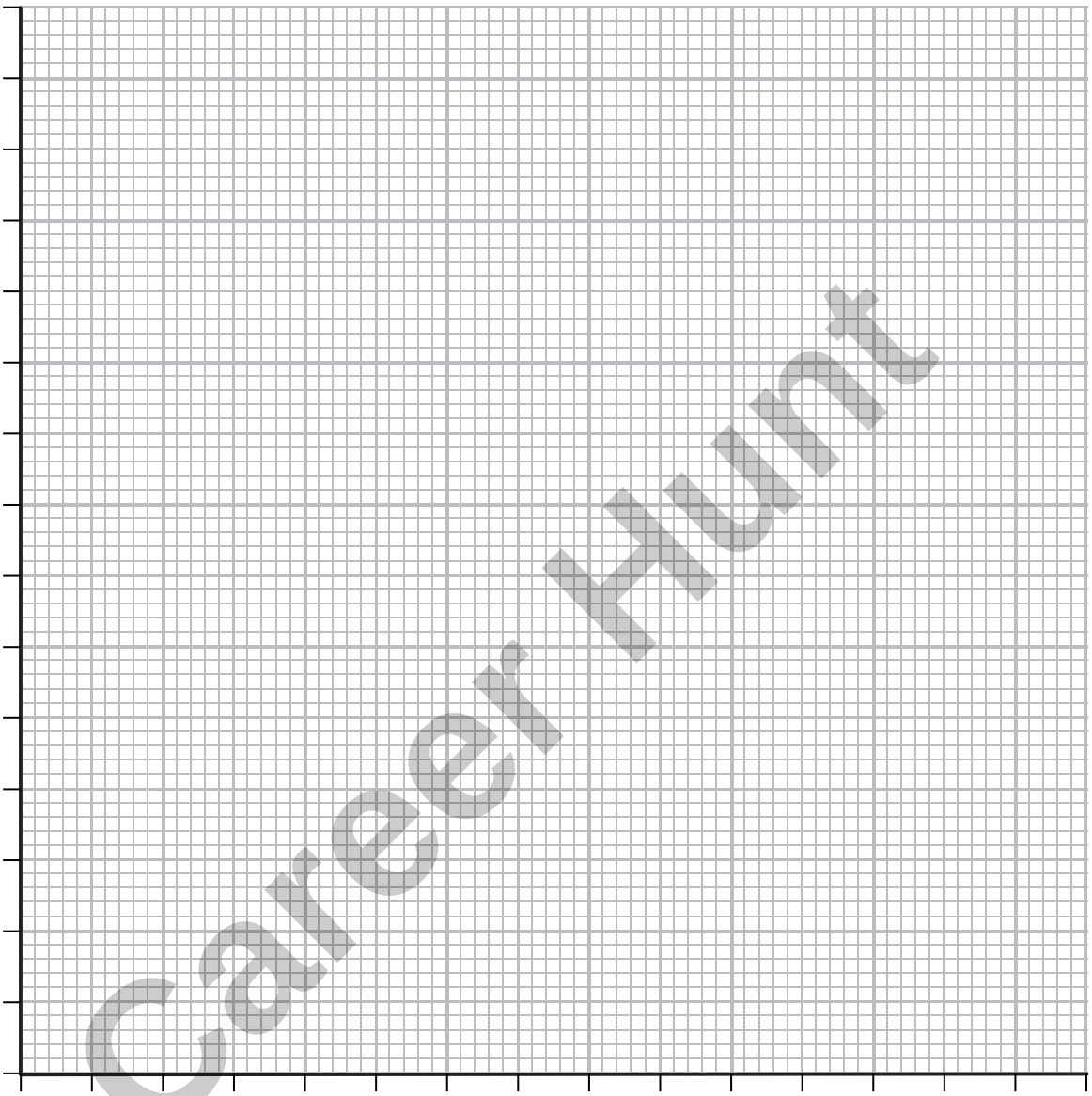
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(ii) Use the grid to plot a graph to show the relationship between the number of elastic bands and the difference in length.

(5)



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(iii) Describe your line of best fit.

(2)

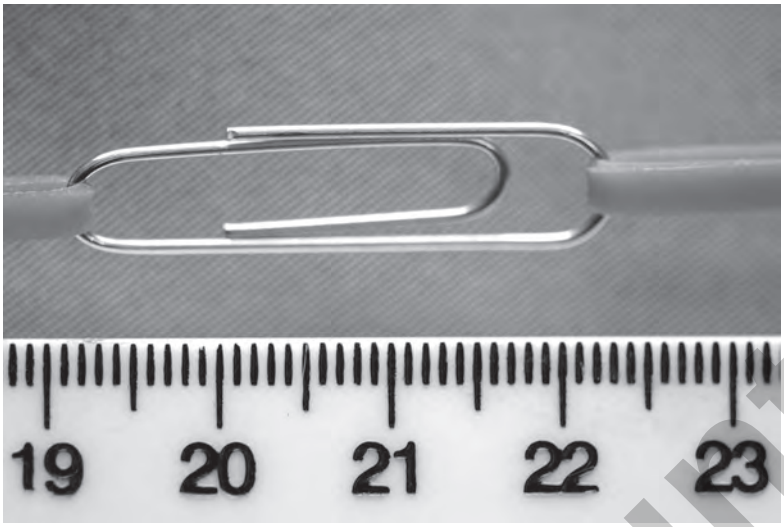
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(b) Photograph **B** shows a paperclip in one of the chains against the same metre rule.



Photograph B

Use photograph **B** to estimate the length of this paperclip.

(2)

Length ..... cm

(c) Look again at photograph **A**.

Suggest two ways that the student could improve his measuring technique.

(2)

1 .....

.....

2 .....

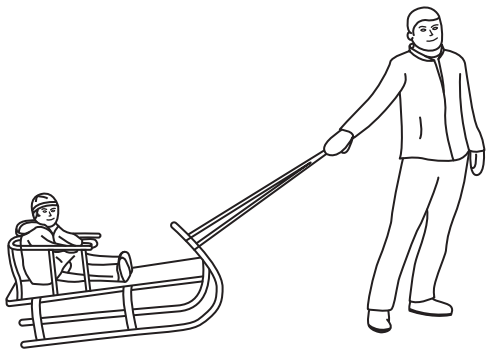
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18 The diagram shows a man pulling a child on a sledge.



(a) The acceleration of the sledge is 1.5 m/s^2.

The mass of the child and sledge is 38 kg.

(i) State the equation linking force, mass and acceleration.

(1)

(ii) Calculate the force needed to produce this acceleration.

(2)

force = ... N

(iii) Suggest a reason why the force exerted on the sledge by the man must be greater than the force calculated.

(1)

.....

.....

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(b) The sledge starts from rest and accelerates at 1.5 m/s^2 until its velocity is 2.8 m/s.

(i) State the relationship between acceleration, velocity and time.

(1)

(ii) Show that the time taken to reach 2.8 m/s is about 2 s.

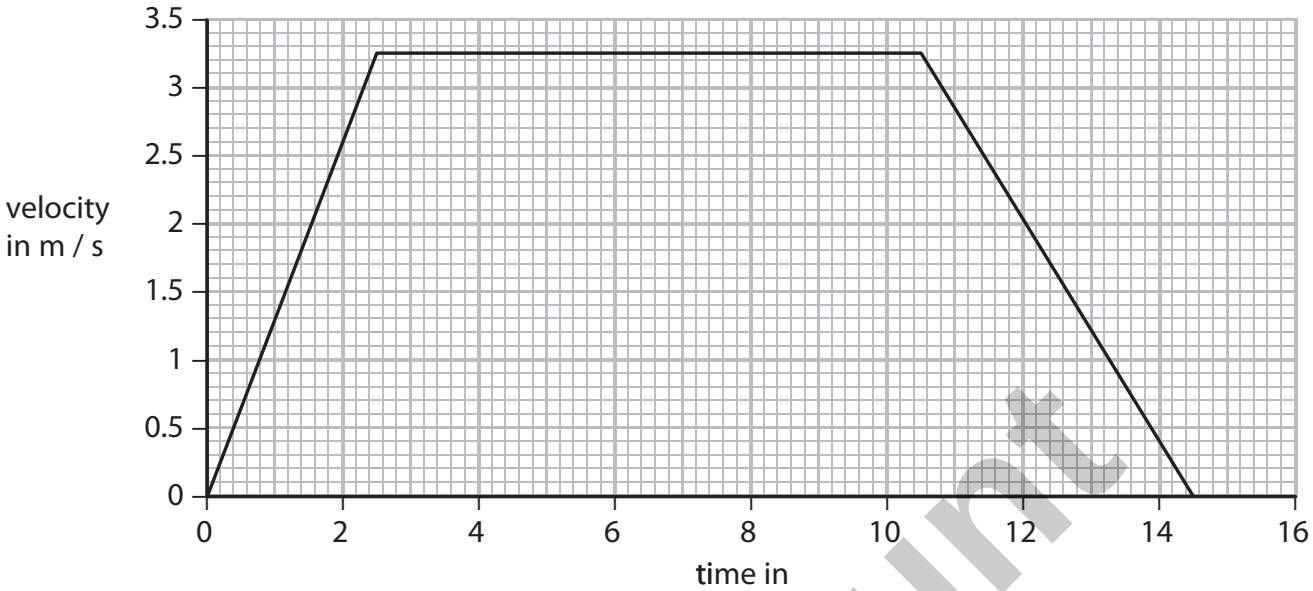
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(c) This velocity-time graph shows the motion of the sledge as it travels down a hill.



(i) Calculate the distance travelled by the sledge.

(3)

distance travelled = ... m

(ii) State the equation linking average speed, distance moved and time taken.

(1)

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(iii) Calculate the average speed of the sledge for the whole journey.

(2)

average speed = ... m/s

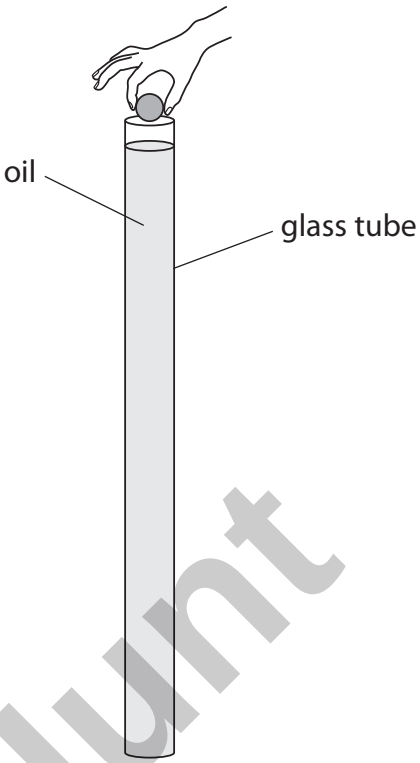
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19 A student investigates terminal velocity.

She uses a tall glass tube filled with oil.

She drops a metal ball into the tube.

The ball falls through the oil.



(a) Use ideas about forces to explain how a falling object can reach a terminal velocity.

(5)

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(b) Describe how the student could find out if the ball reaches terminal velocity as it falls through the oil.

In your answer, you should include

- the measuring instruments that the student will need
- the measurements that she should take
- how she could use her measurements to find out if the ball reached terminal velocity.

You may include a labelled diagram in your answer.

(5)

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20 A student investigates the motion of different falling masses by measuring the time taken for empty cupcake cases to fall from a window.



(a) The student drops one case from the window.

He repeats the experiment with two cases stuck together, then with three cases and then with four.

Name two measuring instruments that he would need for his investigation.

(2)

1 .....

2 .....

(b) What are the dependent and independent variables in this investigation?

(2)

dependent variable .....

independent variable .....

(c) State one factor that the student should keep constant in order to make this investigation valid (a fair test).

(1)

.....

(d) The student draws this table to record his results.

Add suitable headings to his table.

(2)

..... in	..... in .....

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(e) State one way that the student can improve his investigation.

(1)

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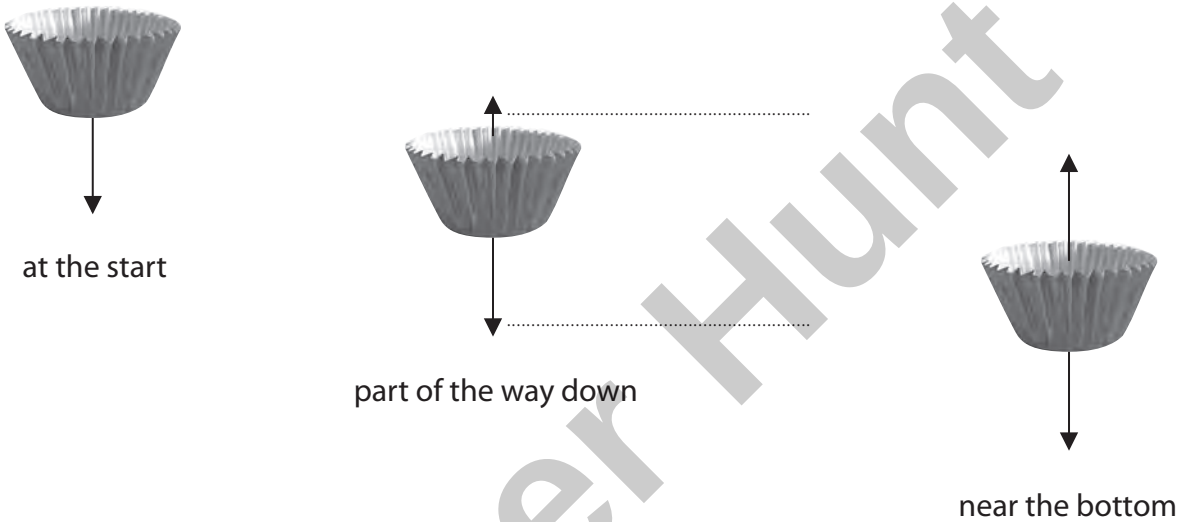
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(f) The student notices that the cases accelerate and then fall at constant speed.

(i) The arrows in the diagrams show the size and direction of the forces acting on a case at different points in its fall.

Label the forces on the middle diagram.

(2)



(ii) Explain why the case accelerates and then falls at constant speed.

(3)

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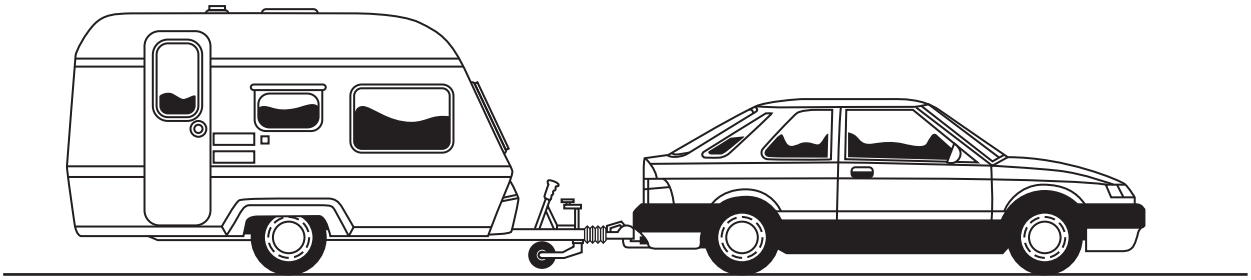
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21 A car pulls a caravan along a horizontal road.



(a) The car pulls the caravan with a resultant force of 170 N for a distance of 110 m.

(i) State the equation linking work done, force and distance.

(1)

(ii) Calculate the work done by the car on the caravan.

(2)

work done = ... J

(iii) State how much energy is transferred to the caravan.

(1)

energy transferred = ... J

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(b) The mass of the car is 1650 kg.

The mass of the caravan is 950 kg.

(i) State the equation linking kinetic energy, mass and velocity.

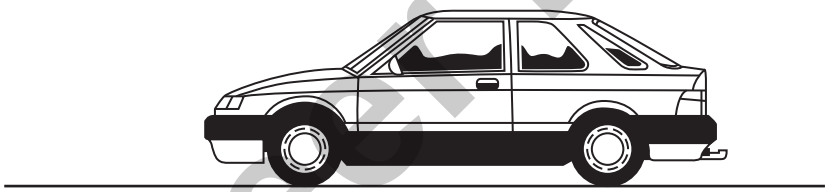
(1)

(ii) Calculate the total kinetic energy when the car and caravan travel together at a constant speed of 23 m/s.

(3)

total kinetic energy = ... J

(c) The caravan is removed and the car makes the return journey without it.



Without the caravan, the car has greater acceleration and uses less fuel.

Explain these changes.

(3)

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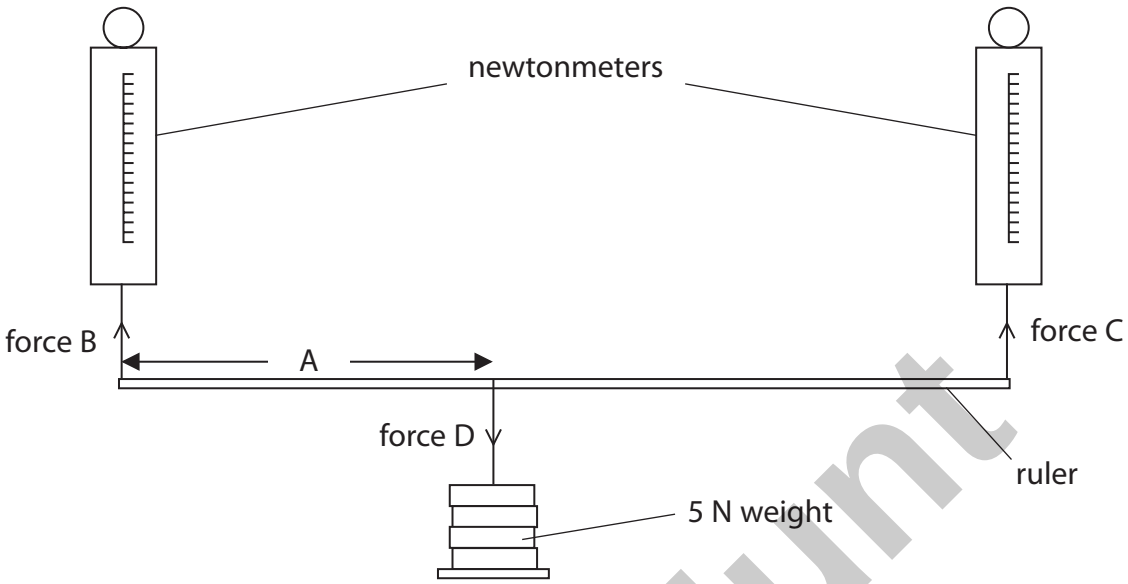
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22 A student investigates the vertical forces acting on the ends of a horizontal ruler when it supports a load.

The ruler hangs from two newtonmeters with a weight suspended from it as shown.



(a) The student moves the weight along the ruler and records forces B and C by taking readings from the newtonmeters.

(i) Which of these is the independent variable in this investigation?

(1)

☒ **A** Distance A

☒ **B** Force B

☒ **C** Force C

☒ **D** Force D

(ii) Which of these is a controlled variable in this investigation?

(1)

☒ **A** Distance A

☒ **B** Force B

☒ **C** Force C

☒ **D** Force D

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(b) The student records these readings.

Distance A in cm	Reading from newtonmeter of force B in N	Reading from newtonmeter of force C in N
0	5.1	0.4
20	4.0	1.1
40	2.9	2.3
60	2.0	3.3
80	1.1	4.8
100	0.2	5.9

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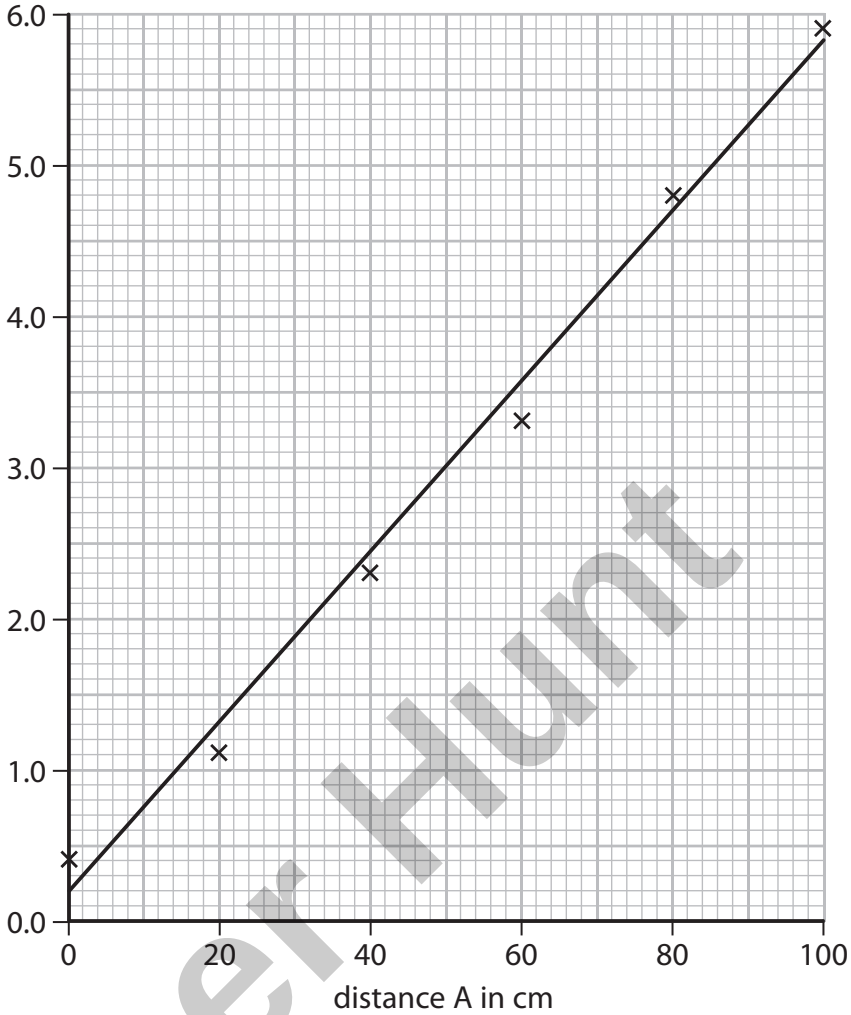
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She plots this graph to show how force C changes with distance A.

.....

in .....



(i) Complete the student's graph by labelling the vertical axis.

(1)

(ii) Using the same grid and axes, plot a second line to show how force B varies with distance A.

(3)

(iii) Use the lines on the graph to find distance A for which force B and force C are equal.

(1)

Distance = ... cm

(c) Suggest why neither force B nor force C are ever zero during the investigation.

(1)

.....

.....

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23 A student investigates the extension of a rubber band when masses are added.

(a) Tick the boxes to select the correct items of apparatus that the student would need in order to complete this investigation.

Two items have already been selected.

(2)

Item	Tick (✓) if item needed
ammeter	
steel spring	
retort stand and clamp	
rubber band	✓
ruler	
thermometer	
mass hanger	
masses	✓

(b) The table below shows the student's results.

Mass in g	Force in N	Extension in cm
0	0	0.0
150	1.5	2.4
350	3.5	6.3
550		12.8
750	7.5	18.6
1050	10.5	24.0

(i) Complete the table by inserting the missing force.

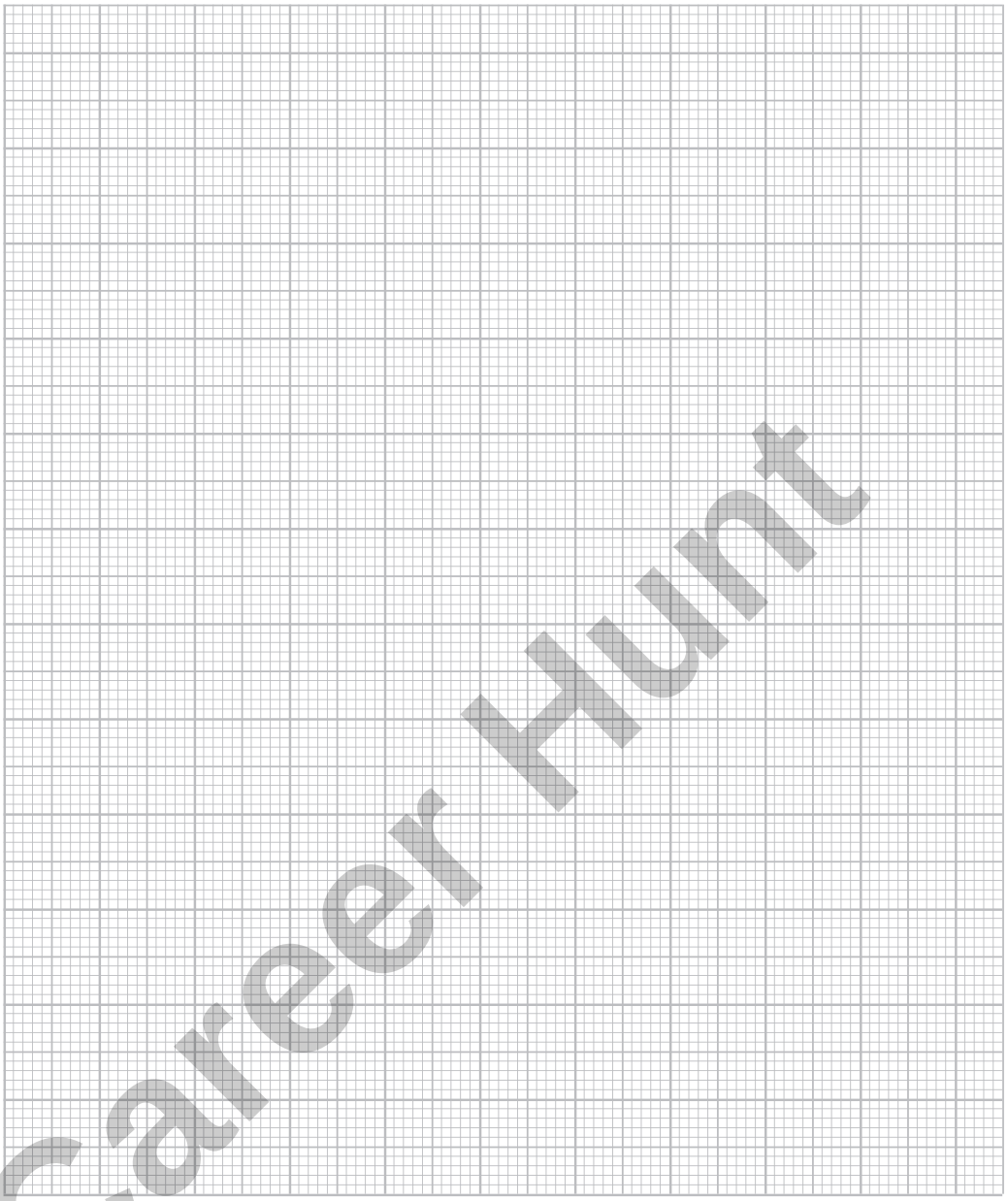
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(ii) Plot a graph to show how force varies with extension.

(5)



(iii) Use the information from the graph to explain whether the rubber band obeys Hooke's Law.

(2)

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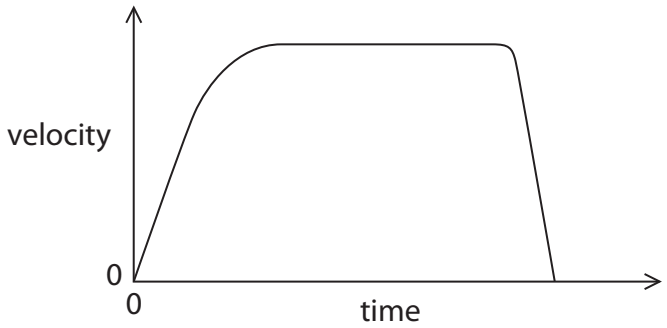
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24 A toy car rolls down a ramp and hits a cushion.

The graph shows how its velocity changes with time.



(a) Constant velocity on the graph is shown by

(1)

- ☒ **A** the area under the line
- ☒ **B** the horizontal part of the line
- ☒ **C** the sloping line at the end
- ☒ **D** the sloping line at the start

(b) The distance travelled is shown by

(1)

- ☒ **A** the area under the line
- ☒ **B** the horizontal part of the line
- ☒ **C** the sloping line at the end
- ☒ **D** the sloping line at the start

(c) The average velocity of the toy car is given by

(1)

- ☒ **A** the change in velocity divided by the time taken
- ☒ **B** the distance moved divided by the time taken
- ☒ **C** the time taken divided by the change in velocity
- ☒ **D** the time taken divided by the distance moved

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25 A racing cyclist practises by riding around a track.



A student wants to find the average speed of the cyclist.

Describe a method that the student could use to find the average speed.

(5)

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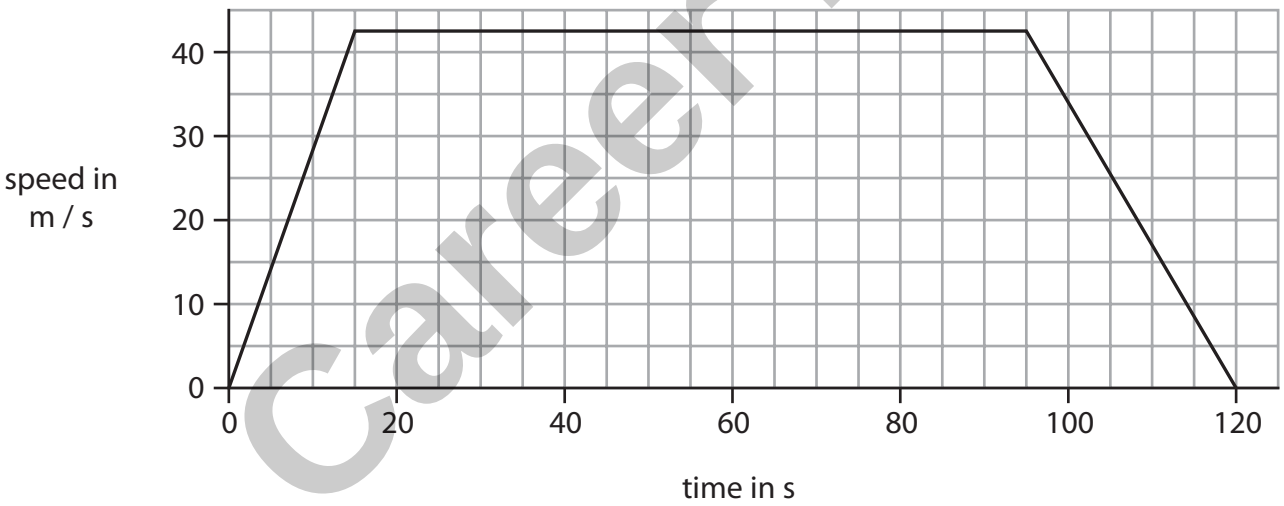
26 An aeroplane takes two minutes to travel the short distance between airports on two islands.



The graph shows how the speed of the aeroplane changes as it

- takes off
- flies across the sea
- lands on the other island

When it is flying across the sea, the aeroplane travels at a constant speed.



(a) Use the graph to answer the following questions.

(i) State the value of the constant speed.

(1)

speed ..... m/s

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(ii) Calculate the acceleration of the aeroplane at the start of the journey and give the unit.

(3)

acceleration = ... unit .....

(iii) Calculate the total distance that the aeroplane travels.

(3)

distance = ... m

(b) Each airport has a runway that is about 500 m long.

When it lands, the speed of the aeroplane is 40 m/s.

Explain why the airline should not use an aeroplane that has more mass and needs a higher speed for landing.

(3)

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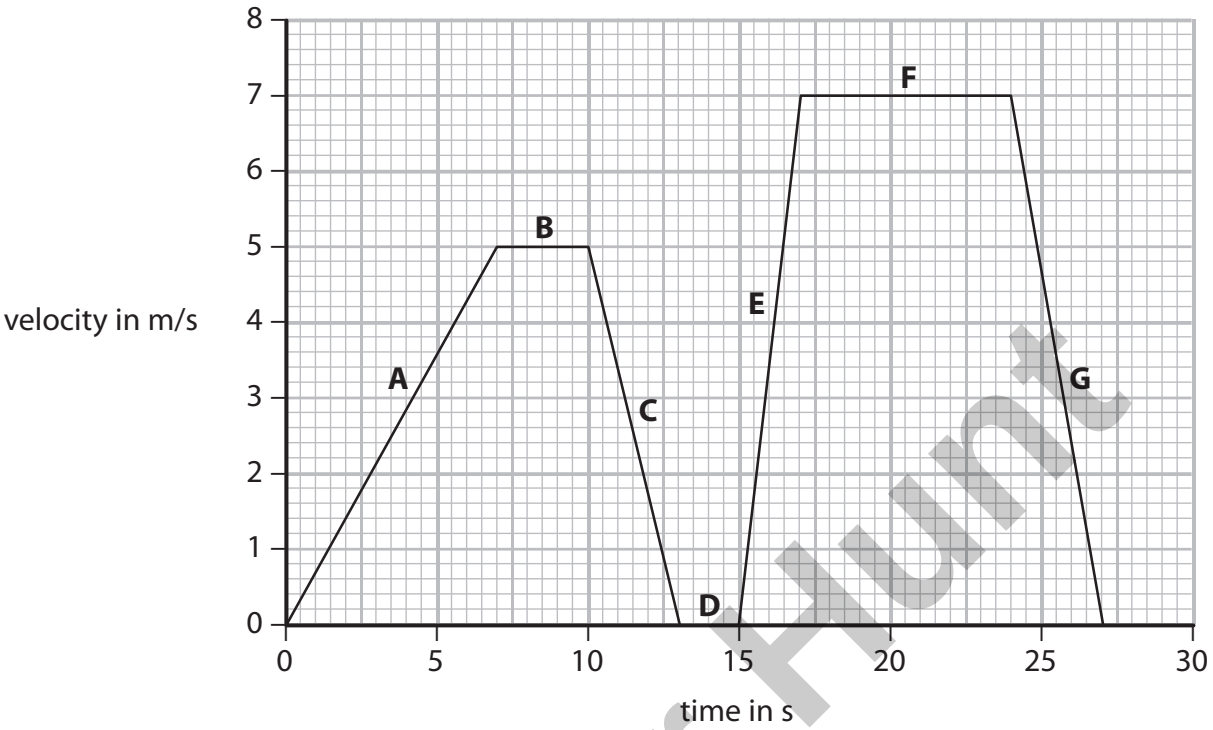
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27 A student cycles to school.

The graph shows the stages A to G of the journey.



(a) Describe the motion of the student during stages B and D.

(2)

Stage	Description
B	
D	

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(b) State how the graph shows that the acceleration for stage E is greater than the acceleration for stage A.

(1)

.....

.....

.....

(c) Calculate the distance that the student travels in the last 10 s of the journey.

(4)

distance = ... m

(d) The total distance travelled is 106.5 m.

Show that the average speed of the journey is about 4 m/s.

(3)

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28 A rabbit runs across the road in front of a car.

The driver applies the brakes.



State **four** factors that affect the chance of the rabbit escaping without being hit.

(4)

1 .....

.....

2 .....

.....

3 .....

.....

4 .....

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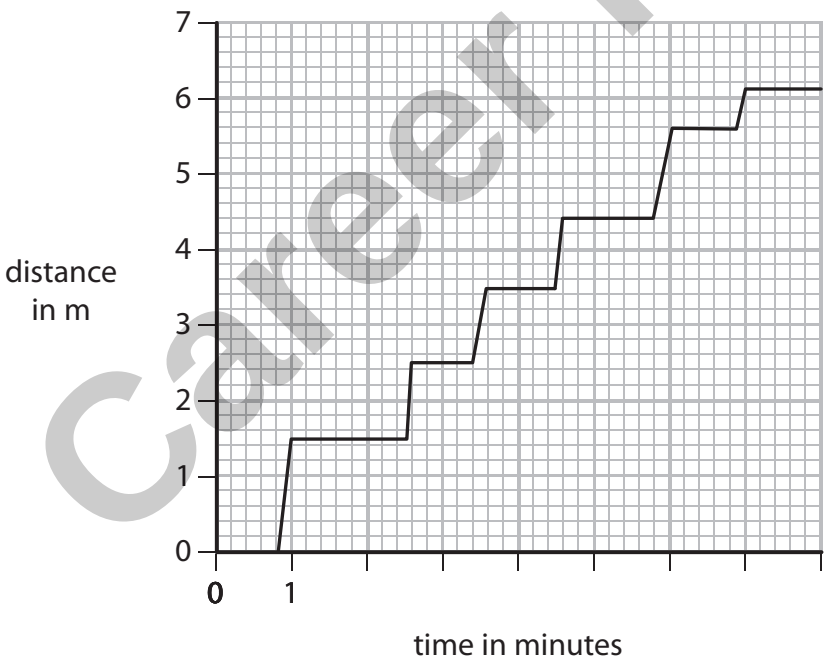
29 The diagram shows some people waiting in a queue at a supermarket.



The queue moves forward each time a person leaves the checkout.

Person X spends seven minutes in the queue before reaching the checkout.

The graph shows how distance changes with time for person X.



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(a) (i) What is the initial length of the queue?

(1)

initial length = ... m

(ii) Explain how you could use the graph to work out the number of times person X is stationary.

(2)

.....

.....

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.....

(b) (i) State the equation linking average speed, distance moved and time taken.

(1)

(ii) Calculate the average speed of person X in the queue.

Give the unit.

(3)

average speed = ... unit .....

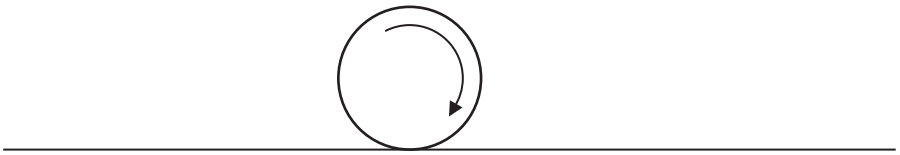
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30 A golfer practises hitting balls on a golf course.

(a) Ball X rolls along level ground, as shown in the diagram.



(i) Add labelled arrows to the diagram to show the directions of two of the forces acting on ball X.

(2)

(ii) Explain why ball X slows down and stops.

(3)

(b) The golfer hits ball Y at an angle into the air.

He gives it the same initial kinetic energy as ball X.

Suggest why ball Y travels much further than ball X before it stops.

(1)

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(c) The mass of ball Y is 45 g.

The golfer gives the ball 36 J of kinetic energy when he hits it.

(i) State the equation linking kinetic energy, mass and speed.

(1)

(ii) Calculate the initial speed of ball Y.

(4)

initial speed = ... m/s

(iii) Ball Y reaches a maximum height of 30 m.

Suggest how the golfer should hit ball Y so it can reach a greater height.

(1)

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31 (a) A boy of mass 43.2 kg runs and jumps onto a stationary skateboard.



The boy lands on the skateboard with a horizontal velocity of 4.10 m/s.

(i) State the relationship between momentum, mass and velocity.

(1)

(ii) The skateboard has a mass of 2.50 kg.

Using ideas about conservation of momentum, calculate the combined velocity of the boy and skateboard just after the boy lands on it.

(4)

combined velocity = ... m/s

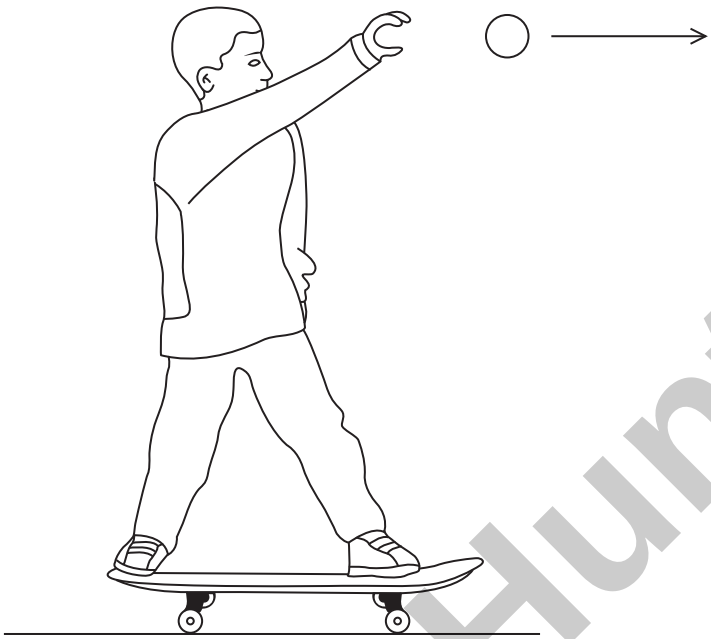
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(b) The boy holds a heavy ball as he stands on a stationary skateboard.

The boy throws the ball forwards while still standing on the skateboard.



Explain what happens to the boy and the skateboard.

(2)

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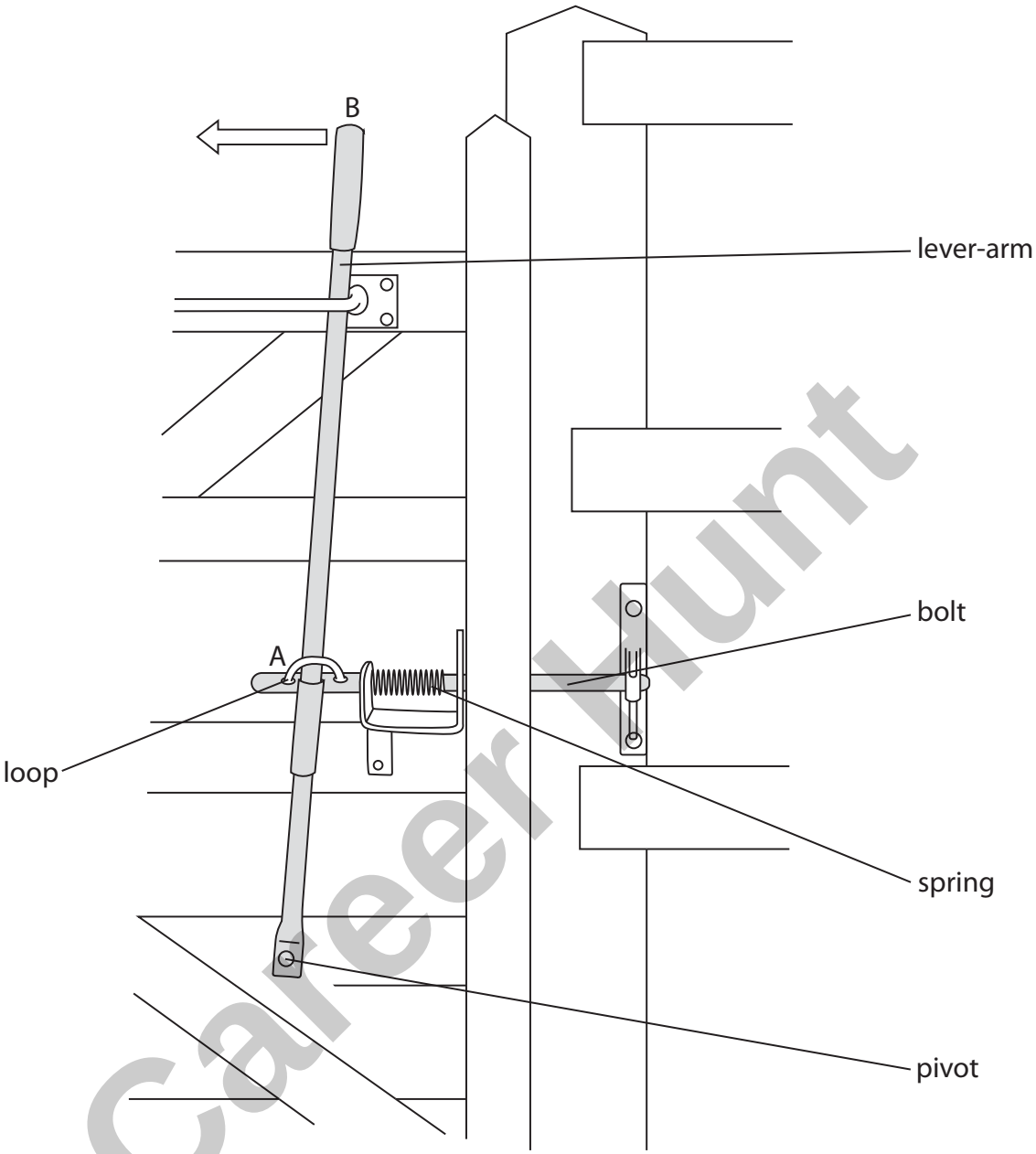
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32 The diagram shows a gate with a lever-operated catch.

A loop on the bolt fits around the lever-arm at A.



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(a) (i) Describe how the lever-arm is used to move the bolt.

(1)

.....

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(ii) Suggest why the spring is needed.

(1)

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(b) The lever-arm operates using the principle of moments.

(i) State the principle of moments.

(1)

.....

.....

(ii) The force applied at point B is 22 N.

The pivot is 110 cm from point B and 38 cm from point A.

Calculate the force exerted on the lever-arm at point A by the spring.

(3)

force at point A = ... N

(iii) Explain how the force applied at point B would need to change if the distance from the pivot to point A is increased.

(2)

.....

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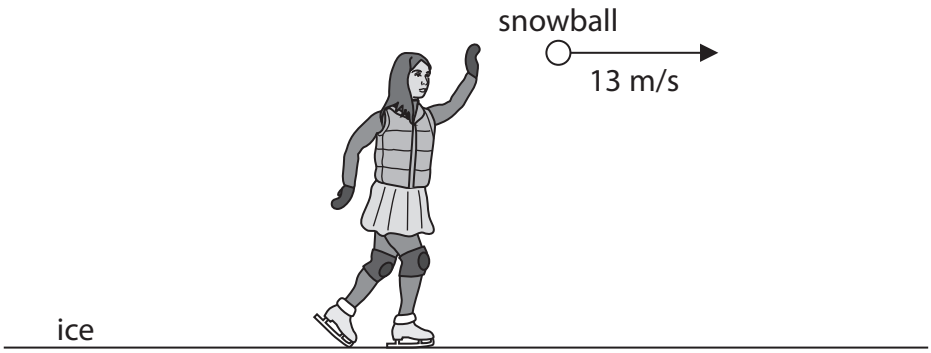
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33 An ice skater throws a 0.23 kg snowball with a velocity of 13 m/s.



(a) (i) State the equation linking momentum, mass and velocity.

(1)

(ii) Calculate the initial momentum of the snowball.

(2)

initial momentum = ... kg m/s

(b) When the skater throws the snowball forwards, she slides backwards on the ice.

Explain why she moves in this direction.

(3)

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(c) The skater wears soft knee pads that compress easily.

Explain how the pads protect her knees when she falls on the ice.

(3)

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34 Some quantities are vectors, others are scalars.

(a) Complete the table ticking the boxes to show which quantities are vectors and which are scalars.

One has been done for you.

(2)

Quantity	Vector	Scalar
distance		
force		
momentum	✓	
speed		
velocity		

(b) A car travels at 20 m/s.

The mass of the car is 1500 kg.

(i) State the equation linking momentum, mass and velocity.

(1)

(ii) Calculate the momentum of the car.

(2)

momentum = ... kg m/s

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(c) In a crash test, a car runs into a wall and stops.



(Author: Brady Holt, 2010)

The momentum of the car before the crash is 22500 kg m/s.

The car stops in 0.14 s.

(i) Calculate the average force on the car during the crash.

(2)

average force = ... N

(ii) Use ideas about momentum to explain how seat belts can reduce injuries to passengers during a crash.

(3)

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35 Cars have a number of features that make them safer in a collision.

(a) Apart from seat belts, name two safety features that reduce the risk of serious injury in a car crash.

(2)

1 .....

2 .....

(b) Photograph A shows a person wearing a seat belt.



© WHO 2013

Photograph A

(i) Using ideas of momentum and force, explain how a seat belt reduces the risk of serious injury in a car crash.

(4)

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(ii) Photograph B shows a full-body harness used in a racing car.



Photograph B

Suggest why a full-body harness is used in a racing car, instead of an ordinary seatbelt.

(1)

.....

.....

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(c) Photograph C shows a crash-test dummy in a car. The car has crashed into a concrete wall.



© Peter Ginter/Getty Images

Photograph C

State what happens to the momentum of the car during the crash.

(1)

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36 (a) State the equation linking momentum, mass and velocity.

(1)

(b) A truck of mass 10 000 kg is moving with a velocity of 4.5 m/s.

A car of mass 1500 kg has the same momentum as the truck.

Calculate the velocity of the car.

(3)

velocity = ... m/s

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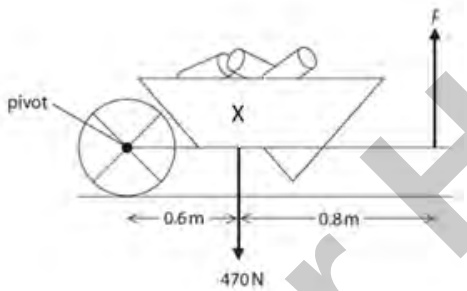
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Chapter 1: Forces and Motion Answer

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Question number			Answer	Notes	Marks
1	(a)	(i)	work done = force × distance (moved);	Accept correct symbols e.g. W = F x d W = F x s	1
		(ii)	substitution; evaluation; e.g. (work =) 140 × 39 5500 (J)	 5460	2
		(iii)	same answer as 5(a)(ii)	allow 'the same'	1
	(b)	(i)	X in line with the weight arrow and vertically between the tail of the arrow and the top of the wheelbarrow (not including the logs);  	judge alignment with weight arrow by eye	1
		(ii)	moment = force × (perpendicular) distance (from pivot);	condone M = F x d M = F x s	1
		(iii)	principle of moments (stated or implied); total distance hand to pivot calculated; substitution showing either correct moment (or both); final rearrangement and evaluation; e.g. (total) clockwise (moment) = (total) anticlockwise (moment) (distance) = 0.6 + 0.8 = 1.4 m 470 × 0.6 = F × 1.4 F = 470 × 0.6 / 1.4 = 200 (N)	 accept 1.4 or 0.6 + 0.8 seen in working accept 282 seen in working allow 201, 201.43 350, 352, 353, 352.5 gets 2 marks	4

Total 10 marks

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Question number	Answer	Notes	Marks
2 (a) (i)	momentum = mass x velocity;	w rds or correct symbols p = m x v reject M for momentum	1
(ii)	substitution; evaluation; e.g. (p =) 0.50 x 3.1 (p =) 1.6 (kg m/s)	ignore - signs allow 1.55 1 mark max for 1.5	2
(iii)	substitution into correct equation; evaluation; e.g. F = 1.55(- 0) ÷ 0.070 (F =) 22 (N)	no mark for equation as given in paper allow ECF from (ii) ignore - signs allow F in range 22-23 (N) inclusive allow method using F=ma.	2
(b)	any two of: MP1. (forces) equal; MP2. (forces) opposite OR up and down; MP3. mention of Newton's third law;	ignore references to balanced forces 'every action has an equal and opposite reaction' scores 2 marks	2
(c)	any two of: MP1. pressure is force / area; MP2. forces (on wood and hammer) are equal; MP3. smaller area of nail is in contact with wood / ORA;	 allow pressure is inversely proportional to area award if clear which end of the nail has the smaller area	2

Total 9 marks

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Question number	Answer	Notes	Marks
3 (a)	A - Force X 7.5 N, Force Y 7.5 N ;		1
(b)	idea that force X decreases; from 15 (N) / to 0 (N);	ignore references to force Y and moments 'it goes from 15 to 0' gets 2 marks	2

Total 3 marks

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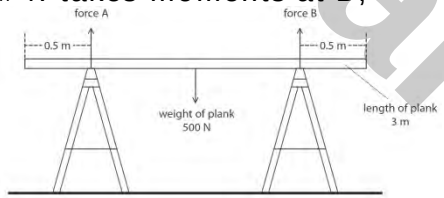
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Question number			Answer	Notes	Mark
4	a	i	moment = force x (perpendicular) distance (from pivot)	in words or accepted symbols	1
		ii	MP1. calc of 1 correct moment (about the pivot); MP2. stated equivalence of clockwise moment= anticlockwise moment /principle of moments; MP3. final value; e.g. 2 x 60 =120 (one mark) 2 x 60= 10 x F_N (two marks) $F_N = \frac{2 \times 60}{10}$ =12 (N) (three marks)	in words or in numbers allow working in cm or m	3
	b		MP1. Increases (force on newtonmeter); MP2. (because) weight of bar has a moment; MP3. in same direction (clockwise) as 2 N weight;	may be shown by a calculation allow F_N = 62(N) for three marks	3
				total = 7 marks	

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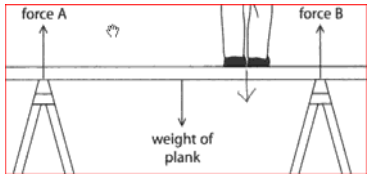
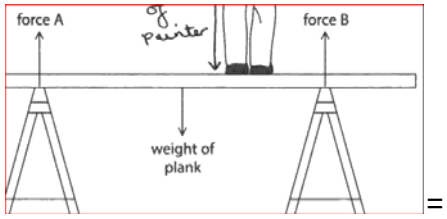
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Question number	Answer	Notes	Marks
5 (a)	B		1
(b) (i)	#1. states principle of moments ; #2. moment= force X (perpendicular) distance from pivot: #3. calculates **one** moment about either A or B; #4. takes moments at B;  e. moments clockwise = moments anticlockwise • moment = weight x distance • 500 x 1 • 1 x 500 = Ax2	Ignore bald '500/2 =250' Accept for #2: in words or in recognisable symbols or in numbers from the diagram Accept qualitative alternative for last 2 marking points: '2 forces so divide weight in half' OWTTE = 1 mark if then qualified by distance consideration = 2 marks	4
(ii)	Upward Force at point B 250(N);	allow arrow for clockwise or anticlockwise	1

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Question number	Answer	Notes	Marks
(c) i	Arrow down from painter; (vertical, below feet)		1
ii	Both **forces** increase;	 =0	
	Force at B larger than force at A / RA ;	ignore: • both moments increase • 'force B is larger'	2
		Total	**9**

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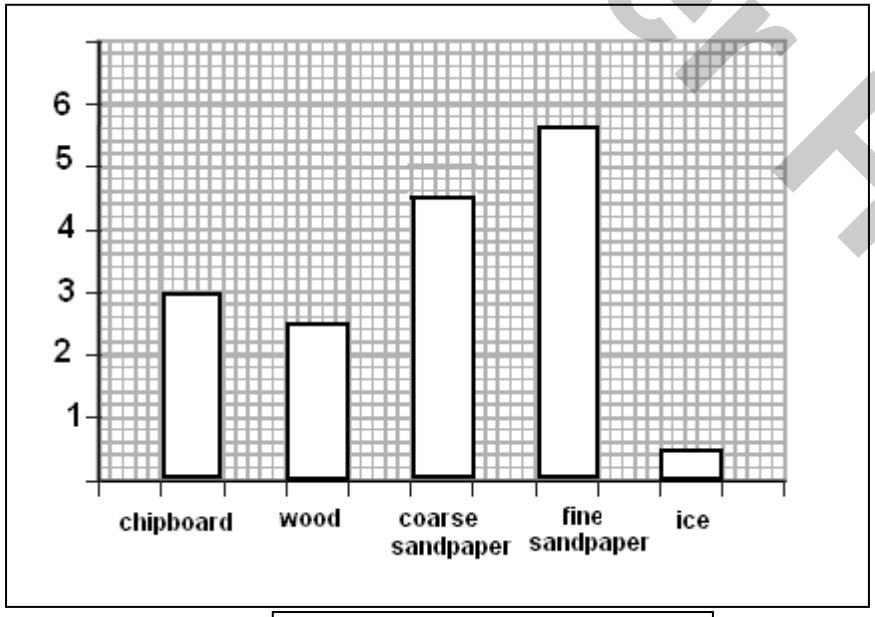
Question number	Answer	Notes	Marks
6 (a) i	Any ONE sensible suggestion from ensuring good contact; increasing friction; increasing pressure;	allow: • to prevent slipping sideways • make it easier to control	1
ii	Keep a fair test / controlled variable;	allow: it not an independent variable ignore: all mention of accuracy	1

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Question number			Answer	Notes	Marks
6	(b)	(i)	(Type of) surface(s);	do not accept: • a (single) named surface • type of block • material of block	1
		(ii)	4.5;		1
		(iii)	**Axes labelled**- quantity and unit; **Linear scale** such that longest bar occupies at least half the grid; **Plotting---ignore order of bars** 5 bars correctly plotted;; If only 3 bars correctly plotted allow 1 mark for plotting	allow force (N) force/N tolerance is +/- 0.5 small sq allow ecf from table ALL data plotted correctly as floating "x's" gets only one mark for plotting Reject both **plotting** marks if a **line** graph is drawn (only scale and axes marks are available in this case)	4



Type of surface	Average
chipboard	3.0
wood	2.5
coarse sandpaper	4.5
fine sandpaper	5.7
ice	0.5

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Question number	Answer	Notes	Marks
6 (c)	Any two of the following five ideas: #1 different experimental set-up; e. • different masses/weights • different kind of wooden block • different speed of pull #2 variable friction; e. • the surfaces were not uniformly smooth • the wooden block did not move evenly across the surface #3 errors in the force meter reading; e. • errors recording the force on the N-meter • faulty scale on N-meter • zero errors / different ranges of N-meters used • different angle of N-meter #4 different contact; e. • the weights on the block may not have been evenly placed on the block • the block was not pressed down onto the surface evenly #5 friction reduces as the experiment progresses; e. • the wooden block becomes smoother as the experiment proceeds • it moves over the surface more easily as the experiment progresses • lubricant on block	Ignore: • unqualified 'broken N-meter' • human error • 'strength of pull' • anomalous results • surface area of surface	2

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Question number	Answer	Notes	Marks
6 (d)	Any two from: Pressure less; Area larger; Use of formula P =F/A;	Load is the same/wood is thinner	2
(e)	Any TWO sensible suggestions;; e. place a lubricant between the two surfaces make the surfaces smoother decrease weights /masses on block	allow: • named lubricants • change the surfaces so that are not so rough • reduce the area (of contact) • decre se mass of block	2
		Total	**14**

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Question number	Answer	Notes	Marks
7 (a)	(metre) ruler;	allow set square, tape measure, digital callipers ignore metre stick	1
(b)	Up to five marks, no more than 3 from each section:- **Recording data** Any three of - MP1. measure original length; MP2. add a (known) weight/force/load/mass; MP3. measure the new length / extension; MP4. Repeat for range of values of load; MP5. Experimental detail; **Handling data / conclusions** Any three of - MP6. Calculate extension; MP7. Plot graph of extension/length against force/weight/load; MP8. Graph should be a straight line; MP9. Extension graph should pass through origin; MP10. Force proportional to extension;	 e.g. • distance measurements from the same point each time • use of pointer/indicator • reduce parallax • repeats **and** average (for each load) Allow length, but not mass calculate k from data k is constant Not for length graph allow load for force	5

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Question number	Answer	Notes	Marks
8 (a) (i)	kinetic energy = ½ × mass × velocity^2	Accept symbols KE = ½ × m × v^2	1
(ii)	Conversion of units; Substitution and rearrangement into correct formula; Calculation; e.g. 18 MJ = 18 000 000 J v^2 = 18 000 000 × 2 ÷ 250 000 (= 144) v = 12 (m/s)	at any stage POT error max 2 marks e.g. 3.8 x 10^n or 1.2 x 10^n	3
(iii)	Energy is transferred to surroundings;	Allow to heat, sound, other forms / energy decreases	1
(b) (i)	Any two of - MP1. GPE = m.g.h; MP2. passengers have moved to a higher point/upwards; MP3. work is done to move the passengers; MP4. passengers are further from the centre of the earth;	allow 'lift' for 'passengers' 'gravity force' (still) acts below ground level, reject 'gravity' moved in opposite direction to force of gravity	2
(ii)	max of 3 from each list to total of 4 **When entering station**- MP1. KE → GPE; MP2. Less work done by the brakes (to stop the train); MP3. Less (braking) force needed (to stop) ; MP4. train stops more quickly OR brakes are needed for less time (to stop); **When leaving station-** MP5. GPE → KE; MP6. Less work done by the motor (to accelerate); MP7. Less force needed (to accelerate	Allow energy for work an effect on the brakes, e.g. don't get so hot / are quieter / last longer / are less worn Allow less power/ current	4

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	the train); MP8. train accelerates more quickly OR force needed for a shorter time (to reach a given speed);	needed motor lasts longer / is less worn	

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Question number	Answer	Notes	Marks
9(a)	9100 (N)		1
(b) (i)	F = m x a;	accept standard symbols or in words or rearranged	1
(ii)	substitution and rearrangement; evaluation; e.g. (a =) 400/910 (a =) 0.44	-1 for POT error allow 0.4, 0.43956044 0.43 gains 1 mark only	2
(c)	any three from: MP1. speed increases; MP2. so drag {starts to act / increases}; MP3. downward forces increase; MP4. (hence) acceleration decreases;	ignore references to the initial acceleration award 1 mark for mention of terminal velocity if no other mark awarded allow air resistance / friction increases allow unbalanced force decreases	3
(d)	acceleration increases; with any one from: • weight decreases / downward force reduces; • unbalanced force increases; • mass decreases;	total marks = 9	2

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Question number	Answer	Notes	Marks
10(a) (i)	6 (m/s);		1
(ii)	10 (s);		1
(b) (i)	Acceleration = **change in** velocity / time (taken) ;	allow accepted symbols	1
(ii)	Substitution in correct equation; Evaluation; Unit; e.g. 12 ÷ 10 = 1.2 m/s^2	 ms^{-2} condone m/s/s	3
(c) (i)	(average) speed = distance (moved) / time ;	allow accepted symbols	1
(ii)	Substitution in correct equation; Evaluation; e.g. 390 ÷ 60 6.5 (m/s)	 (388.5 ÷ 60 = 6.475)	2
(d)	MP1 Idea that distance is given by **area** under the graph; MP2 **Comparison** of the two *areas (by eye or by calculation)*;	ignore steepness of lines, velocity, acceleration, width NOTE: a valid comparison that includes MP1 +MP2 gains both marks e.g. the first 30s area is larger than the last 30s	2

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Question number	Answer	Notes	Marks
11(a)	Any two of - MP1. mention of no zero error; MP2. Mention that ruler is should be vertical; MP3. use of a fiducial marker; MP4. use of ruler with finer calibrations; MP5. means to reduce parallax; MP6. use of **calliper**;	Ignore (more) accurate ruler e.g. a pin Allow • more detailed ruler • smaller intervals ignore proximity	2
(b) (i)	Distance		1
(ii)	Any two of - MP1. Idea of weight is the force on the mass / W=mg ; MP2. change grams to kilogram; MP3. 1N of force for every 100g; MP4. g is 10 (N/kg);	in any form including numerical Accept ÷ 1000 Ignore ÷ 100 without further explanation Allow idea of gravitational field strength Accept x 10	2

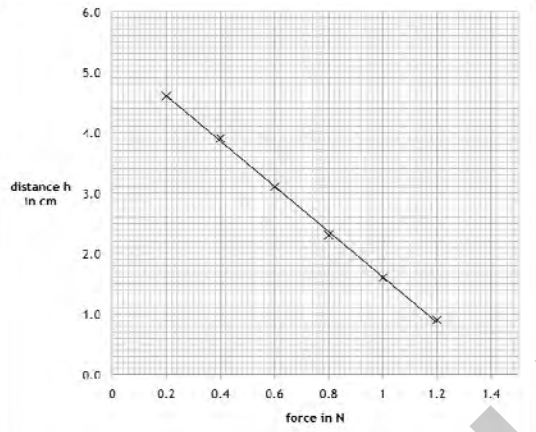
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Question number	Answer	Notes	Mar
(b) (iii)	Suitable linear scale chosen (>50% of grid used);	no awkward scale	5
(iv)	Axes labelled with quantities and unit; Plotting correct to nearest half square (minus one for each plotting error);; Line of best fit acceptable;	Orientation unimportant i.e. two plotting errors = no marks for plotting i.e. straight line	



Force in N	Distance *h* in cm
0.2	4.6
0.4	3.9
0.6	3.1
0.8	2.3
1.0	1.6
1.2	0.9

(iv)	straight line seen extended to the force axis; 1.40 ≤ F ≤1.46 (N);	F value to 3 SF unless line goes through 1.40 accept force = 1.4 Answer in range = two marks	2
(v)	NO mark for Yes/No answer Any two of - MP1. Correct statement of Hooke's law; MP2. graph shows equal decrements for distance with force MP3. (line goes down because) different distance has been measured; MP4. graph does not pass through the origin;	Allow **extension** is (directly) proportional to force • equal steps • the line is straight ignore graph is • directly proportional • inversely proportional • negative correlation • the "wrong" distance is measured • extension can be worked out from data • more force = larger extension	2

Total 14 marks

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Question number	Answer	Notes	Marks
12 (a) (i)	weight (of toy car);	allow mass	1
(ii)	speed (of toy car);	allow: velocity time (to go down the slope)	1
(b)	any 2 of: MP1. angle/gradient/incline/steepness/height of slope; MP2. same car/eq; MP3. surface of slope; MP4. force at launch; MP5. initial speed; MP6. starting height/position/point (of car); MP7. distance travelled/length of slope;	ignore weather conditions	2
(c)	battery joulemeter micrometer newtonmeter ✓ ruler (✓) stopwatch ✓ thermometer one correct tick; two correct ticks;;	allow clear alternative indications e.g. - crosses - shading if more than 2 ticks, -1 for each incorrect tick	2

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(d)	any **5** of: MP1. measure weight/mass; MP2. measure distance (down slope)/start from same point; MP3. measure time/speed (with light gate); MP4. equation seen or described in words: speed = distance / time; MP5. idea that different weights used; MP6. repeat experiment AND average/remove anomalies; MP7. method to improve accuracy, e.g. use of light gates, reaction time considered;	Allow 'find out' for measure	5

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Question number	Answer	Accept	Reject	Marks
13 (a) (i)	Work done = force x distance (in direction of force);	W = F x d d = W / F F = W / d		1
(ii)	Substitution (in correct equation); Answer; e.g.: W = 1.7 x 0.46 = 0.78 (J);	 0.782		2
(iii)	Response must match 7a(ii) ; e.g. 0.78	Accept word answer e.g. “the same”		1
(b) (i)	KE is zero /less / decreased;	No KE The KE is transferred (to other forms)		1
(ii)	Centre of gravity is lower;	Centre of mass is lower Height is lower <u>and</u> reference to mgh		1

Total 6 marks

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Question number	Answer	Notes	Marks
14(a)	B – force;		1
(b)	B – energy;		1
(c)	A - gravitational potential energy;		1
(d)	D – the vertical forces on it are balanced;		1

Total 4 marks

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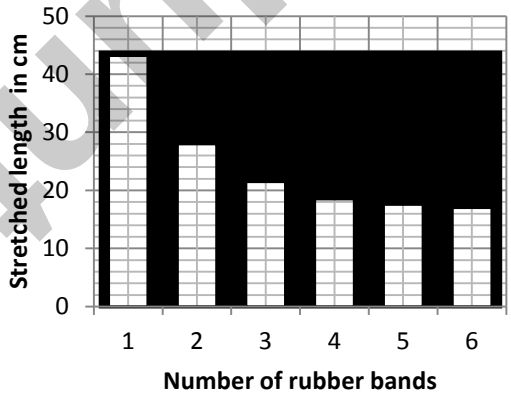
Question number	Answer	Notes	Marks
(i) 15 (a)	18.7 ± 0.5 (cm);	accept any value between 18.2 and 19.2	1
(ii)	Any two of - MP1 Mention of <u>parallax</u> error; MP2 Idea of zero error; MP3 End of ruler is worn; MP4 Hook is curved; MP5 Hook stretches bands to different lengths; MP6 Bands are not close to ruler; MP7Bands are not parallel to ruler; MP8 Bands are twisted;	Ignore human error Ignore inaccurate scale Ignore anomaly, no average, references to Hooke's law	2
(b)	Idea of a controlled variable; e.g. force kept constant temperature kept constant	Allow properties of bands, e.g. type, brand, material, thickness, elasticity, original length Ignore idea of consistent technique, e.g. using same equipment	1

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Question number	Answer	Notes	Marks
(c) (i)	Discrete/discontinuous; OR Independent;	Allow non-continuous, categoric	1
(ii)	Axes labelled - quantities and distance unit; Suitable scale chosen - longest bar occupies at least half the grid; All 5 bars for given data correctly plotted;;	Ignore orientation Ignore the 4 band value Bar length plotted to nearest small square. Deduct one mark for each plotting error (max -2) Data plotted correctly, but only as floating "x's" gets maximum of one mark for plotting Reject both plotting marks if a line graph is drawn (only scale and axes marks are available in this case)	4
(iii)	MP1 Idea of inverse relationship; MP2 Idea of non linearity;	Allow: pattern statements negative correlation Accept ecf "curved line"	2



Number of rubber bands	Stretched length in cm
1	43.2
2	28.0
3	21.5
4	(Ignore)
5	17.6
6	17.0

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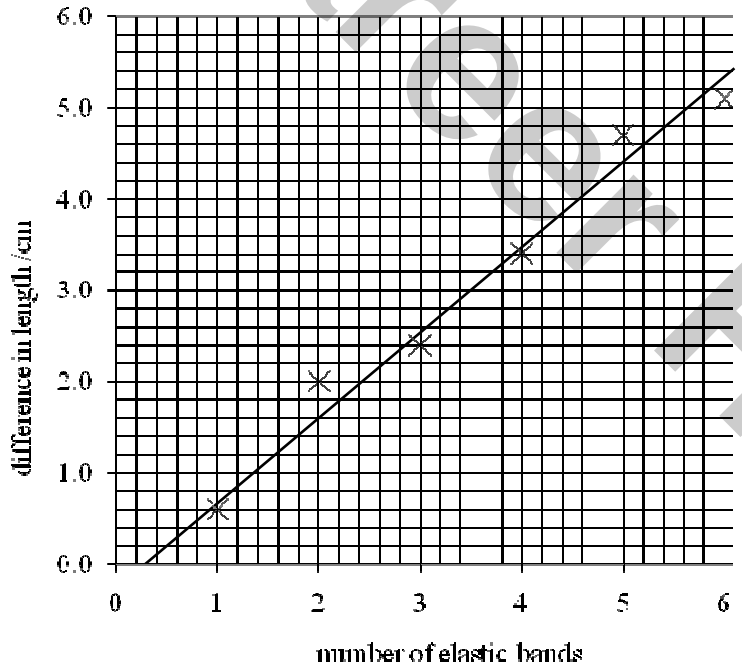
Question number	Answer	Notes	Marks
16(a)	weight of (the) plank		1
(b) (i)	moment = force x (perpendicular) distance (from pivot)		1
(ii)	substitution; final value; e. 1200 x 0.75 900 (Nm)		2
(c)	principle of moments (stated or implied); correct calculation of distance from hand to pivot; calculation of total anticlockwise moment; final value; e. (F x 2.25) + (200 x 0.75) = (1200 x 0.75) F = 330 (N)	Allow ecf from (b) 2.25 (m) seen in working (F x 2.25) + (200 x 0.75) Allow 333 N	4

Total 8 marks

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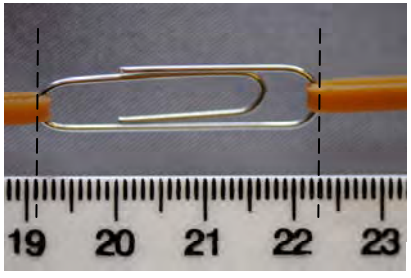
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Question number			Answer	Accept	Reject	Marks
17	a)	(i)	5.1			1
		(ii)	Suitable scale chosen (>50% of grid used); Axes labelled with quantities and units; Plotting to nearest half square (minus one for each plotting / error);; Line of best fit acceptable; Sample graph:  	Ignore 6 bands point Line below points 2,5 and above points 1,3,4 Ecf from (a)(i) e.g. an appropriate curve Orientation of axes unimportant 1 0. 2 2. 3 2. 4 3. 5 4. 6 (5.1		5

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Question number			Answer	Accept	Reject	Marks
	(a)	(iii)	Any two of It is a straight line; Gradient / slope / correlation is <u>positive</u>; Line does / doesn't pass through origin; Idea of correlated variables, e.g. direct / indirect proportionality [depending on projection to the origin], length increases with number of bands;	Ecf from (a)(i)/(ii) Related statement e.g. curve, line forced through origin or mention of "anomaly"		2
	(b)		3.2 ± 0.1 (cm) ; ; Sample working:  	Allow evidence of two readings from scale for one mark, e.g. subtraction (22.3 - 9.1) or appropriate drawing on the photograph	Direct measurement of photograph with a ruler	2

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Question Number			Answer	A	Reject	Marks
	(c)		Responses may refer to measuring the length of either object (the chain or the single paperclip from photographs A and B) Any two of: Either object - parallel with scale; closer to scale; use fiducial mark e.g. a set square; take parallax into account; Minimise effect of friction on stretched chain; Remove paperclip from chain for measurement;	Ignore: repetition, measuring paperclip from zero Allow sensible equipment changes, e.g. more precise scale, using stiffer paperclips / links		2
					Total	**12**

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Question number	Answer	Notes	Marks
18 (a) (i)	force = mass x acceleration;	in words or in accepted symbols e.g. F=ma	1
(ii)	substitution; evaluation; e. 38 x 1.5 57 (N)	 57000 (N) scores 1 mark	2
(iii)	any suitable suggestion; e.g. friction between snow/ground and sledge ground is not level towing rope/direction at an angle to the ground/direction of movement	allow air resistance/drag	1
(b) (i)	acceleration = **change** in velocity; time (taken)	in words or in accepted symbols e.g. $a=\frac{\Delta v}{t}$ $a=\frac{v-u}{t}$ not 's' for 'v'	1
(ii)	*working must be shown* rearrangement of equation OR substitution; evaluation to at least 2SF; e. $t=\frac{2.8}{1.5}$ = 1.9 (s)	Calculation of velocity or acceleration scores 1 mark max. allow 1.87 no unit required	2

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(c) (i)	MP1. statement of total distance = area under graph; MP2. any 1 correct distance for a segment of journey; e.g. calculation of distance during acceleration (½ x 3.25x 2.5 = 4.1 m) calculation of distance during constant speed (3.25x 8 = 26 m) calculation of distance during deceleration (½ x 3.25x 4 = 6.5 m) MP3. correct total distance 36.6 (m);	may be assumed by an attempt at sum of the areas allow range of 36-37 (m)	3
(ii)	(average) speed = $\frac{\text{distance (moved)}}{\text{time (taken)}}$;	in words or in accepted symbols e.g. v=s/t condone s=d/t	1
(iii)	substitution; evaluation; e.g. 36.6/14.5 2.52 (m/s)	allow ecf from (c)(i) for distance ignore s.f. allow answers that round to 2.5 or 2.6 (m/s)	2

Total 13 marks

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Question number	Answer	Notes	Marks
19 a	any FIVE from: MP1. Object has weight or there is a downward force (due to gravity on the object); MP2. So it accelerates (downwards); MP3. there is (a force of) drag (upwards or to oppose movement); MP4. drag increases as speed increases; MP5. eventually drag = weight ; MP6. (hence) resultant force is zero; MP7. (hence) object travels at constant speed;	allow: gravity pulls it down the speed/velocity increases oil resistance / water resistance / air resistance for drag oil friction / water friction / air friction for drag 'drag increases as it accelerates' forces are equal / forces are balanced accept 'no acceleration' DO NOT ALLOW • (The drag) slows it down MP2 • upthrust for drag MP3 • resistance = acceleration for MP5 • terminal velocity for constant speed for MP7	5

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b	<u>Measuring instruments</u> MP1. Timer / stop-clock/ light gate (and data logger); MP2. Ruler / scale; <u>Measurements made</u> MP3. Take time for ball to pass between two points; MP4. determine the distance apart; MP5. Repeat readings lower down; **OR** MP6. For a set time (e.g. for 1 s); MP7. measure distance travelled (in this time); MP8. Repeat readings lower down; **OR** MP9. measure velocity using light gate with data logger; MP10. at two different places; <u>Using measurements</u> MP11. Use speed = distance / time; MP12. How results indicate terminal velocity achieved;	Ignore ticker-timer measurement of mass condone tape measure if the measurements are from top to bottom then only give MP3 or MP4 not both allow velocity for speed	5

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Question number	Answer	Notes	Marks
20 (a)	any two from : a balance/scales; metre rule or measuring tape; stopwatch or stop-clock;	allow newtonmeter	2
(b)	dependent = time (taken for fall);	accept speed (of cupcake cases)	2
	independent = mass (of cupcake cases);	accept number/weight (of cupcake cases)	
(c)	Any ONE of • (constant) height; • still air/no (cross) wind; • from rest/zero force at launch; • identical (cupcake) cases;		1
(d)	time in s; mass in g;	accept in either order accept mass in kg weight in N number of cupcake cases in numbers/no units	2

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(e)	Any one of • detail of any sensible and valid procedure; e.g. repeat readings for time and then average readings • detail of more suitable conditions e.g. measure over a larger fall work indoors/reduce draughts ;	allow more accurate timing methods;	1

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Question number	Answer	Notes	Marks
(f)	down arrow labelled weight;	allow gravitational force/pull ignore 'gravity'	2
(i)	up arrow labelled drag;	allow air resistance accept friction, upthrust ignore lift	
(ii)	any three from MP1. idea of **unbalanced** force; e.g. at the start, the only force is weight part way down, the weight is greater than the drag MP2. (this unbalanced) force causes acceleration; MP3. idea of balanced forces near the bottom; e.g. near the bottom the forces are equal MP4. therefore no acceleration; e.g. it reaches terminal velocity	do not credit repeat of the diagram above there is no upward force at the start weight equals drag	3

(Total for Question 3 = 13 marks)

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Question number	Answer	Notes	Marks
21 (a) (i)	work done = force x distance moved ;	Accept W = F x d Allow rearrangements do not accept eqn in units only	1
(ii)	Substitution into correct equation; Calculation; 170 x 110 19 000 (J)	Accept **18 700** (J)	2
(iii)	exactly same as their answer to (ii);		1

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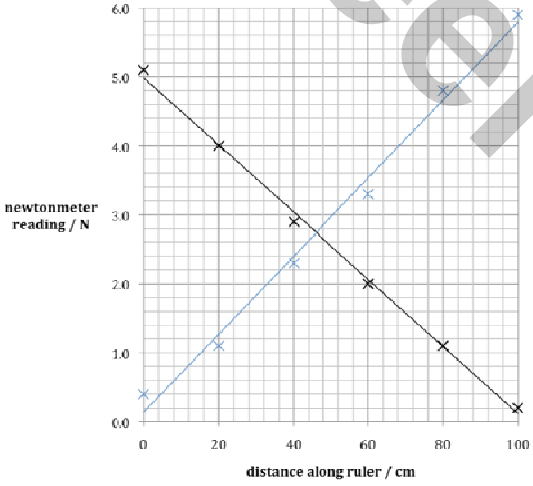
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Question number	Answer	Notes	Marks
(b) (i)	KE = ½mv^2	Accept word equation	1
(ii)	addition of masses before OR addition of energies after; Substitution into correct equation; Calculation; 1650 + 950 = 2600 (OR 436 425 + 251 275 = 687 700) ½ x 2600 x 23^2 688 000	Accept for 1 mark - either 436 000 or 251 000 accept for 2 marks - both 436 000 and 251 000 Accept for 3 marks- 687 700	3
(c)	Any **three** of 1. idea that mass and acceleration are inversely related; 2. Idea that (total) mass is less; 3. Idea of less (air) resistance / friction; 4. Idea of less work done/less energy used; 5. Idea of amount work related to amount of (chemical) energy from fuel;	allow F = m x a mentioned weight for mass drag doesn't have to use energy to pull the caravan	3
		Total	**11**

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Question number		Answer	Notes	Marks
22 (a)	(i)	A – distance A		1
	(ii)	D – force D		1
(b)	(i)	Force (C) in N; or Force in newtons;	Allow: Reading from newton-meter in N	1
	(ii)	Plotting ;; Line of best fit;  0 5.1 20 4.0 40 2.9 60 2.0 80 1.1 100 0.2	To nearest ½ square, penalise errors up to two marks Suited to candidate's plotting (allow a smooth curve) no double lines judge LoBF by balance of points about the line	3
	(iii)	Reading from graph to ± 1 cm; e.g.	To nearest ½ small square	1

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Question number	Answer	Notes	Marks
(c)	weight of ruler;	Accept other valid reasons allow force for weight ignore 'it's got a force acting' 'because of gravity'	1
		Total	**8**

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<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>23 (a)</td><td>all 3 for both marks;;

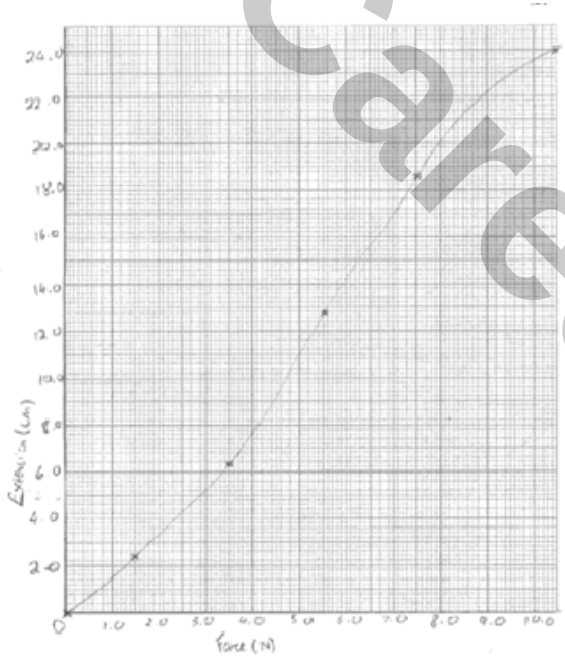
any two for 1 mark ;

<table>
<tr><th>item</th><th>Tick if needed</th></tr>
<tr><td>ammeter</td><td></td></tr>
<tr><td>steel spring</td><td></td></tr>
<tr><td>retort stand and clamp</td><td>✓</td></tr>
<tr><td>rubber band</td><td>given ✓</td></tr>
<tr><td>ruler</td><td>✓</td></tr>
<tr><td>thermometer</td><td></td></tr>
<tr><td>mass hanger</td><td>✓</td></tr>
<tr><td>mass</td><td>given ✓</td></tr>
</table>
</td><td>each incorrect tick = -1</td><td>2</td></tr>
</table>

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(b)	I	5.5 (in the table)		1
	ii	suitable scale for axes; axes labelled with units; points plotted to nearest mm square (minus one for each plotting, up to max 2 marks);; Line (curve) of best fit acceptable; 	-1 for each incorrect plot Allow (ecf) a balanced straight line of best fit that takes account of any plotting errors and indicated anomalies	5
	iii	No / yes (no mark) Idea that Hooke's law should show (direct) proportionality; Use of data (from the table or graph) to explain that the results do not show this; e.g. 'line is a curve', '(table shows) rubber band extends unevenly'	Allow (ecf) - converse from straight drawn line, using data from their graph (not the table) e.g. 'Yes' AND 'line is a straigh	2
			Total	10

Mass in g	Force in N	Extension in cm
0	0	0.0
150	1.5	2.4
350	3.5	6.3
550		12.8
750	7.5	18.6
1050	10.5	24.0

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Question number	Answer	Notes	Marks
24(a)	B – the horizontal part of the line;		1
(b)	A – the area under the line;		1
(c)	B – the distance moved divided by the time taken;		1

Total 3 marks

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Question number	Answer	Notes	Marks
25	Any **5** of 1. determine / measure distance; 2. determine / measure time; 3. Appropriate measuring instrument for distance **OR** time; 4. Use a suitable distance /count laps (of known length); 5. repeat experiment/**calculate** average; 6. Speed = distance / time OR finding the gradient ; 7. Suitable experimental precaution, e.g. reaction time considered, consistent height on track, time from a predetermined consistent point;	Allow idea of published track length use of split times e.g. 1 lap or circuit Ignore 'human error'	5
		Total	**5**

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Question number	Answer	Notes	Marks
26 (a) (i)	42 (m/s)	Allow range 42 - 43	1
(ii)	Attempt to calculate slope; Answer; Unit; 42 ÷ 15 2.8 m/s^2	Allow value from (i) e.g. 43 m/s → 2.9 m/s^2 42.5 →2.83 m/s^2 45 → 3 m/s^2 not 42/120 allow 42/20	3
(iii)	Attempt to calculate an area under graph line; Appropriate further working (e.g. adding areas); Answer; (½ x 15 x 42) + (80 x 42) + (½ x 25 x 42) 315 + 3360 + 525 4200 (m)	Allow value from (i) e.g. 43 m/s → 4300 m first 2 MP may be gained using the trapezium method, i.e. 42 x (120+80)/2 Bald correct answer scores 3	3

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Question number	Answer	Notes	Marks
(b)	Any **three** from 1. Stopping distance affected by speed or mass; 2. For faster plane, stopping distance greater/ runway too short ; 3. for heavier plane stopping distance greater/ runway too short; 4. Attempt to calculate stopping distance from graph; 5. Data shows most/all of runway already used;	ignore time = 500/40 Allow a momentum argument for MP1, 2, 3	3
		Total	**10**

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Question number		Answer	Notes	Marks
27 (a) B		constant velocity of 5 m/s	Allow speed is 5 m/s	2
D		Idea that velocity/speed = 0	Allow "stops", "stationary","at rest"	
(b)		Idea of greater slope (for stage E); e.g. the gradient is steeper	Allow reverse argument, provided stage A is identified e.g. "stage A has a shallower slope" Allow attempts to demonstrate through - ca culation of both gradients - qualitative comp rison of data	1
(c)		distance = speed × time OR distance = area under graph; attempt to find any area; attempt to total correct areas (or use trapezium method); evaluation; e. distance = area under graph 7 × 7 or ½ × 7 × 3 (7 × 7) + (½ × 7 × 3) = 49 + 10.5 59.5 (m)	The correct relationship can be **implicit** in the working 59.5 (m) with no working = full marks Allow the trapezium method - e.g. 7 × ((7+10) ÷ 2) = 7 × 8.5 = 59.5 (m)	4
(d)		Correct equation shown ; e.g. (average speed) = distance (moved) / time (taken) Substitution of correct distance and suitable time; Correct evaluation ; e.g.106.5/27 3.94 (m/s)	Allow d/t Allow (ecf) max 2 4.26 (m/s) (use of time = 25 s) 3.55 (m/s) (use of time = 30 s) Allow reverse argument max 2 e.g. 106.5 ÷ 4 = 26.6 (s)	3

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Question number	Answer	Notes	Marks
28	Any FOUR of Reaction time of driver (inc comment on drink/drugs / driver paying attention / driver distracted /driver tired); Condition of car's brakes/force applied to brakes; Condition of car's tyres; Condition of road surface (inc ice/water/mud /friction ideas); Stopping distance of car; Velocity / speed / behaviour of rabbit (across road); Distance of rabbit from car; Visibility factor (e.g. fog / dirty windscreen); ALLOW MAXIMUM of TWO from these Kinetic energy of car; Momentum of car; Velocity / speed of car; Mass / weight of car / number of passengers;	ACCEPT 'thinking distance / time' as an alternative to these points IGNORE 'condition of driver' ACCEPT 'braking distance (of the car)' as an alternative to these three 'condition' points IGNORE 'condition of car' i.e. momentum of car <u>and</u> velocity of car <u>and</u> mass of car only scores two of the marks available	4

Total 4 Marks

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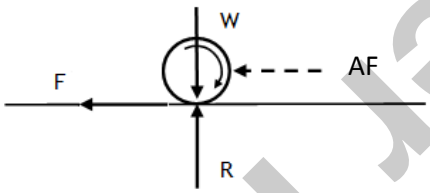
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Question number	Answer	Notes	Marks
29(a) (i)	6.1 (m);		1
(ii)	any two from:- MP1. (on distance-time graph,) flat line means zero speed / eq MP2. (so) count when slope is zero; MP3. 7 (times);	allow flat or horizontal for zero slope	2
(b) (i)	(average) speed = <u>(total) distance moved</u> (total) time taken	allow defined symbols ignore 'triangles'	1
(ii)	Substitution; Calculation; Matching unit; e.g. Average speed = <u>6.1</u> (7x 60) = 0.0145 = 0.015 m/s	allow both substitution and calculation marks for a correct value without working allow 6.1, or ecf for distance 7 for time allow alternatives with compatible unit, e.g. 1.45 cm/s OR 1.5 cm/s 14.5 mm/s OR 15 mm/s 0.87 m/minutes 87 cm/minute 870 mm/minute Allow for 1 mark 6 / 7 or 0.9	3

Total 7 marks

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Question number	Answer	Notes	Marks
30 (a) (i)	Any two of - MP1. arrow downwards, labelled weight; MP2. arrow upwards, labelled reaction/contact force; MP3. arrow to the left, labelled air friction / air resistance / drag; MP4. arrow along the surface, labelled friction; e.g.  	In MP1, 2 & 3, position of arrows unimportant, but direction must match label Allow initial letters as shown in example ignore • gravity allow • mg • force of gravity • arrow drawn on left or right Accept arrow in either direction for MP4 N = normal contact force	2
(ii)	Any three of - MP1. friction/resistance /drag (acts); MP2. (there is an) unbalanced force; MP3. (hence) ball decelerates; MP4. reference to $f_{(R)} = ma$; MP5. (kinetic) energy dissipates / fate of energy discussed;	ignore stem allow • resistive forces > {forward/driving} force • there is a resultant force • its momentum changes • accelerates	3
(b) (i)	idea that friction is (much) less in the air;	allow • RA • no contact / ground friction • less energy lost	1

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Question number	Answer	Notes	Marks
(c) (i)	KE = ½ mv^2;	Words or symbols	1
(ii)	Conversion to kg; Substitution into correct equation; Rearrangement; Evaluation; e.g. 45 g = 0.045 kg (or 1 kg = 1000 g etc) $36 = ½ \times 0.045 \times v^2$ $v^2 = \frac{2 \times 36}{0.045}$ (= 1600) 40 (m/s)	allow • 1000 seen • steps in any order • correct answer with no working for full marks • up to 3 marks for use of 45 kg →1.26 (m/s)- working must be seen	4
(iii)	Any one of- • (Hit the ball transferring) more energy; • (Hit the ball with) more velocity; • (Hit the ball with) more speed; • (Hit the ball with) more force;	Ignore • harder • power Allow • momentum • keep contact for a larger part of the swing • go to a place where g is less (e.g. on the moon) • hit ball at a steeper angle / vertically (e.g. use a more lofted club)	1

Total 12 marks

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Question number	Answer	Notes	Marks
(i) 31 (a)	p = m x v	accept answer in words, standard symbols or rearranged	1
(ii)	statement of conservation of momentum; calculation of momentum before seen; use of correct mass for momentum after; evaluation of velocity; e.g. $m_1v_1 = m_2v_2$ 43.2 x 4.10 OR 177(.12) seen (m_2=) 45.7 (v=) 3.88 (m/s)	 allow in words 3.9, 3.876	4
(b)	MP1. boy and skateboard move backwards/in opposite direction to the ball; Either MP2. because of conservation of momentum/eq; MP3. because of Newton's 3rd law/eq;	 total marks = 7	2

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Question number	Answer	Notes	Marks
32 (a) (i)	lever arm / bolt moves to the left;		1
(ii)	to return the metal bar (and lever) to the right/eq	allow pulls it back (again)	1
(b) (i)	$F_1d_1 = F_2d_2$;	accept answer in words, standard symbols or rearranged clockwise (moments) = anticlockwise (moments	1
(ii)	substitution; rearrangement; evaluation; e.g. $110 \times 22 = 38 \times F_2$ $F_2 = \frac{110 \times 22}{38}$ 63.7 (N)	rearrangement and substitution in either order 63.684 (N) -1 for incorrect rounding	3
(iii)	any two from MP1 (since distance to A greater) moment is greater; MP2 distance to B is constant / still 110 cm; MP3 (hence) force will increase;	allow correct re-calculation with d_B total marks = 8	2

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Question number	Answer	Notes	Marks
33 (a) (i)	momentum = mass × velocity;	symbols and rearrangements e.g. p = m × v	1
(ii)	substitution into correct equation; evaluation; e. (momentum =) 0.23 × 13 = 3.0 (kg m/s)	 allow 3, 2.99	2
(b)	explanation in terms of conservation of momentum OR Newton's third law **conservation of momentum** - any 3 of: MP1. mention of conservation of momentum; MP2. momentum of snowball **and** skater; MP3. (are) equal and opposite; MP4. because momentum initially zero; OR **Newton's third law** - any 3 of: MP1. mention of {action and reaction / Newton III law}; MP2. forces on skater **and** snowball; MP3. (are) equal and opposite; MP4. idea that (magnitude of) rate of change of momentum is same for both forces;	 allow 'her' or similar to mean the skater allow e.g. -3.0 (kg m/s) allow 'her' or similar to mean the skater condone 'push' for force **if no other mark awarded**, allow 'because there is no / little friction' for 1 mark	3

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(c)	explanation in terms of momentum OR acceleration OR pressure **momentum** - any 3 of: MP1. idea of increased time (of impact); MP2. **same** change in momentum; MP3. force is rate of change in momentum; MP4. reduces force (on knee); OR **acceleration** - any 3 of: MP1. idea of increased distance/time (to slow down); MP2. **same** change in velocity / speed; MP3. reduces acceleration; MP4. reduces force (on knee); OR **pressure** - any 3 of: MP1. idea of increased area (in contact with ground / knee); MP2. reduced force; MP3. pressure = force ÷ area; MP4. reduces pressure (on knee);	allow F = change in momentum ÷ time allow same force symbols	3

Total 9 marks

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Question number	Answer	Notes	Marks
34 (a)	Vector quantities – Force, velocity Scalar quantities – Distance, speed	Four correct ticks = 2 marks minus 1 each mistake /omission two ticks in a row is a mistake **Quantity** / **Vector** / **Scalar** distance / / ✓ force / ✓ / momentum / (✓) / speed / / ✓ velocity / ✓ /	2
(b) (i)	Momentum = mass x velocity;	Allow equivalent rearrangement or symbols p= m x v	1
(ii)	Substitution into correct equation; Calculation; e.g. 1500 x 20 30 000 (kg m/s)	Allow 3×10^4 Full marks for correct answer without working (bald answer)	2

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Question number	Answer	Notes	Marks
(c) (i)	Substitution into correct equation; Calculation; e.g. $\frac{22500}{0.14}$ 160 000 (N)	No mark for the equation as it is given on page 2 Accept 2 or more sf, e.g. 161 000, 160 714 Full marks for bald correct answer	2
(ii)	Any three of - MP1. Longer time (of impact); MP2. **Same** momentum change (with or without a seatbelt); MP3. Reduces force; MP4. Passenger stays on seat / is not thrown from vehicle/eq;	Do not credit the equation as it is given on page 2 Allow slows down more gradually	3

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Question number	Answer	Notes	Marks
35 (a)	Any 2 from air bags; side impact beams/bars; crumple zones /collapsible bumpers; collapsible steering column /wheel;	Allow references to strong / laminated / safety glass ignore unqualified bumpers	2
(b) (i)	Any four from MP1. same momentum change (with or without a seatbelt); MP2. (but) time of impact increases; MP3. (which) reduces rate of momentum change; MP4. (therefore) reducing the (average) force; MP5. the seat belt stretches (during collision); MP6. (which) increases the area over which the force acts; MP7. (hence) pressure on body reduces;	Ignore • references to momentum reducing • word equation	4
(b) (ii)	A sensible suggestion; e.g. there is a higher momentum (transfer in collision) there is a larger force during impact straps have a greater area over which force acts larger area of straps reduces the pressure		1

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(c)	Momentum (of car and dummy) reduces to <u>zero</u>; OR All momentum is absorbed by the Earth;		1

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Question number	Answer	Notes	Marks
36 (a)	momentum = mass × velocity;	Allow rearrangements and standard abbreviations p = m x v	1
(b)	Equation; Substitution and rearrangement; Evaluation; e.g. $m_1 \times v_1 = m_2 \times v_2$ 10 000 x 4.5 / 1500 30(m/s)	 bald answer = 3 marks POT =-1	3

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Chapter 2: Electricity Question

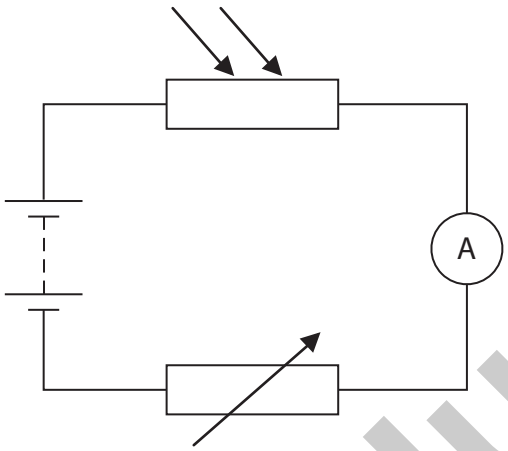
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1 The resistance of a Light Dependent Resistor (LDR) is affected by the amount of light that shines on it.

A student investigates this relationship using the circuit shown.



(a) (i) The student uses a voltmeter to measure the voltage across the LDR.

Add this voltmeter to the circuit diagram.

(2)

(ii) Explain how the student can work out the resistance of the LDR using this circuit.

(2)

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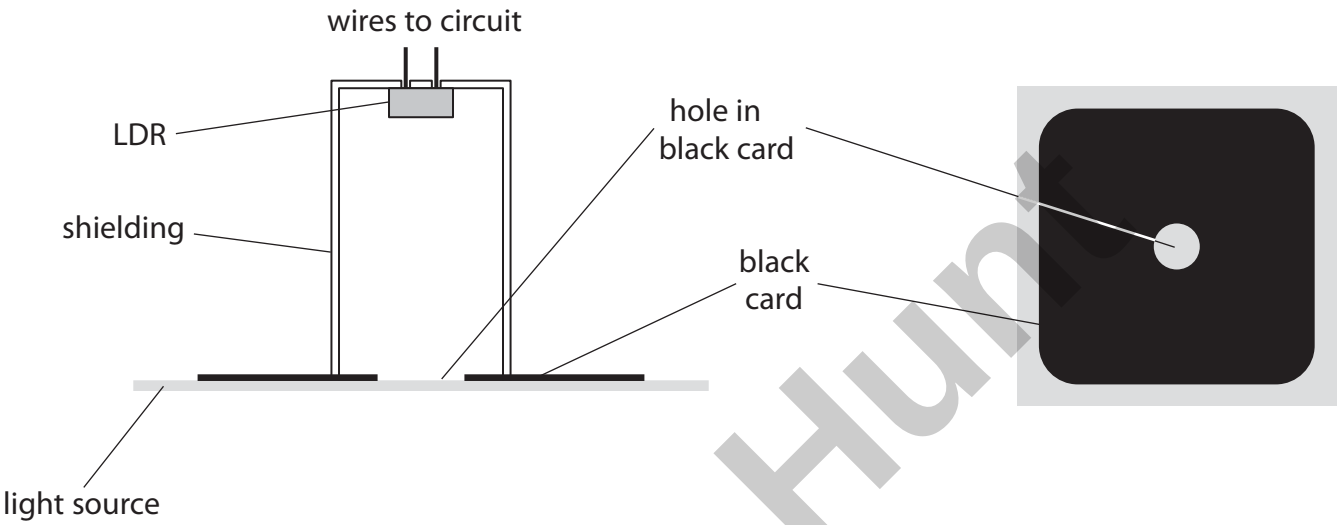
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(b) The student shines light on the LDR through a circular hole in a piece of black card, as shown in the diagram.

The student repeats the experiment using cards with holes of different diameter.

The distance from the card to the LDR is always 5 cm.

The student varies the current in the circuit by adjusting the variable resistor.



(i) The independent variable in this experiment is

(1)

☒ **A** the brightness of the light source

☒ **B** the diameter of the hole

☒ **C** the distance from the card to the LDR

☒ **D** the resistance of the LDR

(ii) A controlled variable in this experiment is

(1)

☒ **A** the current in the circuit

☒ **B** the diameter of the hole

☒ **C** the distance from the card to the LDR

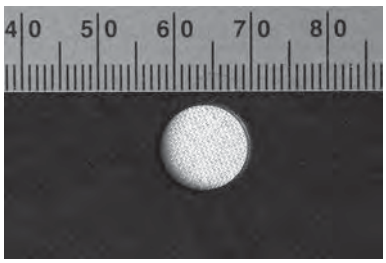
☒ **D** the resistance of the LDR

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(iii) The photograph shows how the student places a metal ruler to measure the diameter of one of the holes.



Suggest how the student can improve this technique while still using the same ruler.

(1)

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(c) The table shows the student's results.

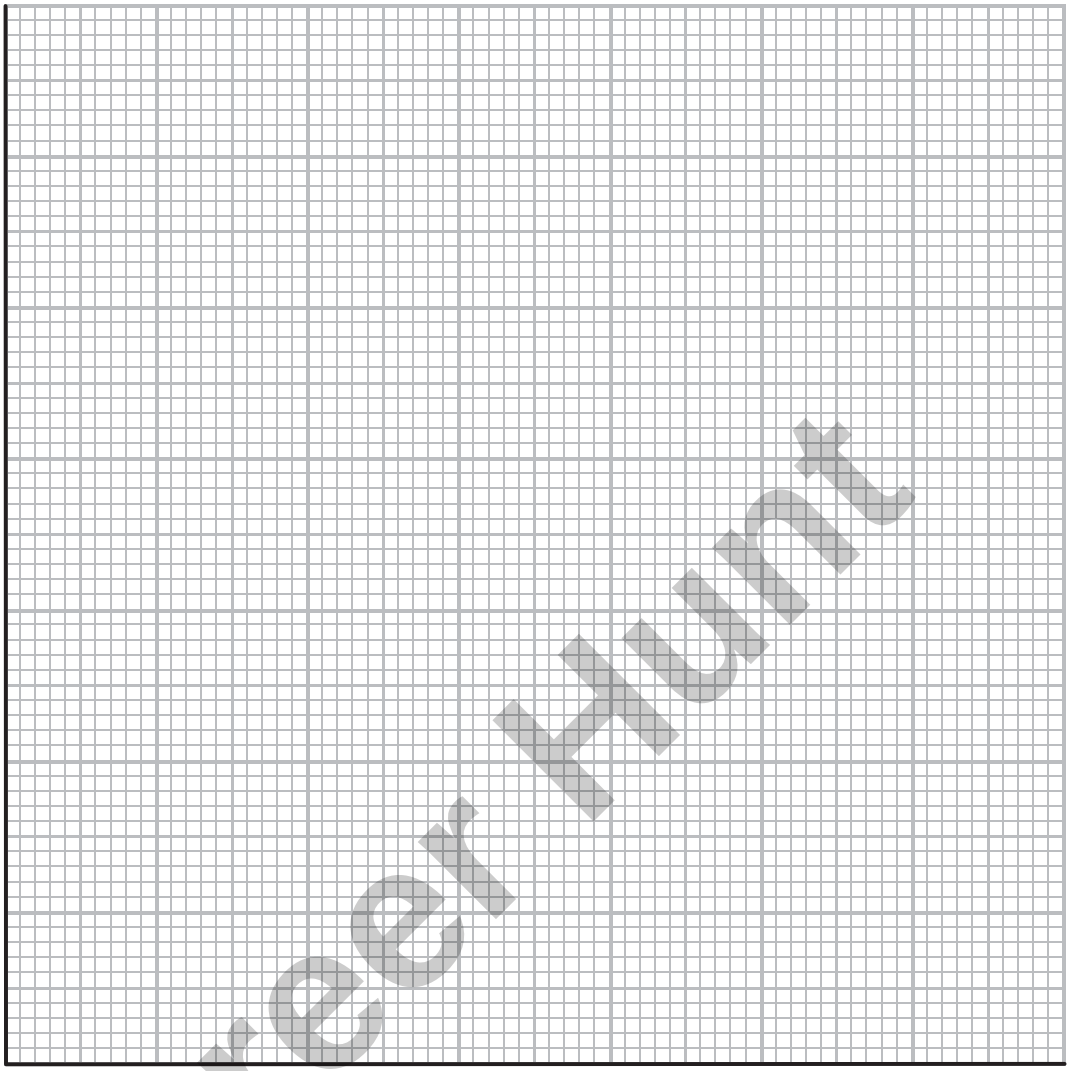
Diameter of hole in mm	Resistance of LDR in Ω
8	1050
10	890
15	640
20	490
23	430
30	340

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(i) Plot the student's results on the grid.

(4)



(ii) Draw a curve of best fit on the graph.

(1)

(iii) Describe the relationship between the resistance of the LDR and the diameter of the hole.

(2)

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(Total for Question 1 = 14 marks)

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2 The table shows information about three electrical appliances.

Appliance	Power in W	Current in A
lamp	40	0.
clothes iron	2200	9.6
television	110	

(a) (i) State the relationship between power, current and voltage.

(1)

(ii) Calculate the current in the television.
[assume that the mains voltage is 230 V]

(2)

current = ... A

(b) The photographs show the different cables used for the clothes iron and the lamp.



clothes iron cable



lamp cable

(i) Suggest why the wires in the clothes iron cable are thicker than the wires in the lamp cable.

(1)

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(ii) The clothes iron cable has three wires, E, N and L.

Which of these wires is connected to the fuse?

(1)

.....

(iii) Suggest why the lamp is safe to use, even though its cable only has two wires.

(1)

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(c) The lamp is switched on for 55 minutes.

Calculate the energy transferred by the lamp in this time.

(3)

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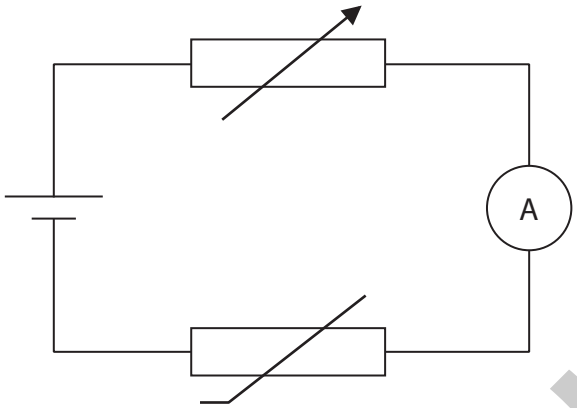
energy transferred = ... J

(Total for Question 2 = 9 marks)

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3 A student investigates the current in a thermistor at different temperatures, using the circuit shown in the diagram.



(a) The student uses a voltmeter to check that the voltage across the thermistor stays constant throughout the investigation.

(i) Add this voltmeter to the circuit diagram.

(2)

(ii) Give a reason for keeping the voltage across the thermistor constant.

(1)

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(iii) Give a reason for including the variable resistor in the circuit.

(1)

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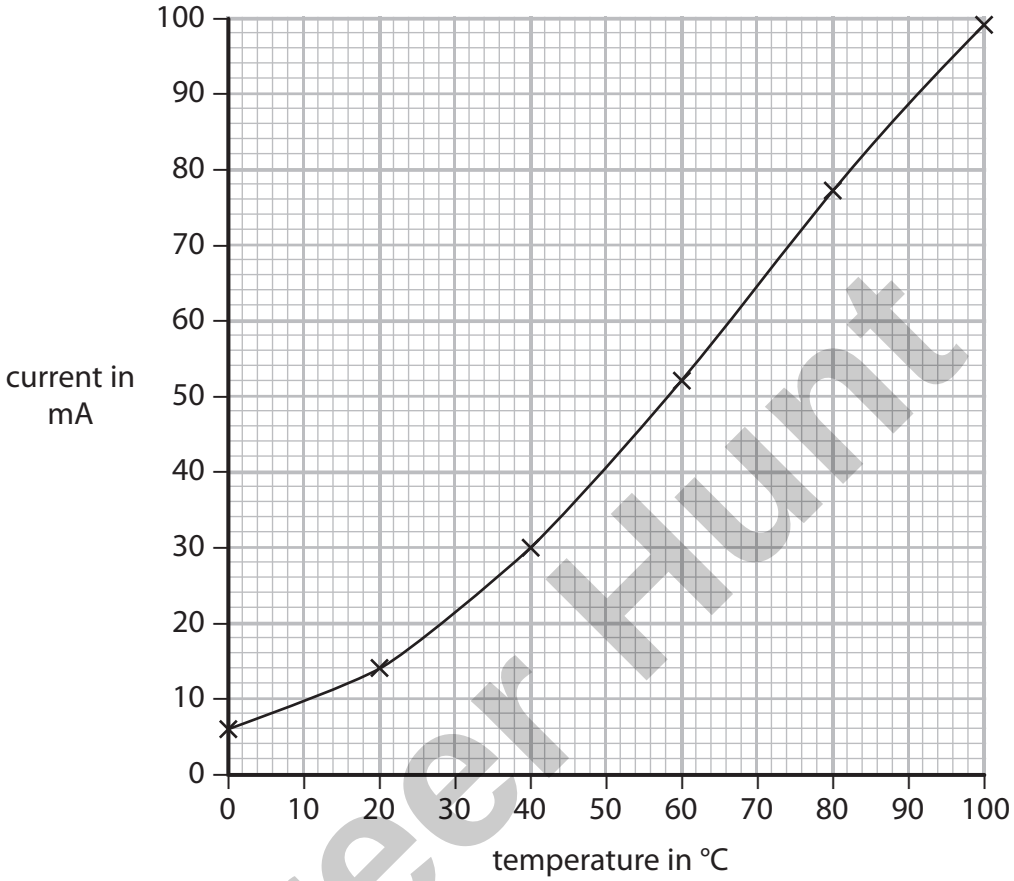
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(b) The student increases the temperature of the thermistor and records the current and temperature readings.

The graph shows the student's results.



The student plans to use his circuit to make an electronic thermometer.

He notices that both the scales on the graph go up to 100.

He thinks that the current reading, measured in mA, gives a direct indication of the temperature measured in °C.

He labels the ammeter's scale 'temperature in °C'.

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Give three reasons why the student's electronic thermometer is unlikely to show the correct temperature.

You may use information from the circuit and the graph to support your answer.

(3)

1 .....

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2 .....

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3 .....

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(Total for Question 3 = 7 marks)

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4 (a) The diagram shows part of an electric circuit.

Complete the circuit diagram by adding

- a resistor in series with the lamp and battery
- a second lamp in parallel with the first lamp
- a voltmeter that measures the voltage across the resistor
- an ammeter that measures the current in the resistor

(4)





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(b) The current in a resistor is measured for different voltages.

The table shows the results.

Voltage in V	Current in A
1.0	0.10
2.5	0.25
3.0	0.30
4.5	0.40
5.0	0.50
6.0	0.60

(i) Plot a graph of this data on the grid.

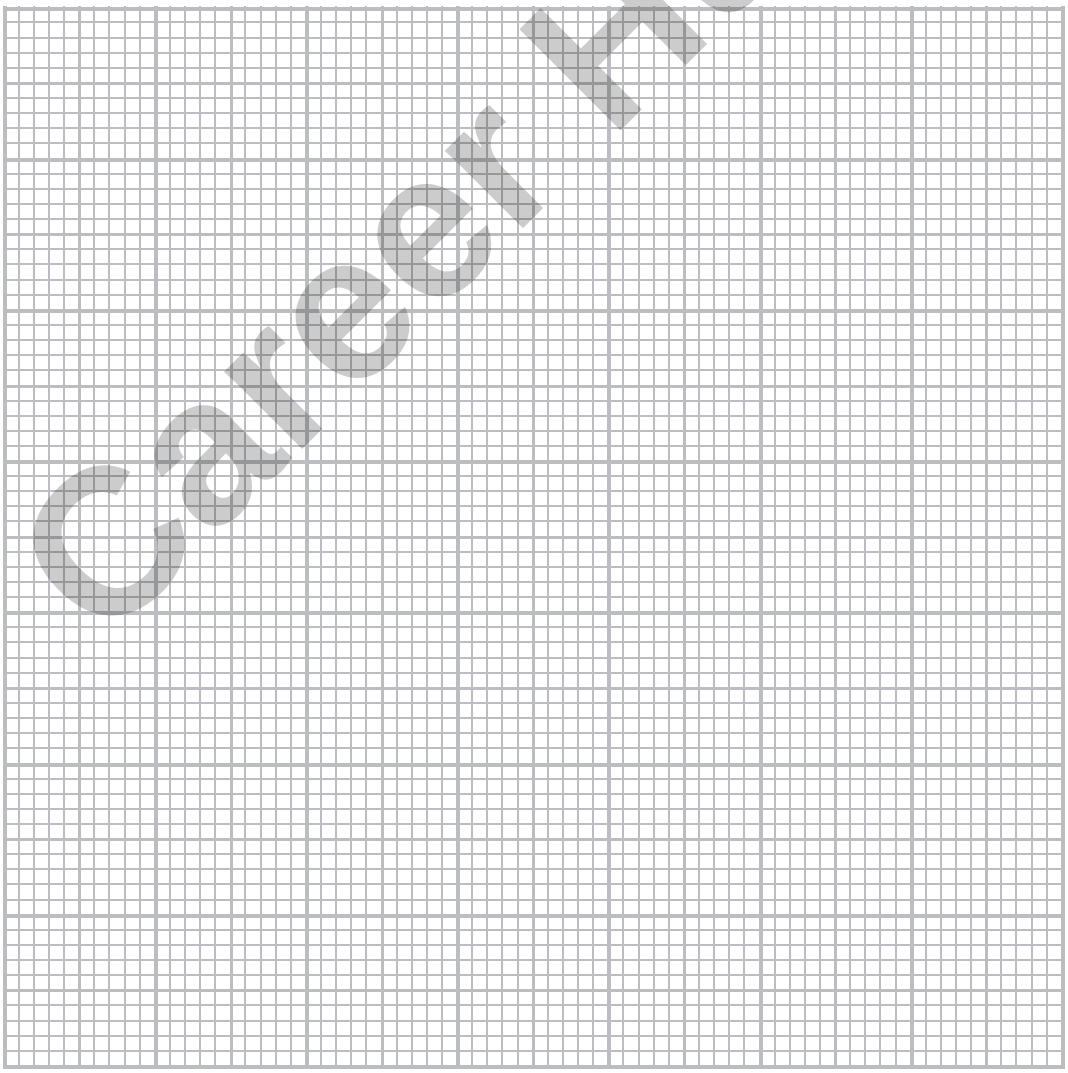
(4)

(ii) Circle the anomalous point on the graph.

(1)

(iii) Draw a line of best fit.

(1)



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(iv) State the equation linking voltage, current and resistance.

(1)

(v) Use your graph to find a value for the resistance of the resistor.

(2)

resistance ..... Ω

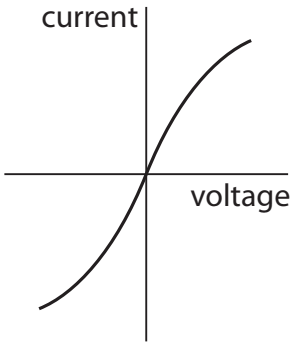
(Total for Question 4 = 13 marks)

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5 The graph shows how current and voltage vary for a filament lamp.



(a) Draw a circuit diagram to show how you should connect the equipment needed to make the measurements needed to plot the graph.

(4)

(b) The resistance of the filament lamp changes as the voltage is increased.

(i) How can you tell this from the graph?

(1)

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(ii) Explain these changes in resistance.

(3)

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(Total for Question 5 = 8 marks)

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6 A student investigates how the resistance of a piece of wire changes with voltage across the wire.

The student connects an ammeter, a voltmeter, a battery, a variable resistor and the wire in an electrical circuit.

(a) (i) Complete the diagram to show how the student should connect the circuit.

(3)



(ii) Describe what she should do to obtain a set of results for her investigation.

(3)

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(b) The student keeps the temperature of the wire constant during the investigation.

(i) Suggest **why** she does this.

(1)

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(ii) Suggest **how** she does this.

(1)

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(c) When the student looks at her results, she notices that the voltage across the wire is directly proportional to the current in it.

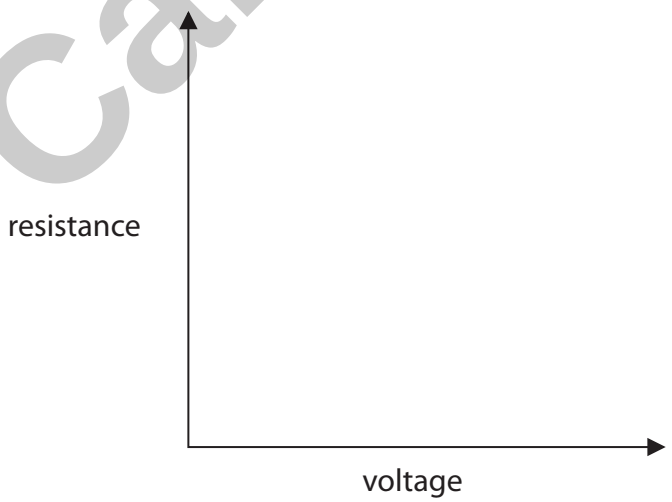
(i) State the relationship linking voltage, current and resistance.

(1)

(ii) The student calculates the resistance and then plots a graph of resistance against voltage.

On the axes, sketch the shape of her graph.

(1)



(Total for Question 6 = 10 marks)

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7 Photograph **E** shows a rechargeable torch.

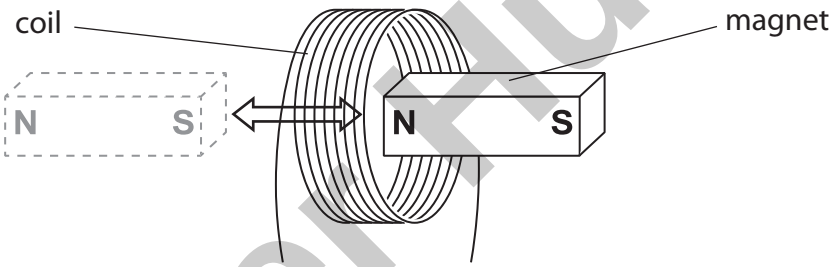


Photograph **E**

(a) When a student shakes the torch, the magnet moves through the coil and back again.

This induces a voltage across the ends of the coil.

The voltage is used to provide current to recharge the battery.



(i) Explain why a voltage is induced.

(2)

(ii) State **one** way to increase this voltage.

(1)

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(b) Photograph **F** shows the components inside the torch.



Photograph **F**

The torch uses a light-emitting diode (LED) to provide light.

(i) When the LED is on, it shows that

(1)

☒ **A** the current is alternating

☒ **B** the torch is switched off

☒ **C** there is a current in the circuit

☒ **D** there is a fault in the circuit

(ii) The manufacturer of the torch states, "An LED is a more efficient source of light than a filament lamp."

Explain this statement in terms of energy transfer.

(2)

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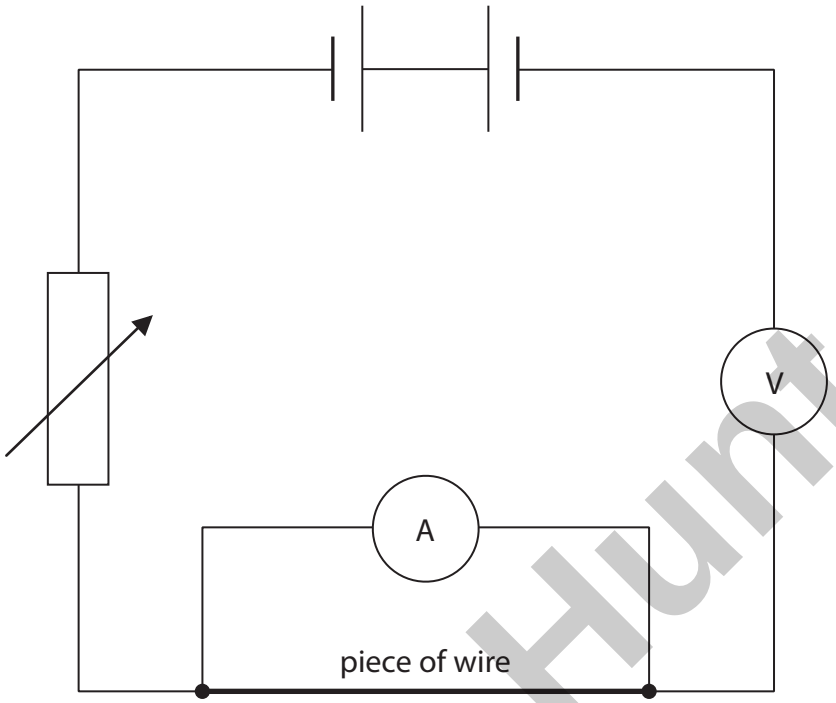
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8 A student plans to measure the resistance of a piece of wire.

He sets up this circuit and finds that it does not work.



(a) Identify the three errors in the student's circuit.

(3)

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2 .....

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3 .....

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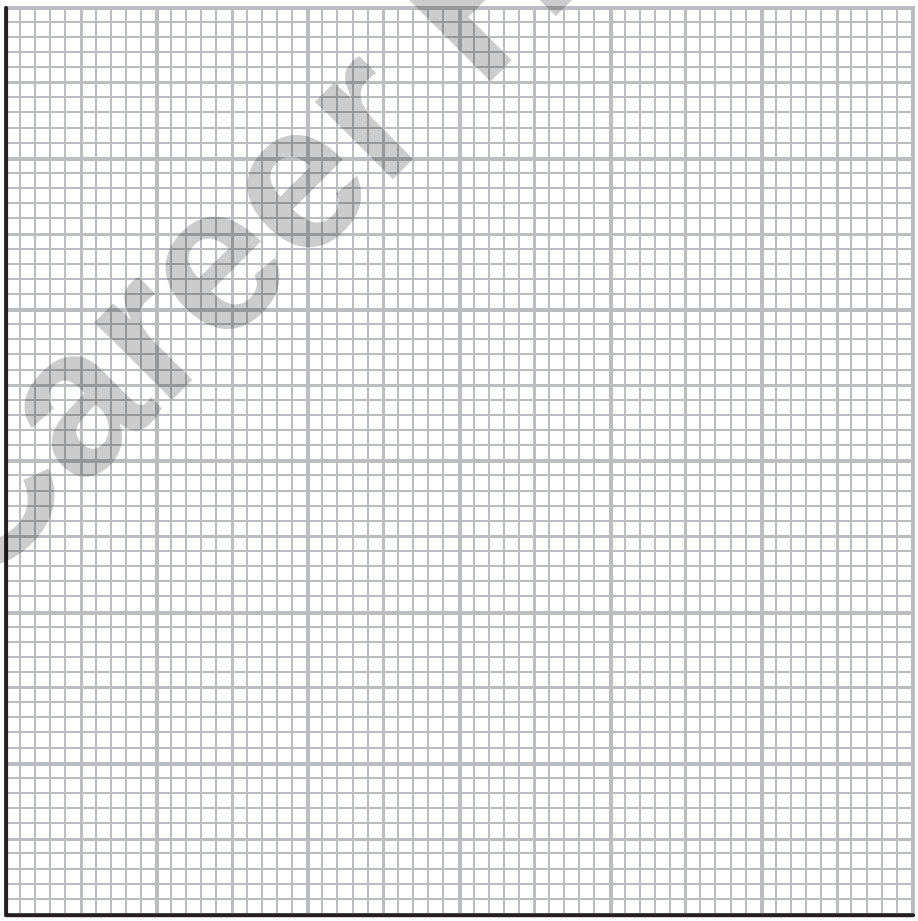
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(b) The student uses a correct circuit to obtain these results.

Current in amps	Voltage in volts
0.00	0.0
0.24	1.5
0.71	4.5
0.89	6.0
1.00	7.5
1.10	9.0

(i) Plot a graph to show the relationship between current and voltage for the wire.

(5)



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(ii) Find the current when the voltage is 2.5 V.

(1)

(iii) Suggest why the line on the graph curves.

(1)

(iv) Describe what else the student should do to find an accurate value for the resistance of the piece of wire at a constant temperature.

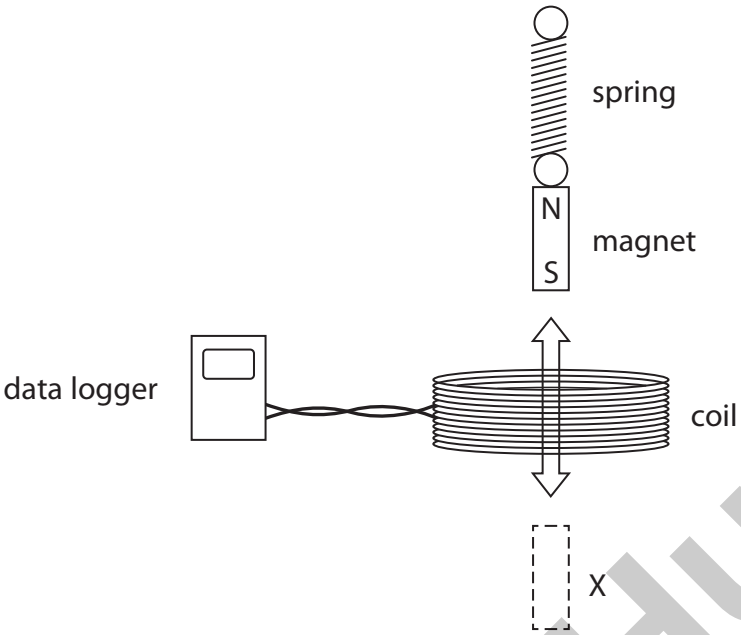
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9 A student investigates how to produce a voltage.

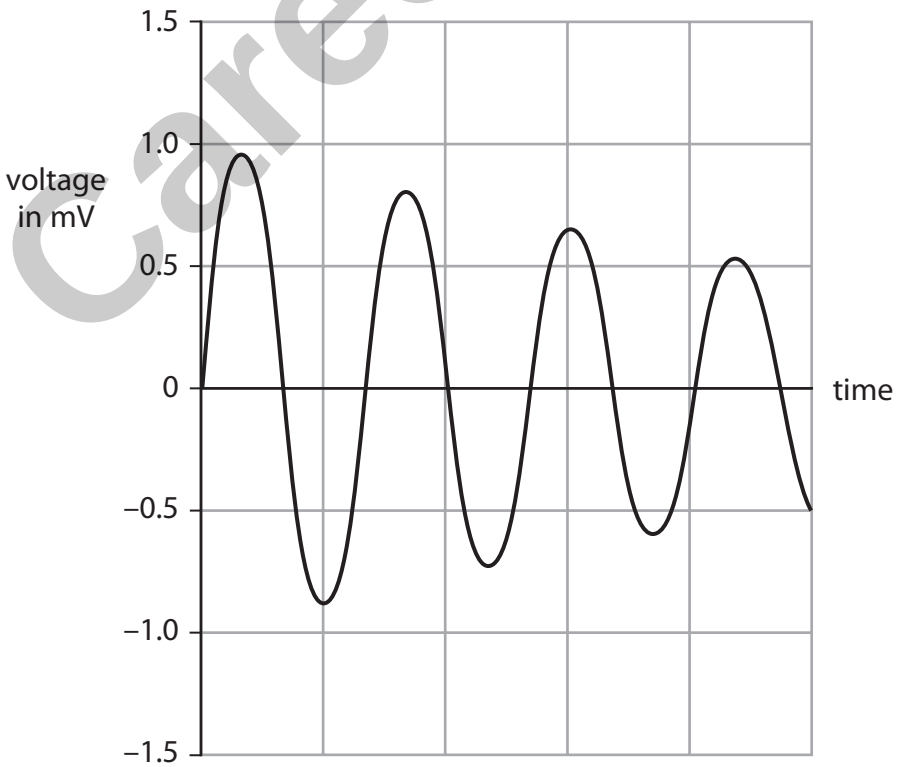
He hangs a magnet from a spring, above a coil that is connected to a data logger.



(a) The student pulls the magnet through the coil to X and then releases it.

The magnet moves up and down through the coil.

The data logger produces this graph of voltage against time.



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(i) Explain why the data logger records a varying voltage.

(2)

(ii) Which feature of the graph shows that the voltage is alternating?

(1)

(iii) Suggest why the voltage changes as shown by the graph.

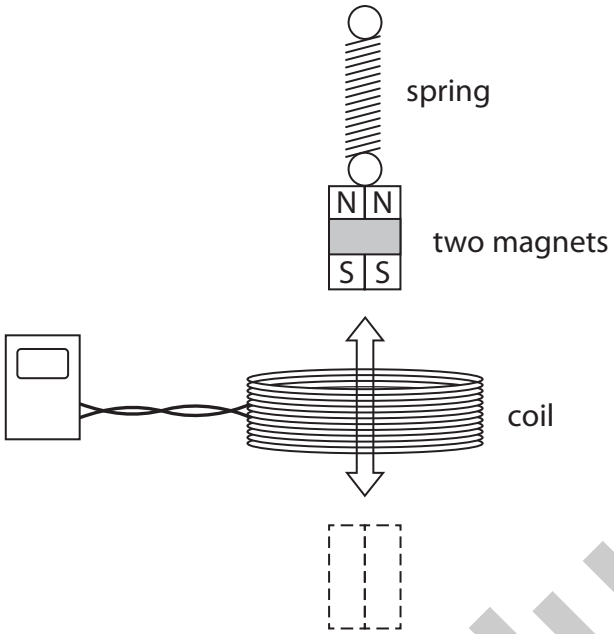
(2)

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(b) The student repeats the experiment using two magnets taped together.

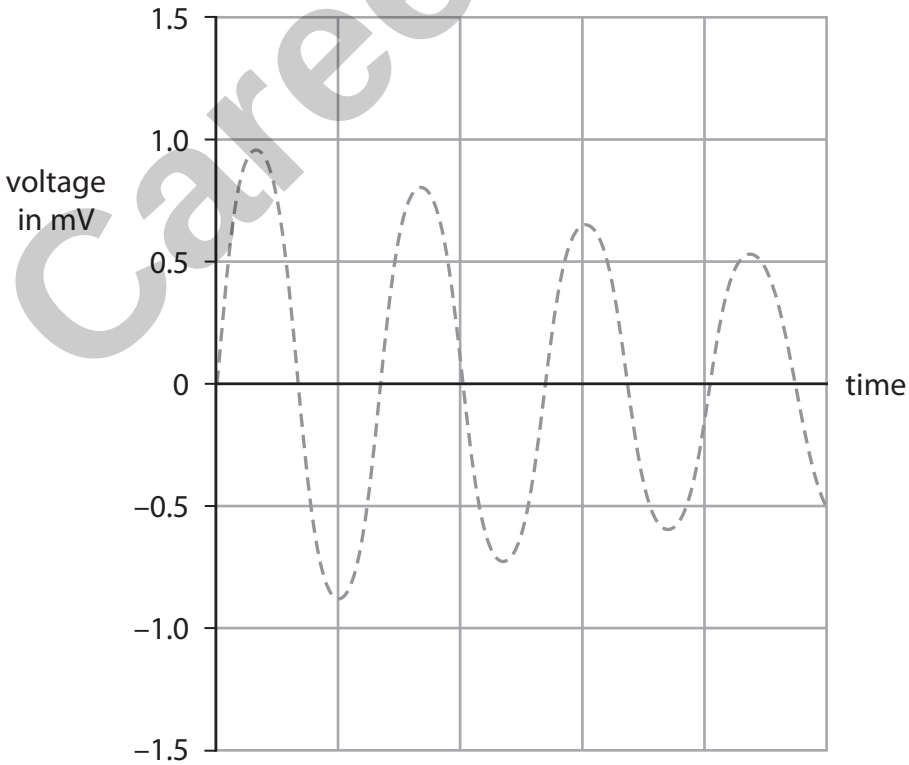


Compared to one magnet, these two magnets take a longer time to move up and down.

The dotted line on the grid shows the original graph for one magnet.

On the same grid, sketch the graph that would be produced using two magnets.

(3)



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10 A student uses an electric heater to investigate efficiency.

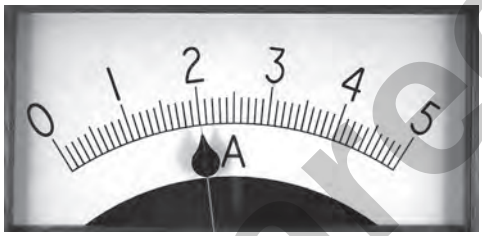
He places the heater in an aluminium block, switches the heater on and measures the temperature of the block each minute for 20 minutes.

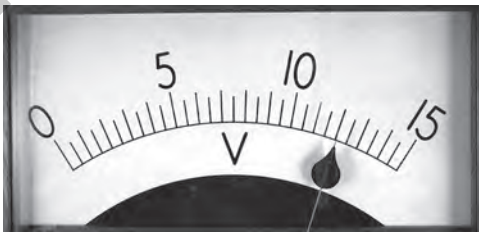


(a) The student wants to calculate the electrical energy supplied to the heater.

(i) Complete the table by recording the readings shown on the meters below.

(2)





Current in amps, A	
Voltage in volts, V	

(ii) Show that the energy supplied to the heater in 20 minutes is about 30 000 J.

(3)

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(b) The student is told that only 22 000 J are used to raise the temperature of the aluminium block by 25 °C.

(i) State the equation linking efficiency, useful energy output and total energy input.

(1)

(ii) Calculate the efficiency of heating the aluminium block.

(2)

Efficiency .....

(iii) The efficiency of the **heater** will be **higher** than this value.

Suggest why.

(1)

.....

.....

.....

(iv) State **one** way in which the student could increase the efficiency of heating the aluminium block.

(1)

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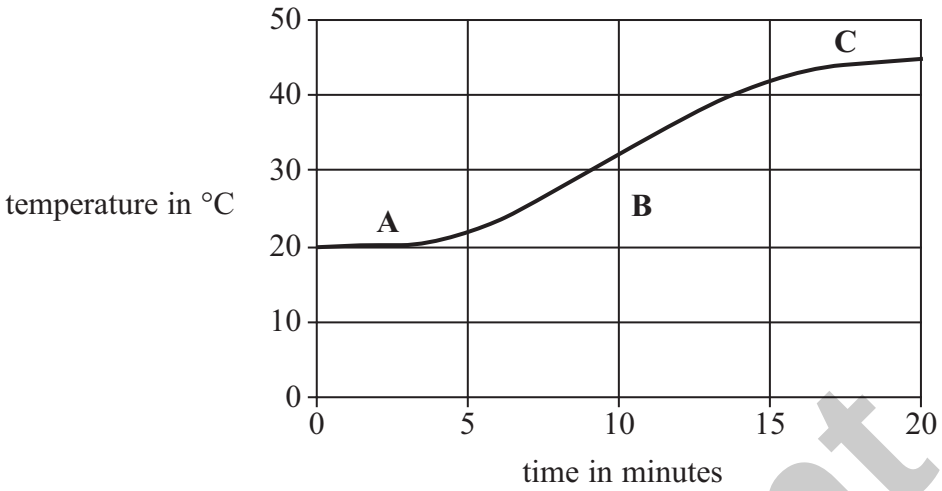
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(c) The graph shows how the temperature of the block increases from 20 °C to 45 °C during the investigation.



Use ideas about heat transfer to help you explain the shape of the graph in

(i) section **A**,

(1)

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(ii) section **B**,

(2)

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(iii) section **C**.

(2)

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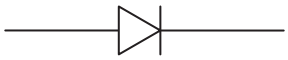
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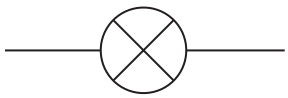
11 (a) The diagram shows some electrical circuit symbols.



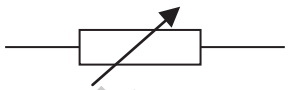
A



B



C



D

(i) Which symbol represents a switch?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(ii) Which symbol represents a diode?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

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(b) A hairdryer connected to the mains supply takes a current of 5.5 A.

(i) Which of these fuses should be used with the hairdryer?

(1)

- ☒ **A** 3 A
- ☒ **B** 5 A
- ☒ **C** 7 A
- ☒ **D** 13 A

(ii) Expla our answer.

(1)

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(iii) The hairdryer has a plastic case so there is no need for an earth wire connection in the plug.

Explain why the hairdryer is still safe to use.

(2)

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(Total for Question 5 = 6 marks)

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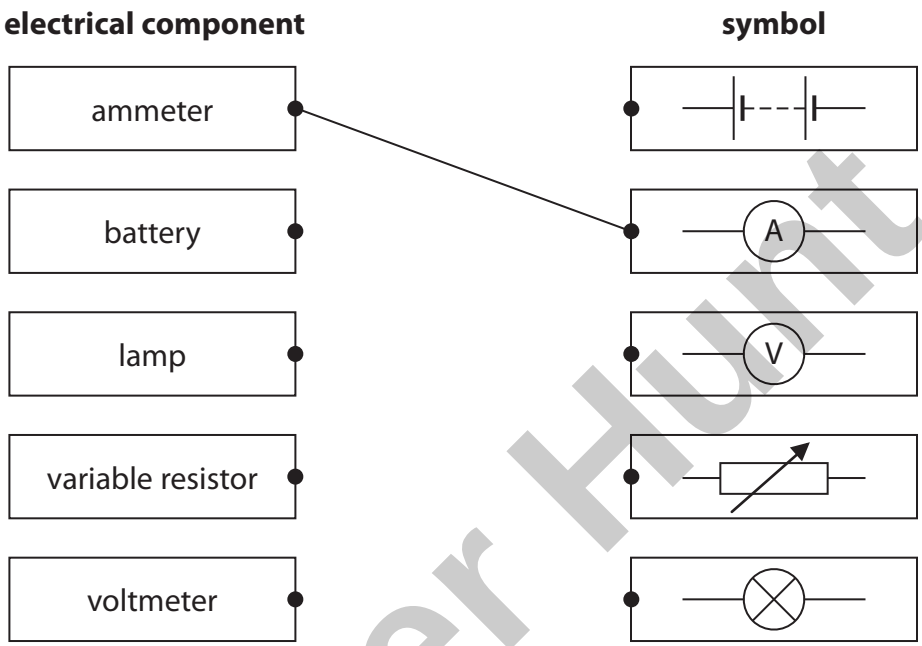
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12 This question is about electrical components.

(a) Draw a straight line from each electrical component to its correct symbol.

One has been done for you.

(3)



(b) (i) Name an electrical component whose resistance decreases when it is moved into brighter light.

(1)

.....

(ii) Name an electrical component whose resistance decreases as its temperature increases.

(1)

.....

(Total for Question 1 = 5 marks)

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13 A kitchen has a water supply, an electricity supply and electric lighting.

There are several electrical appliances in the kitchen including a toaster, a kettle, a clothes iron, a microwave oven and a dishwasher.

Discuss three hazards of using electricity in this kitchen.

(6)

1 .....

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2 .....

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3 .....

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(Total for Question 2 = 6 marks)

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14 A student has two computer hard drives.

One is black and one is white.

The student places the white hard drive on top of the black one as shown in photograph A.



Photograph A

The student connects both hard drives to a computer so that they receive the same amount of electrical power. The temperature of the hard drives rises as they work.

The student then rearranges the hard drives so that the black one is on top as shown in photograph B.



Photograph B

The hard drives are still working, but their temperature is lower than before.

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Explain why the hard drives work at a lower temperature when the black one is on top.

(4)

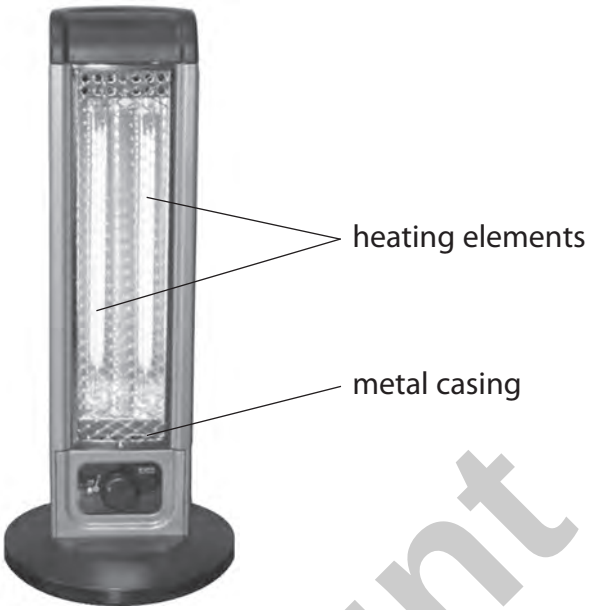
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15 The photograph shows an electric heater.



(a) The power of the heater is 2000 W.

The heater is connected to a 230 V mains supply.

(i) State the equation linking power, current and voltage.

(1)

(ii) Calculate the current in the heater.

(2)

current = ... A

(iii) Which of these fuses should be used with the heater?

(1)

☒ **A** 1A

☒ **B** 5A

☒ **C** 7A

☒ **D** 13A

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(b) The two heating elements can be connected in series or in parallel.

Describe an advantage of each method.

(2)

series .....

.....

parallel .....

.....

(c) Some electrical appliances are fitted with an earth wire.

(i) Describe how an earth wire acts as a safety feature.

(4)

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(ii) Explain why this heater should be fitted with an earth wire.

(2)

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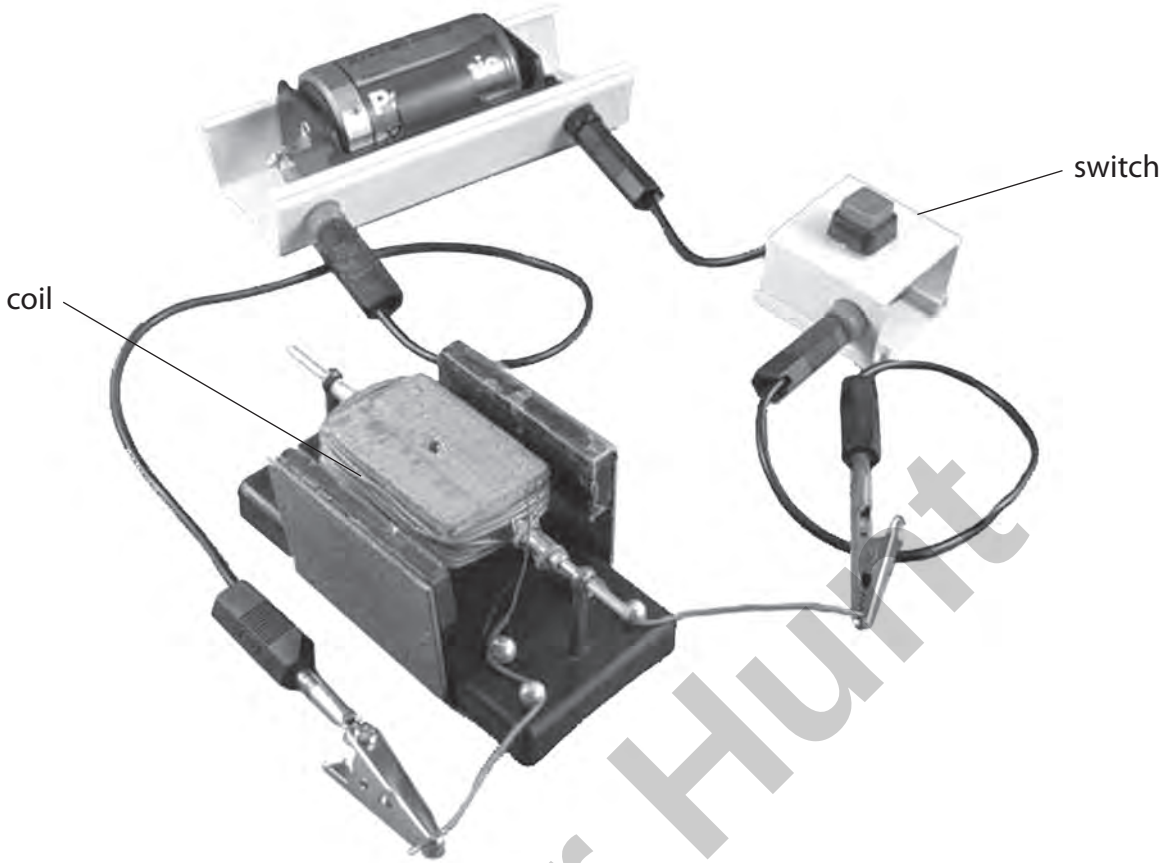
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16.5 The photograph shows a small electric motor.



(a) Explain why the coil starts to spin when the switch is closed.

(4)

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(b) (i) Suggest how to make the coil spin in the opposite direction.

(1)

.....

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(ii) Suggest how to make the coil spin more slowly.

(1)

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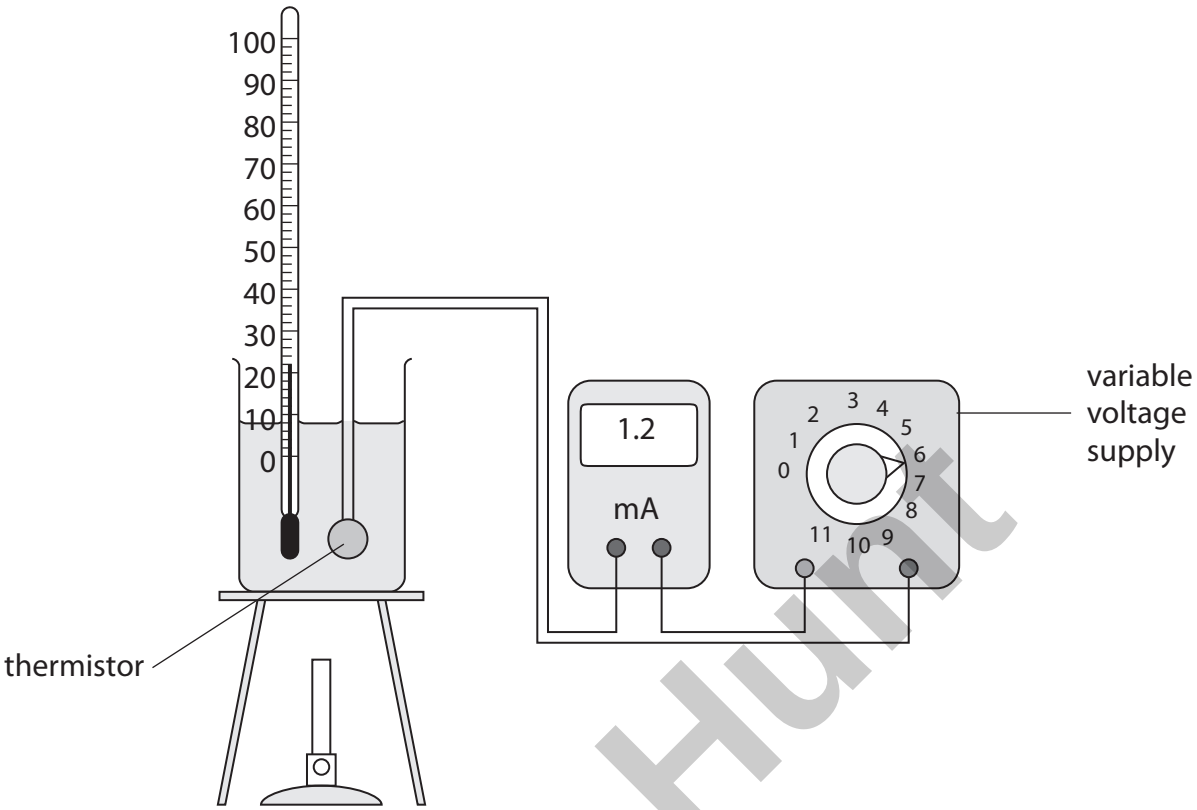
(Total for Question 5 = 6 marks)

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17 (a) A student uses this apparatus to investigate how the resistance of a thermistor changes with temperature.



(i) Draw a circuit diagram for this investigation.

(2)

(ii) The student wants to measure the voltage across the thermistor.

On your diagram, add a symbol to show how she should connect the voltmeter to the circuit.

(1)

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(iii) Explain how the student can use the apparatus to investigate how the resistance of the thermistor varies with temperature between 0 °C and 100 °C.

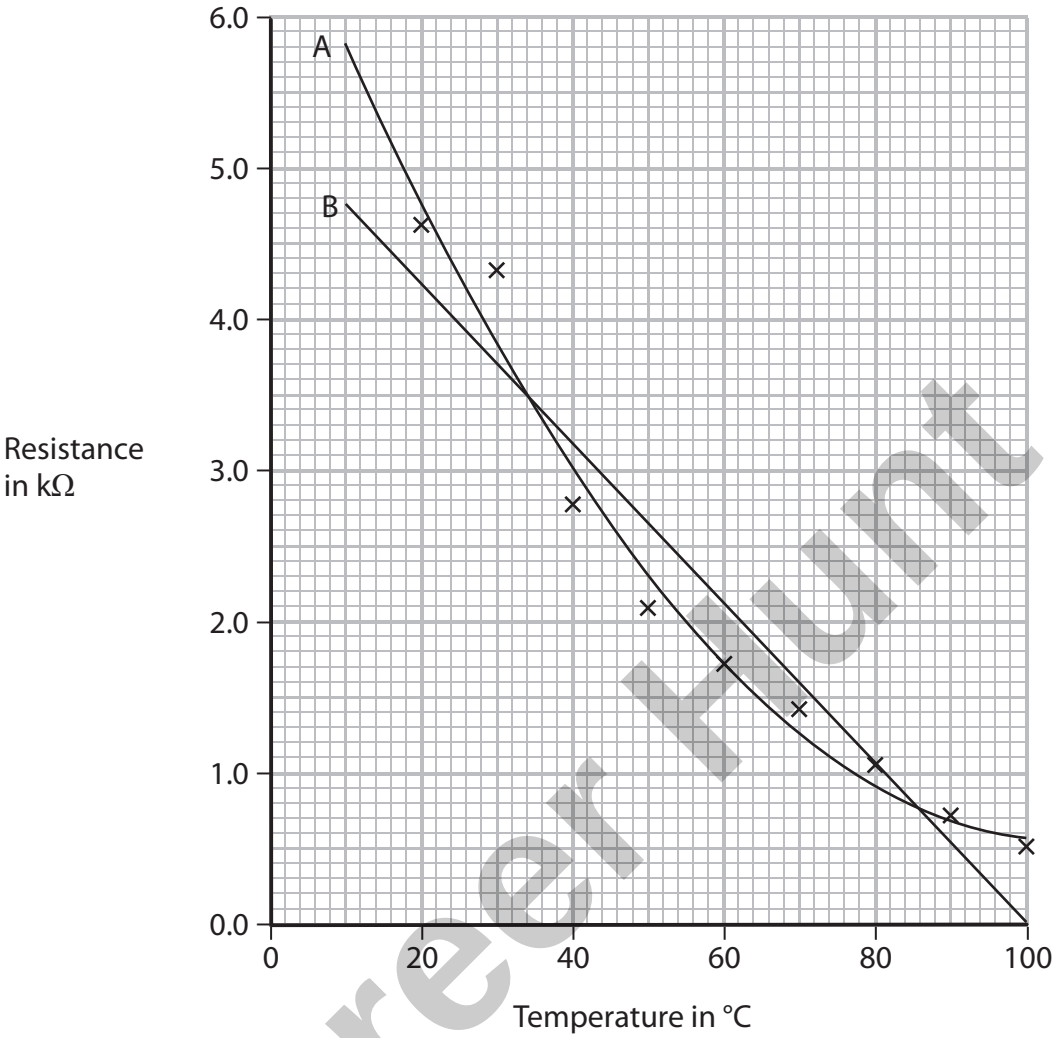
(5)

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(b) The graph shows the student's results.



Two students discuss the line of best fit for this graph.

One student thinks it is the curved line A.

The other student thinks that it is the straight line B.

(i) Suggest which line is better, giving a reason for your choice.

(1)

.....

.....

.....

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(ii) Suggest why measuring the resistance of the thermistor at 10 °C could help to decide which line is better.

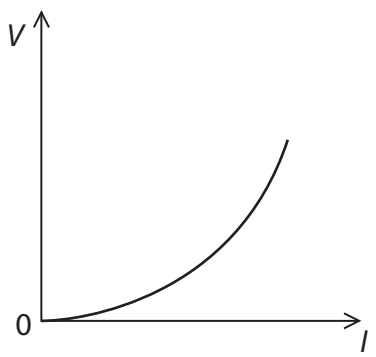
(1)

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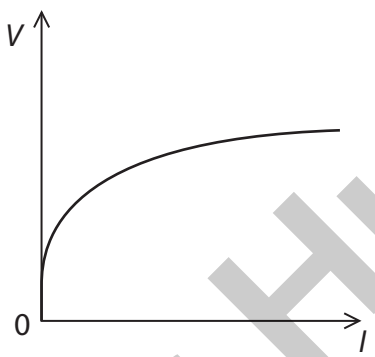
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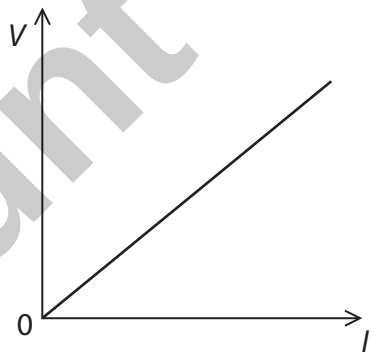
(c) These graphs show the voltage (*V*) changes with the current (*I*) for three components.



J



K



L

The components are a metal wire at constant temperature, a diode and a filament lamp.

Which letter represents the correct graph for each component?

(2)

metal wire at constant temperature .....

diode .....

filament lamp .....

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18 A student investigates how the resistance of a thermistor varies with temperature.

(a) Draw the circuit symbol for a thermistor.

(1)

(b) The student uses voltmeter and ammeter readings to find the resistance at each temperature.

One set of readings is shown below.

temperature in °C	voltmeter reading in V	ammeter reading in mA
80	13.2	2.60

(i) State the equation linking voltage, current and resistance.

(1)

(ii) Show that the resistance of the thermistor at 80 °C is about 5000 Ω.

(3)

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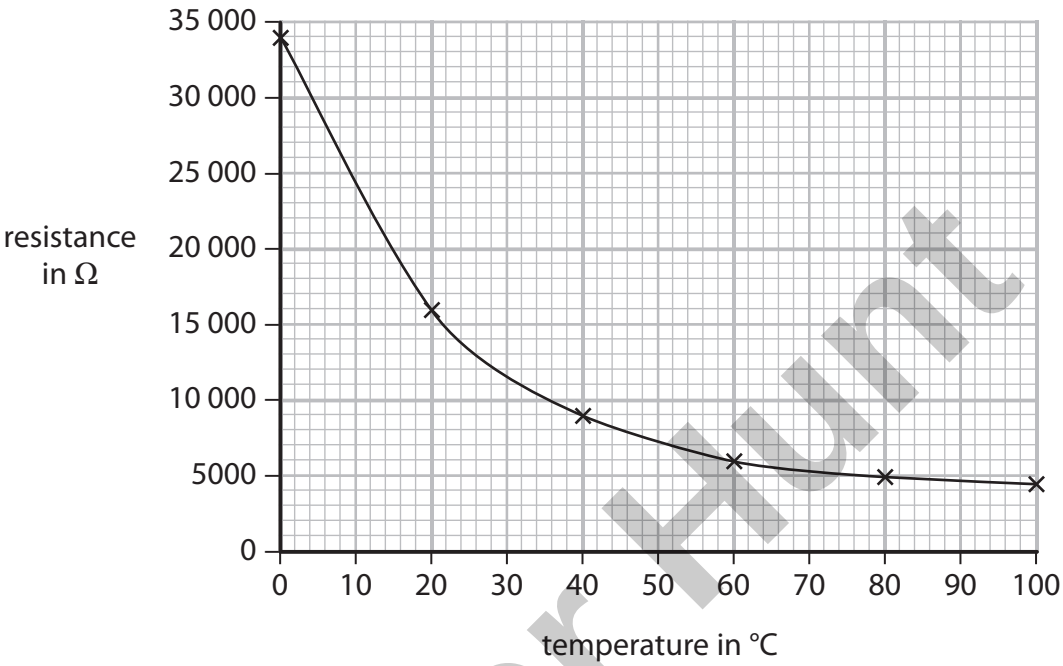
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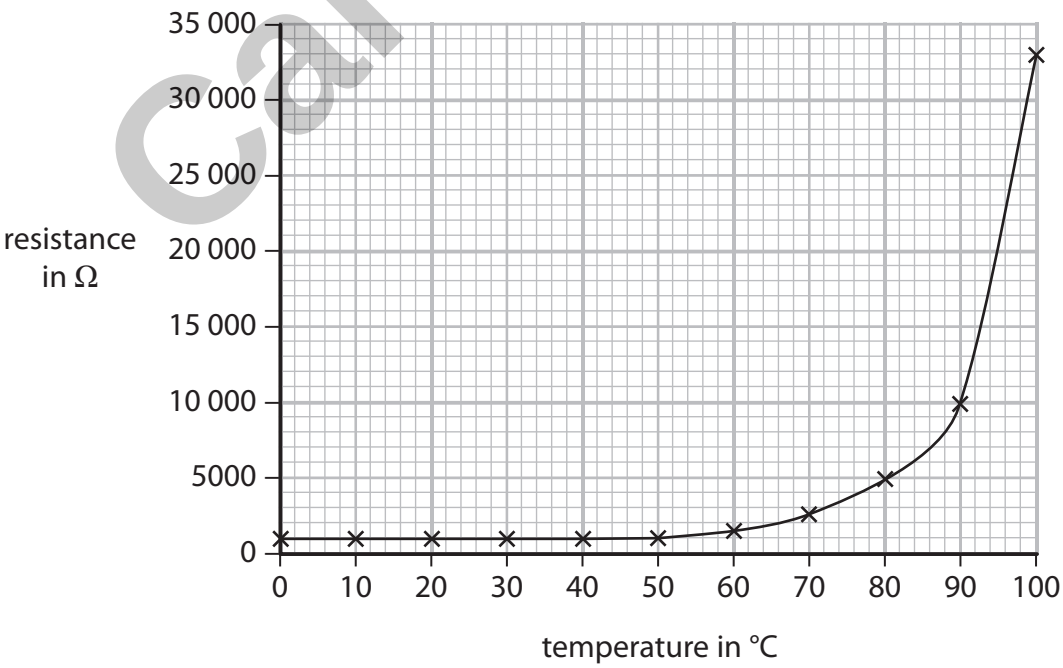
(c) Another student takes measurements for two more components, A and B.

The graphs show the results.

Component A



Component B



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Compare the results for component A and component B.

(5)

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19 A light dependent resistor (LDR) can be used as a sensor to detect light intensity.

Describe how the resistance of an LDR varies as the light intensity changes.

You may sketch a graph to help your answer.

(3)

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20 The diagram shows the driving force on a sports car as it moves along a race track.



(a) Name **two** forces that oppose the driving force.

(2)

1 .....

2 .....

(b) The car has a mass of 1400 kg.

The acceleration of the car is 5.5 m/s^2.

(i) State the equation linking force, mass and acceleration.

(1)

(ii) Calculate the force causing this acceleration.

(2)

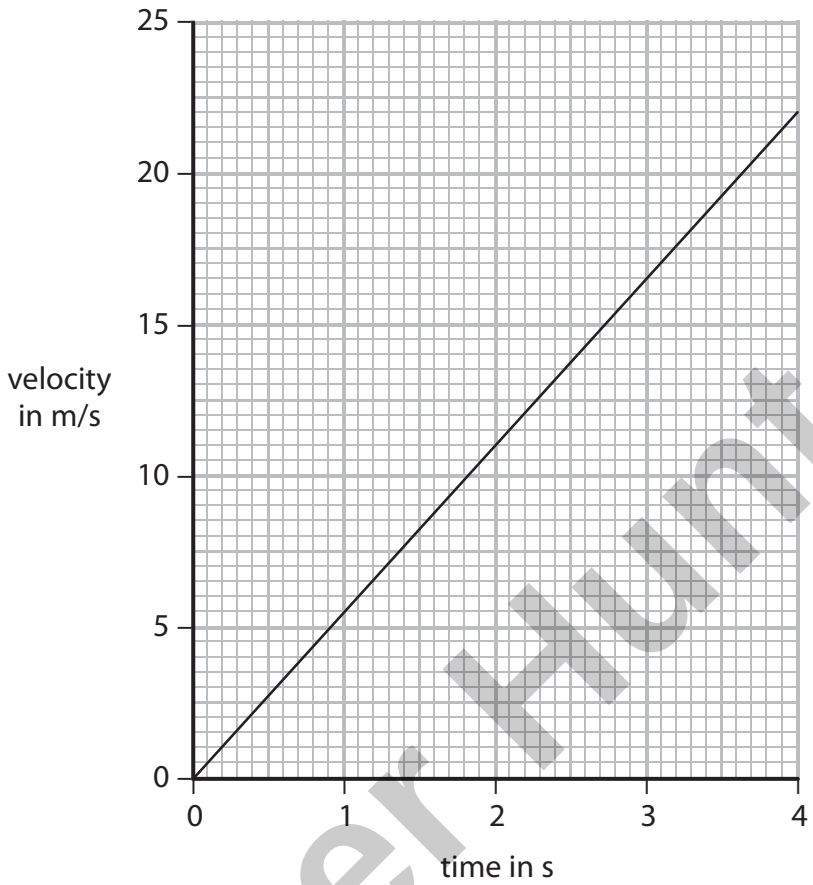
Force = ... N

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(c) Graph **1** shows how the velocity of the car changes with time.



Graph **1**

Calculate the distance that the car travels in the first four seconds.

(3)

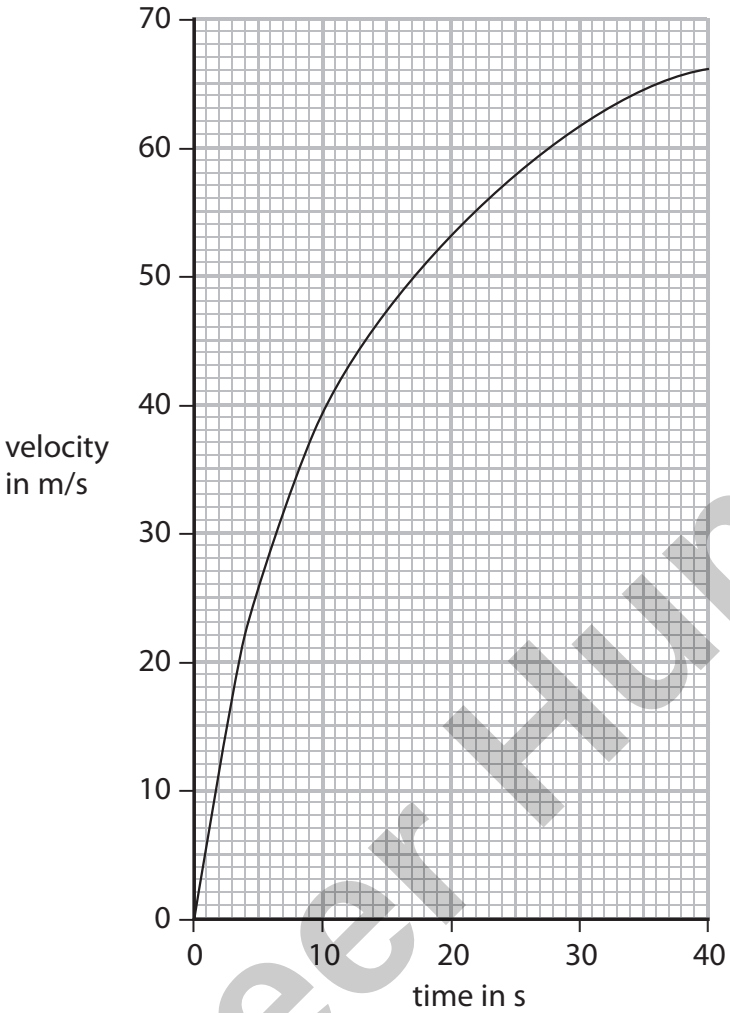
Distance = ... m

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(d) As the car travels further along the track, its acceleration changes as shown in graph **2**.



Graph **2**

(i) Which feature of graph **2** shows that the acceleration changes?

(1)

.....

(ii) The acceleration changes even though the driving force does **not** change.

Suggest **two** possible reasons for this change in acceleration.

(2)

1 .....

.....

2 .....

.....

(Total for Question 9 = 11 marks)

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21 **10** (a) All metals are good conductors of electricity.

Which of these non-metals can conduct electricity?

(1)

- ☒ **A** carbon
- ☒ **B** chalk
- ☒ **C** plastic
- ☒ **D** rubber

(b) The current in a metallic conductor is a flow of

(1)

- ☒ **A** negatively charged electrons
- ☒ **B** negatively charged protons
- ☒ **C** positively charged electrons
- ☒ **D** positively charged protons

(c) Some metals and alloys are magnetic.

Which of these is magnetic?

(1)

- ☒ **A** aluminium
- ☒ **B** copper
- ☒ **C** gold
- ☒ **D** steel

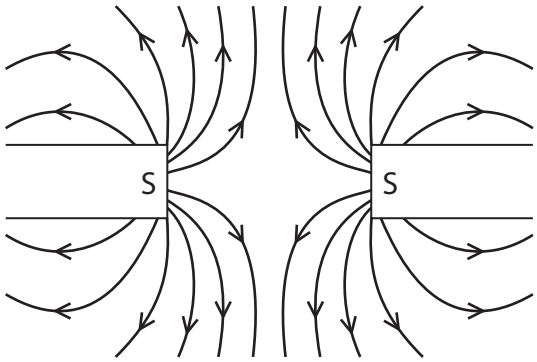
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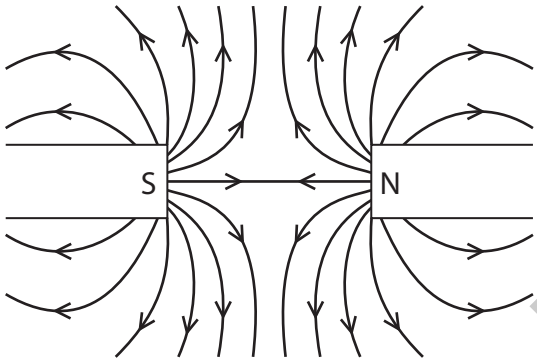
(d) Which of these field patterns is correct?

(1)

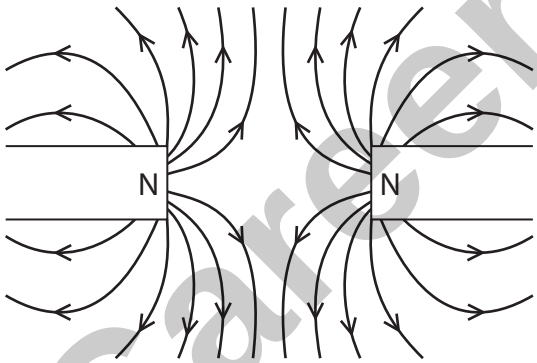
☒ **A**



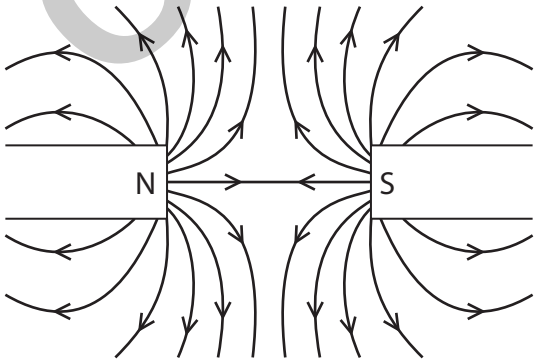
☒ **B**



☒ **C**



☒ **D**

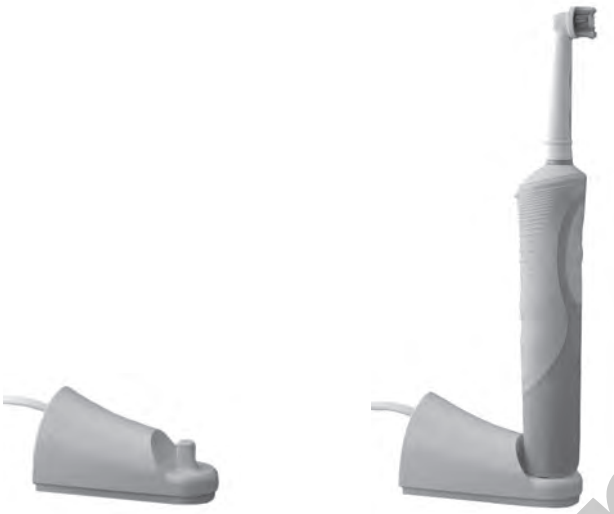


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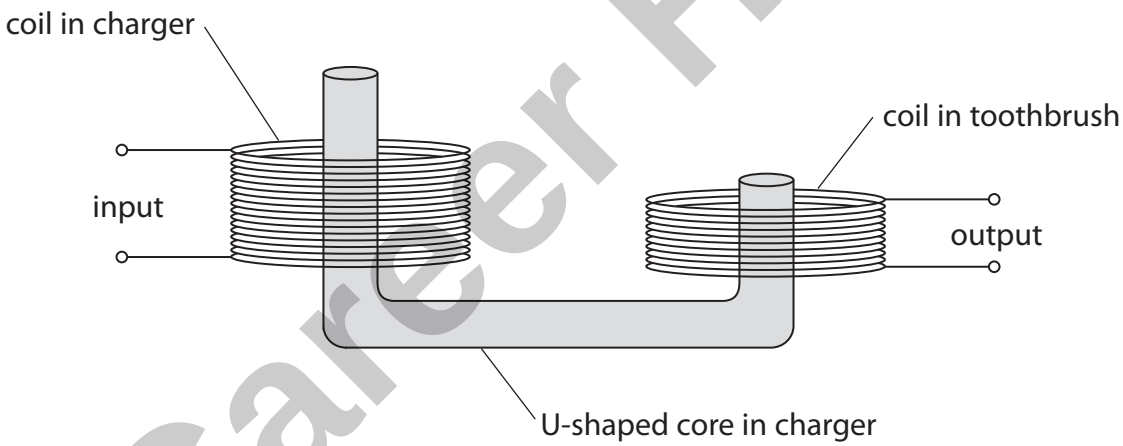
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22 The photographs show how an electric toothbrush fits on its charger.



The charger and the toothbrush each have a coil of wire inside them.

The diagram shows how the two coils are linked by a U-shaped core.



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This arrangement of core and coils acts as a transformer that reduces voltage.

(a) (i) Name the type of transformer that reduces voltage.

(1)

.....

(ii) Explain why the core is made of a soft magnetic material, such as iron.

(2)

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.....

.....

(b) (i) State the equation linking the input (primary) and output (secondary) voltages and the turns ratio of a transformer.

(1)

(ii) The transformer has 520 primary turns and 30 secondary turns.

The input voltage to the transformer is 44 V.

Calculate the output voltage.

(2)

output voltage = ... V

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(c) (i) The alternating current in the transformer has a frequency of 27 000 Hz.

The toothbrush vibrates at the same frequency when it is being charged.

Explain why these vibrations cannot be heard.

(2)

.....

.....

.....

.....

(ii) A circuit in the toothbrush delivers regular pulses of direct current.

There is a pulse every 1.5 ms.

Calculate the frequency of the pulses.

(2)

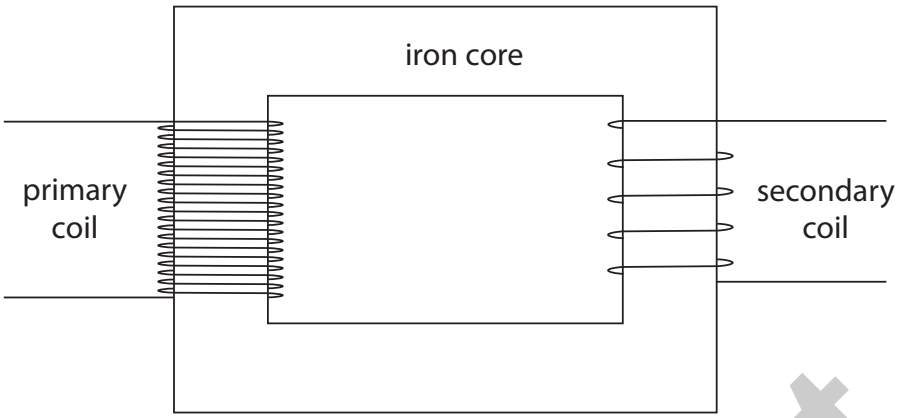
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frequency = ... Hz

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23 The diagram shows parts of a transformer.



(a) The input voltage to the transformer is 230 V a.c.

The output of the transformer is 25 V a.c.

There are 100 turns on the secondary coil.

(i) Name the type of transformer shown in the diagram.

(1)

.....

(ii) State the equation linking input (primary) voltage, output (secondary) voltage, primary turns and secondary turns.

(1)

(iii) Calculate the number of turns on the primary coil.

(2)

number of turns .....

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(b) Explain how a transformer works.

In your answer, you should include the reasons for using

- two coils
- the iron core
- an alternating supply

(5)

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(Total for Question 2 = 9 marks)

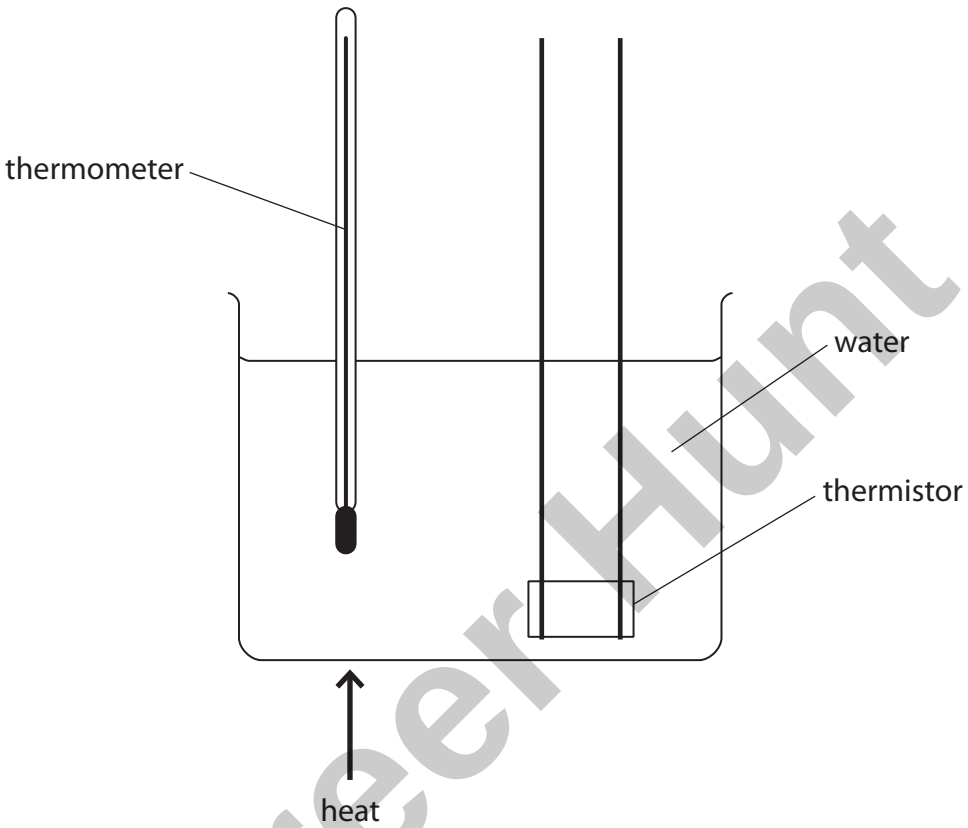
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24 A student investigates how the voltage across a thermistor varies with temperature.

The student keeps the current in the thermistor constant, but varies the temperatures between 20 °C and 100 °C.

(a) The diagram shows how the student sets up his apparatus.



Suggest three changes to this set up that would improve the accuracy of the measurement of the thermistor temperature.

(3)

1 .....

.....

2 .....

.....

3 .....

.....

(b) What instrument should the student use to measure the current in the thermistor?

(1)

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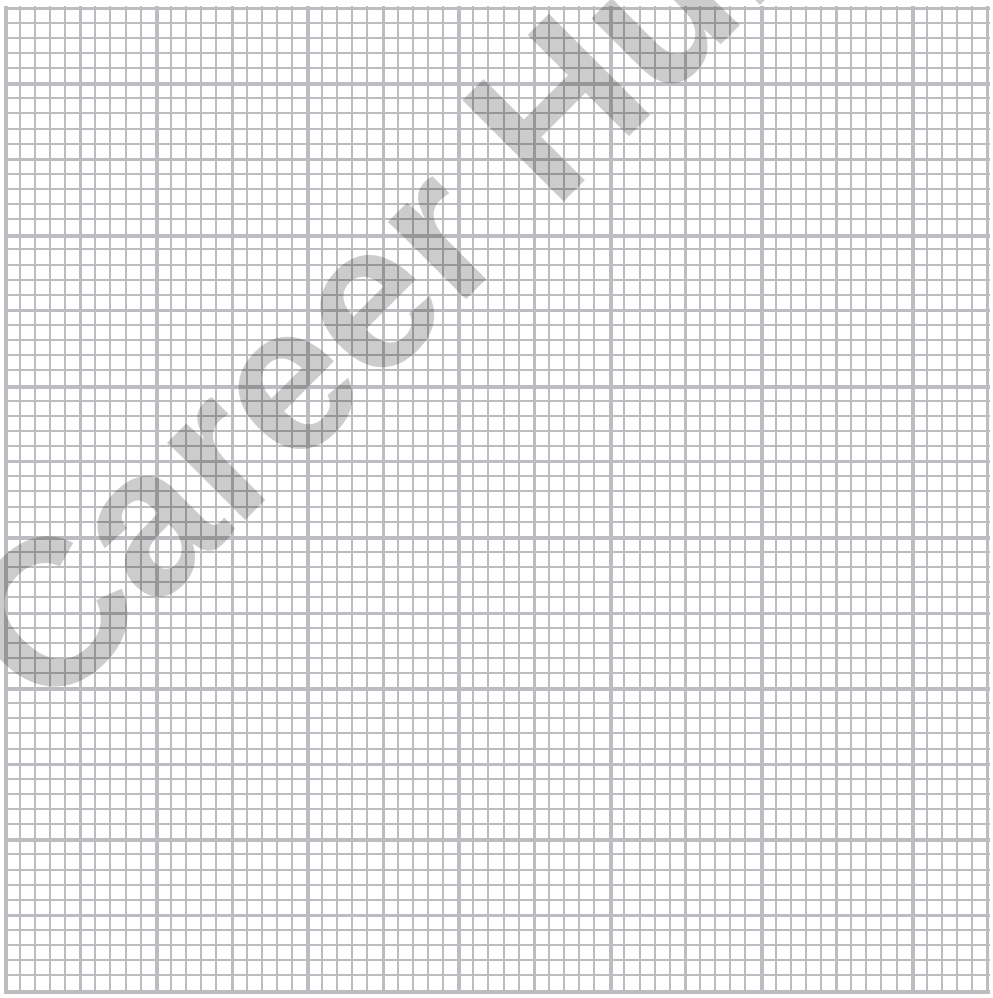
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(c) The table shows the student's results.

Temperature in °C	Voltage in V
20	6.0
40	2.2
60	1.1
80	0.2
100	0.4

(i) Plot a graph of voltage against temperature and draw the line of best fit.

(5)



Circle the anomalous point on your graph.

(1)

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(d) (i) State the equation linking voltage, current and resistance.

(1)

(ii) At room temperature the thermistor has a resistance of 680 Ω.

The voltage across it is 5.9 V.

Show that the current in the thermistor is about 8.5 mA.

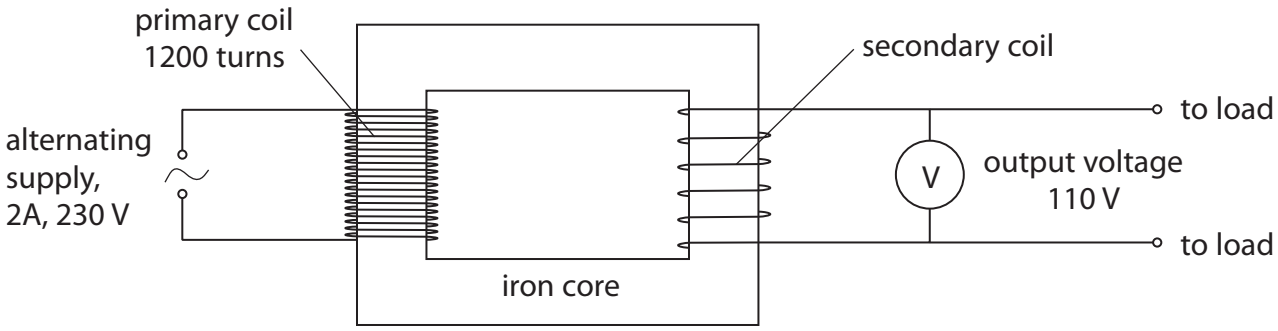
(3)

(Total for Question 3 = 14 marks)

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25 The diagram shows a transformer that is 100% efficient.



(a) (i) State the equation linking input power and output power for the transformer.

(1)

(ii) Calculate the output current of the transformer.

(2)

output current = ... A

(b) (i) State the equation linking input voltage, output voltage and turns ratio for the transformer.

(1)

(ii) Calculate the number of turns on the secondary coil of the transformer.

(2)

number of turns = ...

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(c) Explain how a transformer works.

In your answer, you should include the reasons for using

- two coils
- an iron core
- an alternating supply

(5)

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(Total for Question 4 = 11 marks)

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26 A student has some LEDs connected in a circuit. They emit light of different colours.

(a) (i) The different colours of light are waves which must have

(1)

- ☒ **A** the same amplitude in free space
- ☒ **B** the same frequency in free space
- ☒ **C** the same speed in free space
- ☒ **D** the same wavelength in free space

(ii) When an LED is on, it shows that

(1)

- ☒ **A** there must be alternating current in the circuit
- ☒ **B** there must be a current in the circuit
- ☒ **C** there is a fault in the LED
- ☒ **D** a fuse has blown

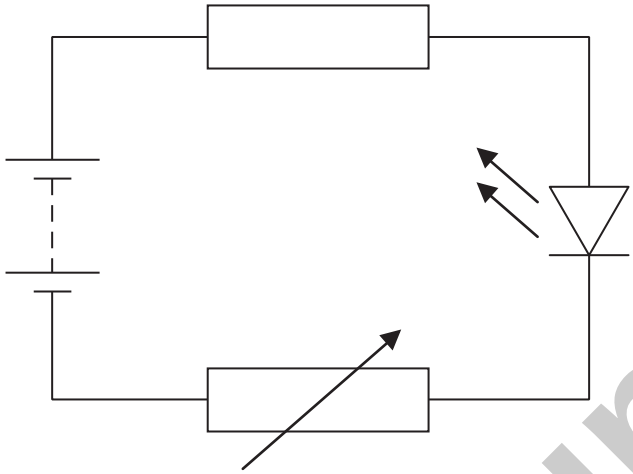
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(b) An LED needs a minimum voltage to make it emit light.

The student investigates this minimum voltage using the circuit shown.



(i) The student uses a voltmeter to measure the voltage across the LED.

Add this voltmeter to the circuit diagram.

(2)

(ii) The student gradually increases the voltage across the LED and records the minimum voltage at which the LED emits light.

The results for some different LEDs are shown in the table.

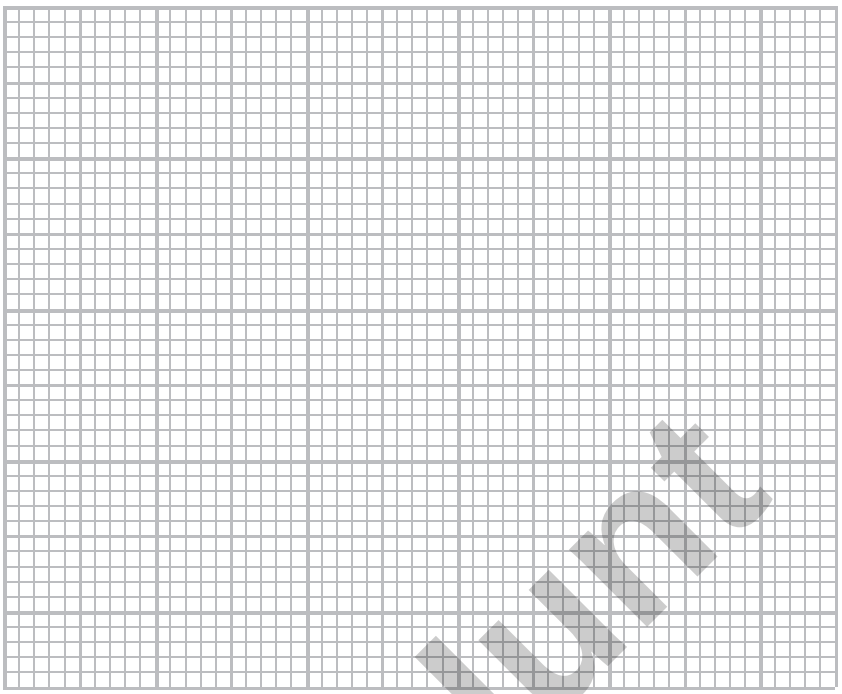
Colour of light from LED	Minimum voltage in V
Red	1.7
Blue	3.6
Yellow	2.1
Orange	2.0
Green	3.0

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Display the results of the student's investigation on the grid.

(4)



(iii) The student concludes:



The minimum voltage depends on the wavelength of the light emitted.

Evaluate the student's conclusion.

(2)

.....

.....

.....

.....

(Total for Question 10 marks)

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27 Electrical energy can be transmitted using a high voltage of 132 kV.



(a) A voltage of 132 kV is the same as

(1)

☒ **A** 132 V

☒ **B** 1320 V

☒ **C** 132 000 V

☒ **D** 132 000000 V

(b) Using a high voltage increases the

(1)

☒ **A** current in the wires

☒ **B** efficiency of transmission

☒ **C** energy lost as heat

☒ **D** resistance of the wires

(c) The high voltage can be reduced using a

(1)

☒ **A** generator

☒ **B** magnet

☒ **C** transformer

☒ **D** transmitter

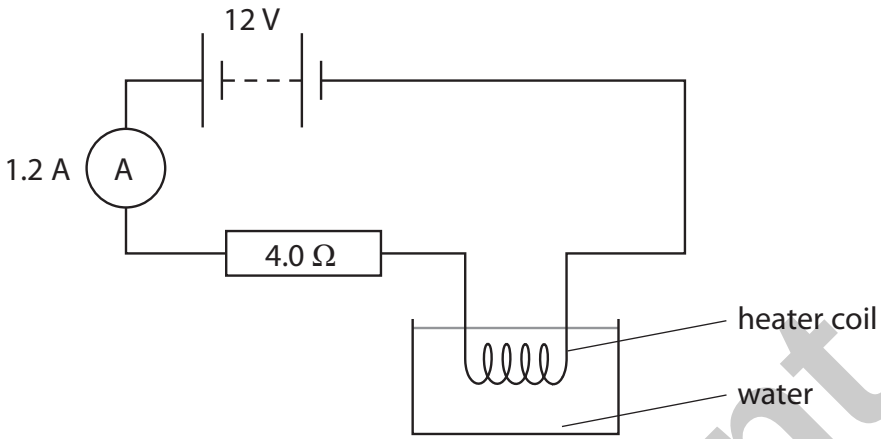
(Total for Question 6 = 3 marks)

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28 The diagram shows a heater coil and a resistor connected to a 12 V battery and an ammeter. The ammeter reading is 1.2 A.



(a) (i) State the equation linking voltage, current and resistance.

(1)

(ii) Calculate the voltage across the 4.0 Ω resistor.

(2)

Voltage = ... V

(iii) Show that the voltage across the heater coil is about 7 V.

(2)

(iv) Calculate the energy transferred to the heater coil in 5.0 minutes.

(3)

Energy transferred = ... J

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(v) At first, the temperature of the water increases.

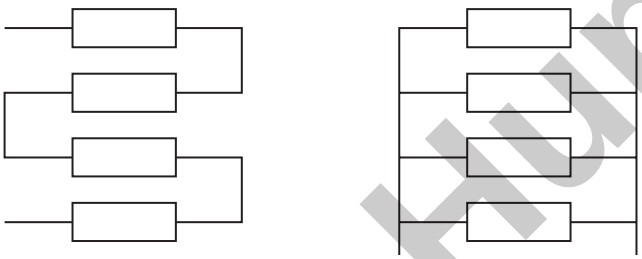
After a while, the temperature reaches a steady value below the boiling point of water.

Explain why the temperature reaches a steady value.

(2)

(b) Resistors can be used as heating elements in the rear windows of cars.

The diagram shows two possible designs.



X **Y**

(i) Complete the table by placing a tick (✓) in the correct boxes.

(1)

Design	Series	Parallel
X		
Y		

(ii) Describe the advantages and disadvantages of design **X** when used as a heater in a car window.

(3)

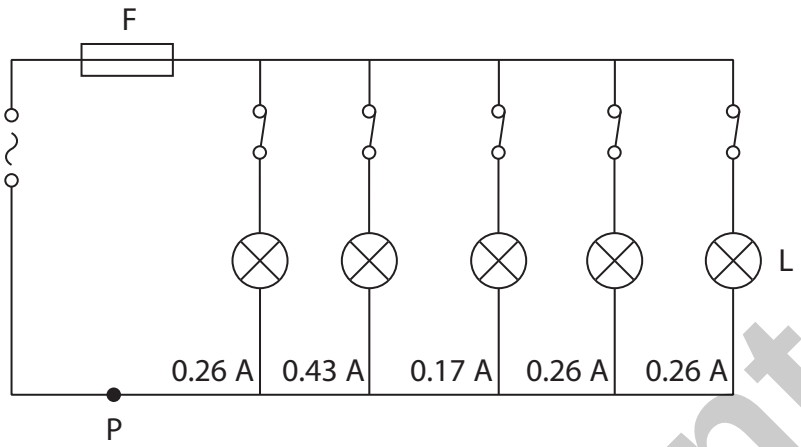
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29 The diagram shows part of a lighting circuit in a house.

The circuit is protected by fuse F.



(a) Give two reasons why the lamps are wired in parallel.

(2)

1 .....

.....

.....

2 .....

.....

.....

(b) What is the current at P?

(1)

☒ **A** 0.17 A

☒ **B** 0.26 A

☒ **C** 0.43 A

☒ **D** 1.38 A

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(c) Explain how the fuse protects the circuit.

(3)

.....

.....

.....

.....

.....

.....

(d) (i) State the equation linking power, current and voltage.

(1)

(ii) Calculate the power of lamp L.
[assume the mains voltage is 230 V]

(2)

power = ... W

(iii) Calculate the amount of energy transferred by lamp L in 3 minutes.

Give the unit.

(3)

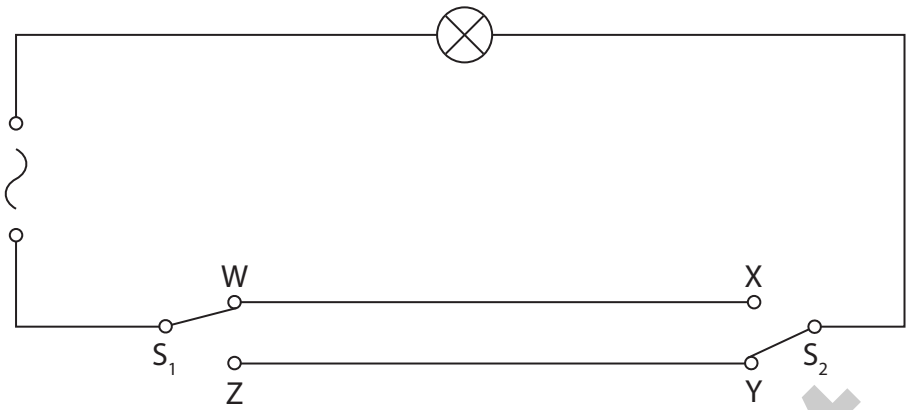
energy transferred = ... unit .....

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(e) This diagram shows another lighting circuit.



(i) Complete the table by putting a tick (✓) in the box if the lamp is lit and a cross (✗) in the box if the lamp is not lit.

(2)

S_1 position	S_2 position	lamp lit (✓ or ✗)
W	X	
W	Y	
Z	X	
Z	Y	

(ii) Suggest where this circuit would be useful in a house.

(1)

.....

.....

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30 A student investigates how the resistance of a thermistor varies with temperature.

(a) Draw the circuit symbol for a thermistor.

(1)

(b) The student uses voltmeter and ammeter readings to find the resistance at each temperature.

One set of readings is shown below.

temperature in °C	voltmeter reading in V	ammeter reading in mA
80	13.2	2.60

(i) State the equation linking voltage, current and resistance.

(1)

(ii) Show that the resistance of the thermistor at 80 °C is about 5000 Ω.

(3)

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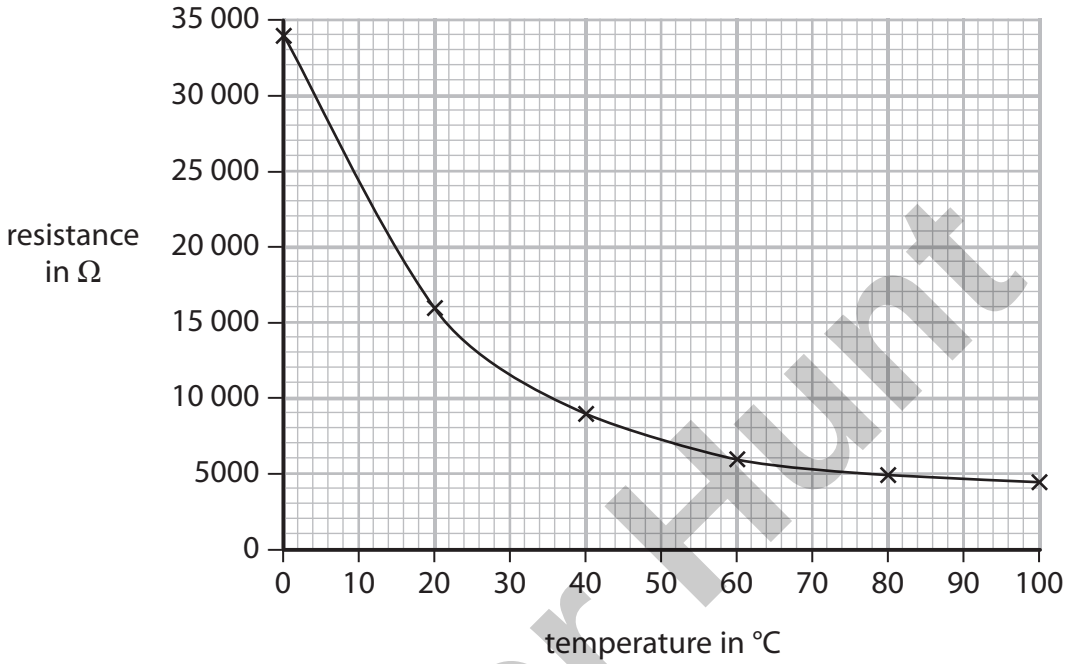
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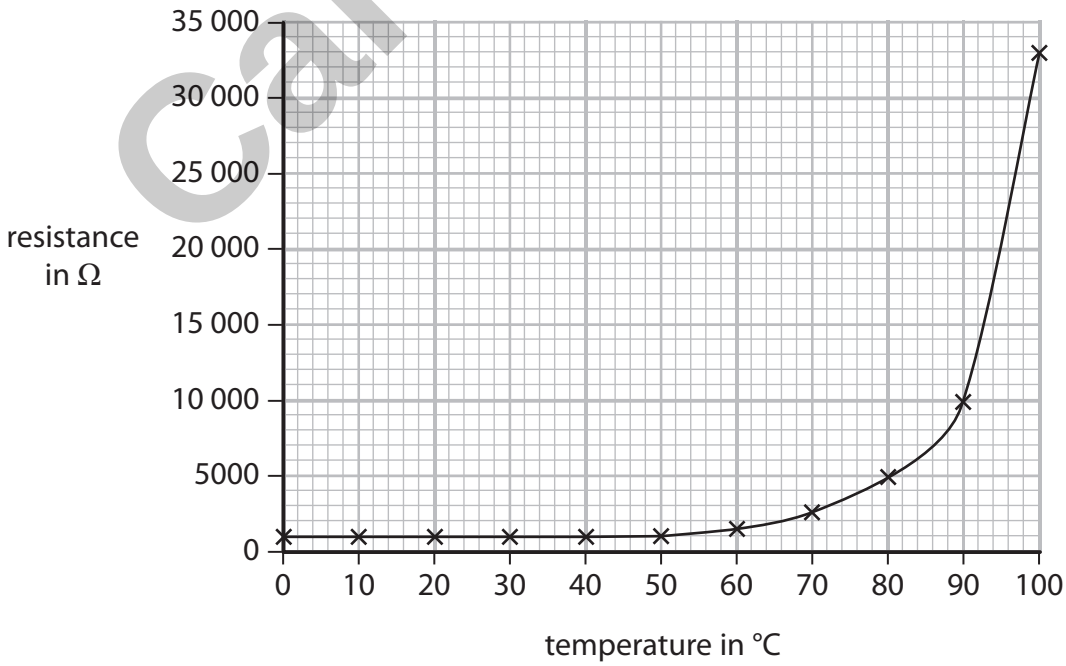
(c) Another student takes measurements for two more components, A and B.

The graphs show the results.

Component A



Component B



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Compare the results for component A and component B.

(5)

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31 (a) A student investigates the resistance of a lamp.

(i) The student uses a circuit that contains an ammeter, a battery, a lamp and a voltmeter to determine the resistance of the lamp.

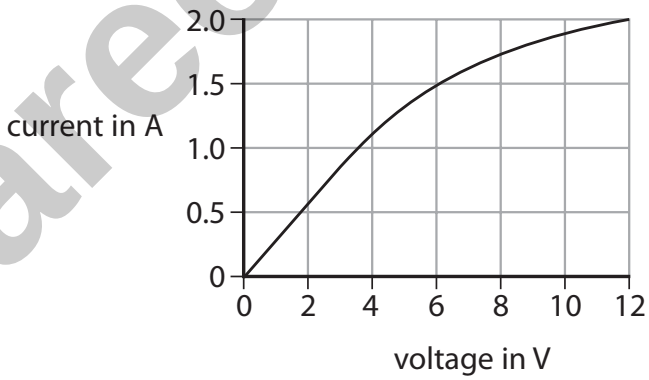
Draw a circuit diagram to show how he should connect the apparatus.

(3)

(ii) State the relationship between voltage, current and resistance.

(1)

(iii) The student obtains this graph for a filament lamp.



Calculate the resistance of the lamp when the voltage is 6.0 V.

Give the unit.

(3)

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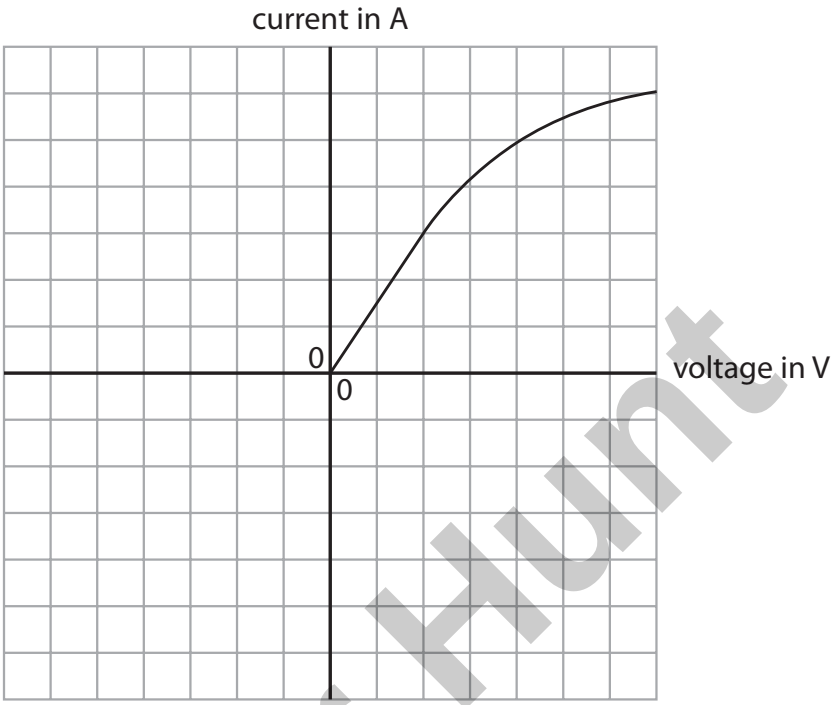
resistance = ... unit .....

(iv) The student reverses the battery connections and then repeats his measurements.

On the axes below, sketch the graph that he would obtain.

Part of the graph has been done for you.

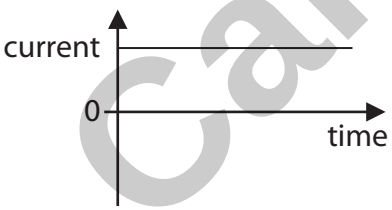
(2)



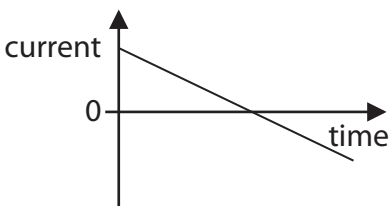
(b) The student replaces the filament lamp with a light emitting diode (LED).
He notices that there is no current in the diode when the battery is reversed.
He replaces the battery with an a.c. supply.

Which graph shows how the current in the diode varies with time?

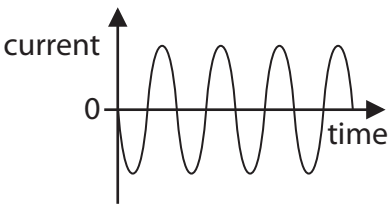
(1)



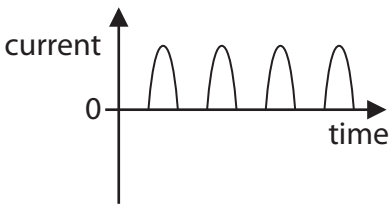
☒ **A**



☒ **B**



☒ **C**



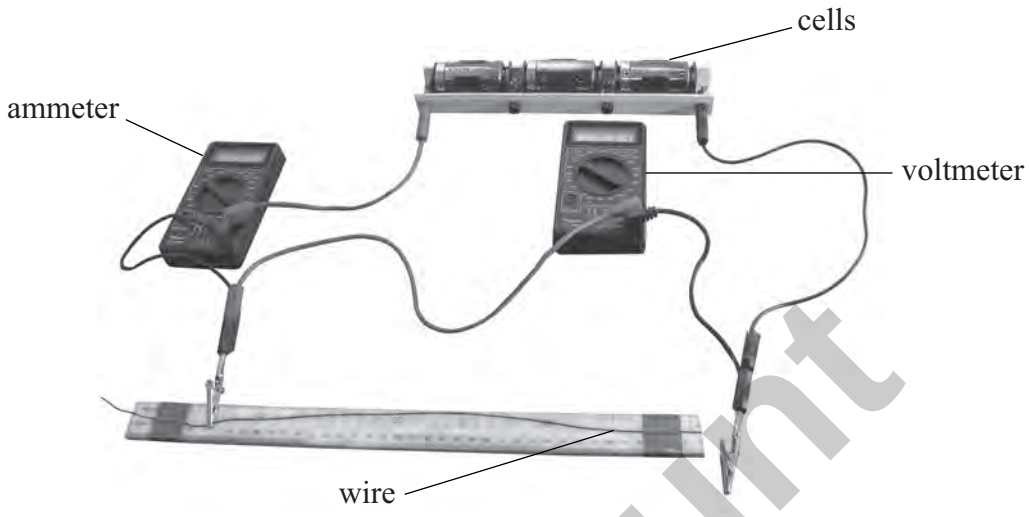
☒ **D**

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32 A student investigates how the resistance of a wire depends on its length.

The photograph shows the circuit that the student uses.



(a) Draw a circuit diagram to show how the components in the photograph are connected.

(3)

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(b) (i) Complete the table by naming the key variables in this investigation.

(1)

independent variable	
dependent variable	

(ii) Describe the method the student should use for this investigation.

(5)

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(c) The table shows the student's measurements.

Length of wire in cm	Voltage in V	Current in A	Resistance of wire in Ω
20	4.5	3.6	1.3
40	4.5	1.8	2.5
60	4.5	1.2	3.8
80	4.5	0.9	5.0
100	4.5	0.7	

(i) State the equation linking voltage, current and resistance.

(1)

(ii) Complete the table by calculating the missing value of resistance.

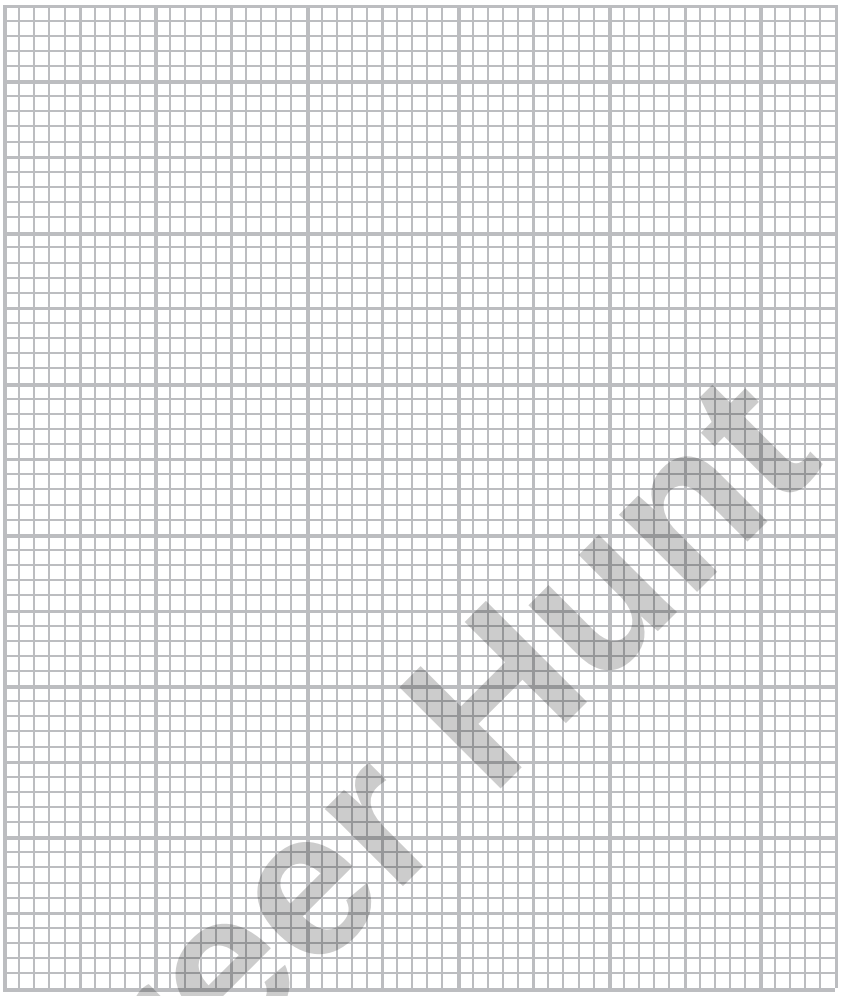
(1)

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(d) (i) Use the results from the table opposite to plot a graph of resistance (y-axis) against length of wire (x-axis) and draw the line of best fit.

(5)



(ii) Write a conclusion for the investigation.

(1)

.....

.....

(iii) Explain how the graph supports this conclu

(2)

.....

.....

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Chapter 2: Electricity
Answer

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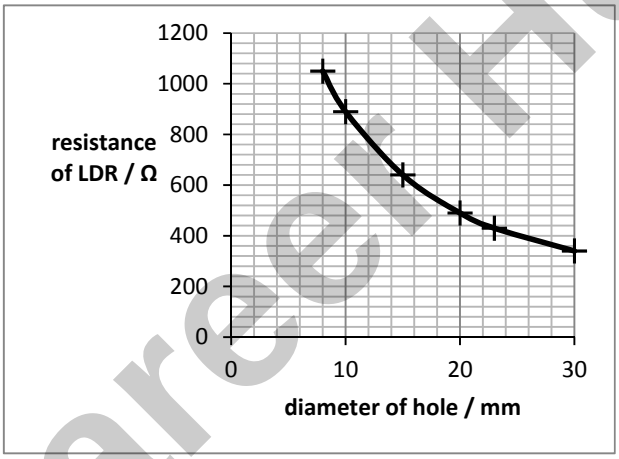
Question number	Answer	Notes	Marks
1 (a) (i)	Voltmeter connected in parallel with a component; component is LDR;	not in parallel with wire	2
(ii)	measure current / take current reading; divide voltage (reading) by current (reading);	accept • number of amps for current • p.d. or number of volts for voltage • R = V/I Ignore triangle mnemonics	2
(b) (i)	B – the diameter of the hole;		1
(ii)	C – the distance from the card to the LDR;		1
(iii)	Any one of - Move ruler to cover half the hole/halfway down the hole; Draw guide lines; Use set square;	idea of measuring across/over the diameter at right angles to ruler Placed against ruler Ignore: move ruler nearer the hole/start from 0 on the ruler	1

Continued

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Question number	Answer	Notes	Marks
1 (c) (i)	suitable scales;	Must use > half width and half height of grid	4
	axes labelled;	units on axis labels ignore orientation of graph	
	Plotting of points;;	to nearest ½ square, up to two marks available for this, -1 each error	
(ii)	line of best fit;	reject dot to dot allow a reasonably smooth curve, points should be evenly distributed about the line	1
		diameter / mm / resistance / Ω 8 / 1050 10 / 890 15 / 640 20 / 490 23 / 430 30 / 340	
(iii)	MP1 Idea of an inverse relationship;	ignore 'negative correlation'	2
	OR		
	Pattern sentence linking resistance and diameter;	e.g. "the bigger the diameter, the lower the resistance"	
	MP2 Idea of a non-linear relationship;	allow exponential decrease	

Total 14 marks

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Question number	Answer	Notes	Marks
2 (a) (i)	P = I x V;	accept standard symbols or in words or rearranged	1
(ii)	substitution and rearrangement; evaluation; e.g. (I =) 110/230 (I =) 0.48 (A)	 allow 0.5, 0.47826 (A) condone 0.47, 0.4782	2
(b) (i)	any suitable suggestion; e.g. carries a high(er) <u>current</u> has low(er) <u>resistance</u>	ignore references to cable overheating/melting	1
(ii)	L or live;		1
(iii)	any suitable suggestion; e.g. double insulated does not have a metal case / has a plastic case	 case is not a conductor / is an insulator	1
(c)	substitution into a suitable equation; time in correct units; evaluation; e.g. (E = I x V x t) (E =) 0.17 x 230 x 55……1 mark (E =) 0.17 x 230 x 55 x 60…2 marks (E =) 130 000 (J)……3 marks OR (E = P x t) (E =) 40 x 55……1 mark (E =) 40 x 55 x 60……2 marks (E =) 130 000 (J)……3 marks	no mark for the equation as given in the paper allow if x60 / 3300 seen anywhere in working 129 030 (J) allow 131 835 for use of V = 235V 132 000(J) total marks = 9	3

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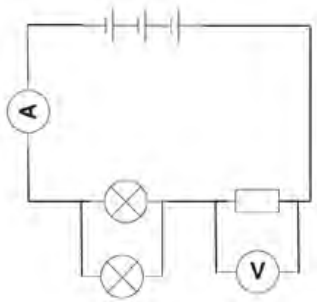
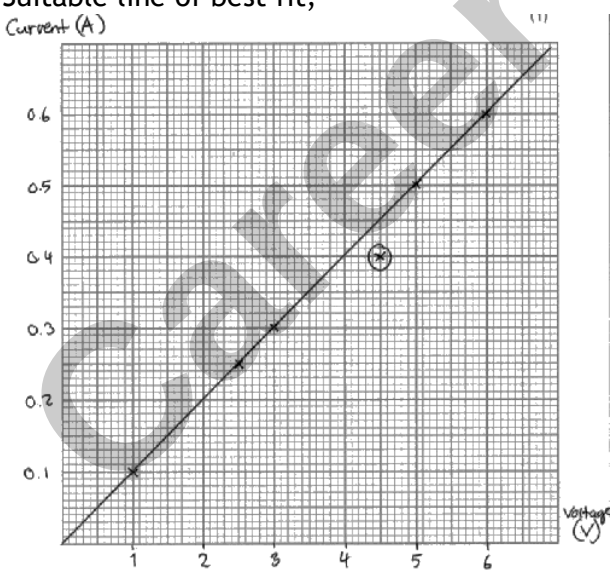
Question number	Answer	Notes	Marks
3 (a) (i)	Voltmeter connected in parallel with any circuit component; Component chosen is the thermistor;	Ignore a line through the voltmeter symbol	2
(ii)	(because voltage is) a controlled variable;	Allow idea of fair test	1
(iii)	Any one of - MP1. Idea of adjustment (of current or **circuit** resistance); MP2. To control the current;		1
(b)	Any three of - **references to the data:** MP1. (yes it works) when the temps are high, the current almost matches the temperature; MP2. (no it's not OK) when the temps are lower, the current value does not match the temperature; MP3. It is only right at 10 (and 100); **Practicality ideas:** MP4. The current cannot be **negative** when the temperature is negative; MP5. Idea that **Voltage** will not be constant/ voltage has to be adjusted to keep it constant; **line ideas** MP6. Line/ graph is curved /eq; MP7. **Line / graph** does not pass through the origin;	however expressed e.g. About t same from 80 °C to 100 °C; e.g. not equal at 20mA 20 °C allow (graph shows that) current not **directly** proportional to temperature allow 0,0	3

Total 7 marks

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Question number	Answer	Notes	Mark
4 (a)	mark each of these independently: MP1. a **resistor** in series with the lamp only; MP2. a second lamp in parallel with the first lamp; MP3. a voltmeter that measures the voltage across the **resistor**; MP4. an ammeter that measures the total current in the circuit;	circuit symbols used must be correct (no square voltmeter/ammeter etc.) 	4
(b) (i)	labels on axes including units; scales on axes; plotting;;	axes can be either way round must occupy >50% in each direction -1 for each error	4
(ii)	I = 0.4, V = 4.5 clearly indicated;		1
(iii)	Suitable line of best fit; 	<table><tr><th>Voltage in V</th><th>Current in A</th></tr><tr><td>1.0</td><td>0.10</td></tr><tr><td>2.5</td><td>0.25</td></tr><tr><td>3.0</td><td>0.30</td></tr><tr><td>4.5</td><td>0.40</td></tr><tr><td>5.0</td><td>0.50</td></tr><tr><td>6.0</td><td>0.60</td></tr></table>	1
(iv)	voltage = current x resistance;	in words or standard symbols	1
(v)	substitution into correct equation using any suitable pair of values taken from the graph line or table; evaluation of R = 10 (Ω);	allow (0.1,1), (0.6,6) etc	2

Total 13 marks

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Question number	Answer	Notes	Marks
5 a	MP1. series circuit containing lamp and some form of power supply; MP2. ammeter in series with lamp; MP3. voltmeter in parallel across lamp; MP4. variable resistor in series OR use of variable power supply;	incorrect symbols or substantial gaps =- 1 ONCE allow either symbol for lamp ignore other components e.g. switch	4
b i	idea that gradient changes; e.g. voltage increases more rapidly than the current	look for a rate change expressed in student terms Accept • line is curved • not a straight line • V is not proportional to I	1
ii	MP1. Lamp heats up; MP2. Greater chance of electron collisions; MP3. (hence) resistance increases;	do not award marks for a description of the shape of the graph	3

(Total for question 5 = 8 marks)

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Question number		Answer	Notes	Marks
6	(a) i	MP1 Any circuit including **correct circuit symbols** for • battery /cell / d.c. power supply • ammeter • voltmeter ;	ignore other components for MP1	3
	ii	MP2 ammeter clearly measures current through the wire; MP3 voltmeter clearly across wire; Idea of measuring current through the wire; Idea of measuring voltage across the wire; Idea of a range of values (of I and V); e.g. alter variable resistor OR repeat for different voltages	allow even if voltmeter in series with ammeter allow circuit line drawn through meter allow voltmeter across a section of the test wire	3
(b)	i	any one of resistance changes (with temperature) ;	Reject incorrect relationship between R and Θ	1 1
	ii	wire gets hot **and** melts/burns/catches fire/dangerous;	Ignore damage to wire Reject insulating the wire	1
	(c)	V proportional to I only at constant temperature; Ohms Law is only true if temperature constant;	Allow to return to room temperature	
	i	any one of putting the wire in a water bath ; taking the reading quickly; switching off between readings; using only small currents; voltage = current × resistance ;	Allow V = I × R and rearrangements	
	ii	horizontal line above axis;		1

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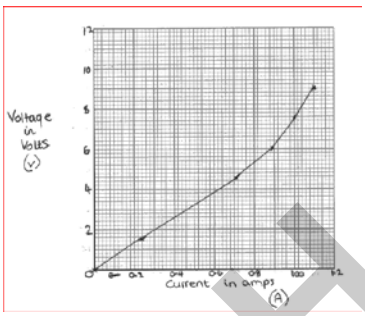
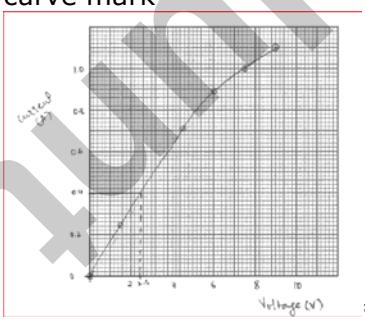
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Question number	Answer	Notes	Marks
7 (a) (i)	Reference to a (magnetic) field / flux / field lines; Which changes in the coil / cuts the coil ORA ;	MUST refer to relative motion between coil / wire and (magnetic) <u>field</u> – references to moving magnet insufficient (and repeat of stem) 'wire cuts (magnetic) field' = 2 marks	2
(ii)	Faster/more energetic movement (shaking);	ACCEPT More <u>turns</u> on the coil (not bigger coil); ACCEPT Stronger magnet / magnetic field (not bigger magnet); REJECT 'more coils' / 'more loops' REJECT 'add another magnet'	1
(b) (i)	C (there is a current in the circuit)		1
(ii)	LED wastes less energy / produces less heat (than a filament lamp); ORA Useful energy output ÷ total energy input is larger for the LED / useful output is closer to total (energy) input; ORA		2

Total 6 Marks

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Question number	Answer	Notes	Marks
8 (a)	any 3 mistakes identified from MP1. cells are connected with wrong polarity; MP2. ammeter is connected in parallel (with wire); MP3. voltmeter is connected in series (with wire); MP4. circuit has not got a switch;	allow RA for any MP allow idea that meters should be swapped for two marks (MP2 and MP3)	3
(b) (i)	suitable scale chosen (> 50% of grid used); axes labelled with quantities and unit; plotting correct to nearest half square (minus one for each plotting error) ;; line of best fit through zero;  = 4 not curve mark  = 5	only scales in 1,2,5,10 or 8 acceptable orientation unimportant points must be shown clearly i.e. two plotting errors = no marks for plotting i.e. smooth curve I V 0.0 0. 0.2 1. 0.7 4. 0.8 6. 1.0 7. 1.1 9.	5
(ii)	0.40 A	range 0.39 A to 0.41 A	1
(iii)	One of - MP1. Temperature (of wire) was not constant; MP2. Resistance (of wire) was not constant;		1

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Question number	Answer	Notes	Marks
(b) (iv)	Any four of -	ignore all details about the circuit already given	4
	MP1. instrument to measure temperature;		
	MP2. means to maintain constant temperature (of wire);	e.g. water bath, switch off and allow wire to cool	
	MP3. use of V = IR;	V ɑ I	
	MP4. idea of repeating / averaging (at same temperature);	obtain a range of values (of V, I)	
	MP5. idea of additional (interpolated) points;		
	MP6. use linear part of the graph;	Allow reference to candidate's graph, e.g. current below 0.6 A	
	MP7. use of gradient;	Orientation unimportant	

Total 14 marks

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Question number	Answer	Notes	Marks
9(a) (i)	any two ideas from:- MP1. voltage / current is <u>induced</u>; MP2. (because) field in coil is changing / field (lines) cut; MP3. current/voltage changes direction when magnet does; MP4. magnet slows down causing decrease in amplitude;	allow voltage for amplitude	2
(ii)	Either of - (voltage/current) changes direction; Positive <u>and</u> negative (voltage/current);	Ignore "wave"	1
(iii)	any two of - MP1. direction of magnet changes; MP2. amount of field (lines) cut changes / rate of flux cutting; MP3. direction of flux cutting changes; MP4. speed of magnet changes / slows down; MP5. as movement diminishes, so does voltage;		2
(b)	Any three of - MP1. Alternating trace that diminishes; MP2. Amplitude is larger; MP3. Frequency is lower;		3

Total 8 marks

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Question number	Answer	Notes	Marks
(i)	Current – 2(.0) (A);		1
10 (a)	Voltage – 12(.0) (V);		1
(ii)	Using E = V x I x t (formula given on sheet)	ecf from a i	
	Time conversion;		1
	Substitution;		1
	Answer;	If time conversion not done / incorrect then ALLOW	1
	e. 20 minutes = 20 x 60 seconds = 1200 seconds E = 12 x 2 x 1200 28 800 (J)	E = V x I x 20 with subs of V and I for 1 mark ALTERNATIVE APPROACH (using power) Calculate power of heater = V x I; Calculate 30000 ÷ (20 x 60); to show comparability;	

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Question number		Answer		Marks
(b)	(i)	Efficiency = useful energy output / total energy input;		1
	(ii)	Substitution into correct equation; Calculation; e. 22 000 / 30 000 = 0.73	ALLOW values calculated using their answer to (a) (ii) e.g 2 000 / 28 800 = 0.76 ALLOW percentages	1 1
	(iii)	Calculation of useful energy doesn't allow for energy lost;		1
	(iv)	Insulate the block (to reduce energy loss);		1
(c)	(i)	Energy raising temperature of the heater / Time for energy to transfer between heater and thermometer;		1
	(ii)	Heat transfers through block by conduction; input (energy) greater than output (energy);		1 1
	(iii)	ANY TWO of Energy lost to surroundings; by radiation; at higher rate; most of the heat supplied is lost / energy input and output nearly equal;		2
			Total	**10**

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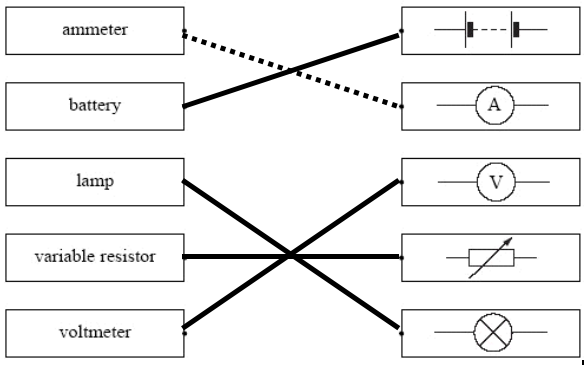
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Question number		Answer	Notes	Marks
11 (a)	(i)	A		1
	(ii)	B		1
(b)	(i)	C		1
	(ii)	nearest above (DOP)		1
	(iii)	Comment on device – (plastic) insulator / does not conduct;	(double) insulated / no current (through) / cannot become live	1 1
		Comment on user - no risk of shock / electrocution;	No electricity reaches user / person cannot touch live parts	

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Question number	Answer	Notes	Marks
12(a)	 all 4 lines;;; any 2 lines;; any one line;	(dotted line is given)	3
(b) (i)	light dependent resistor / LDR;	allow • photo sensitive resistor • light sensitive resistor allow recognisable spellings	1
(ii)	thermistor;	allow recognisable spellings total marks = 5	1

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Question number	Answer	Notes	Marks
13	Max of three electrical hazards identified;;;		6
	Max of three amplifying details relevant to the hazard(s) identified;;;	Max of 2 amplifications for any one hazard. A repeated amplification can only be credited once e.g. shock, fire, provide plenty of sockets e.	
	MP1. Idea of **water** in contact with something electrical e.g. plugs/sockets/switches;	Idea that water conducts electricity; Idea that this can cause shock;	
	MP2. Idea that an electrical device with a heating element reaches a **high temperature**;	(risk of) burns; idea that insulation can melt and cause a fire;	
	MP3. Idea that **damaged equipment** poses a hazard; e.g. microwave oven	Live parts should not be exposed; Idea that this can cause shock; leaky microwave radiation can cause cancer;	
	MP4. Idea **overloaded** cables or sockets;	circuits should have correct fuses; can cause a fire; don't use multiway socket extensions; provide sufficient sockets;	
	MP5. Idea of **trip hazard** from trailing cables;	Do not use extension cables; Provide sufficient sockets; Use short mains leads; NOTE	

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	MP6. Idea of **misusing equipment** e.g. sticking metal objects into a socket or exposed heating element;	Appropriate training/safety regime, e.g. use of 'blanks' to cover sockets that children can reach; Idea that this can cause shock; Use proper (insulated) tools;	

Total 6 marks

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Question number	Answer	Notes	Marks
14	Any four of - MP1. either transfer between the two is by conduction; or same SA either way up. MP2. **Infrared** (radiation) mentioned; MP3. Idea of emission of thermal energy; MP4. a correct effect of (surface) colour on emission; MP5. Comparative of surfaces; MP6. correct statement about thermal energy flow at **equilibrium** temperature;	– ignore other comments about conduction, convection , absorption and reflection for thermal energy accept heat or radiation e. black emits heat e. • black is a good emitter • white is a poor emitter e.g. the black loses more heat than the white	4

Total 4 marks

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Question number	Answer	Notes	Marks
15 (a) i	Power = current x voltage;	Accept • rearranged equation • equation in recognised symbols	1
ii	Substitution and rearrangement; Evaluation; eg I = 2000 / 230 8.7 (A)	Accept • 9 (A) • 8.695…..(A) ETC NOT • 8.6 incorrect truncation • 9.0 incorrect rounding	1 1
iii	D 13 A		1
b	Series – single switch to control both; Parallel – independent control;	Allow idea of one element failing (and the other continuing) ignore comments about voltages or currents there is no mark for getting the 2 answers reversed	1

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c i	ANY FOUR FROM – MP1. earth connected to (metal) casing; MP2. If casing becomes live/ live wire touches case; MP3. Provides low resistance path (to earth); MP4. (So) large/surge current <u>in earth wire</u>; MP5. (hence) fuse breaks/melts/blows; MP6. (so) circuit switches off or current stops or supply cuts off;	Allow circuit breaker(RCCB) DO NOT CREDIT: the electricity goes to the ground/eq for MP3	4
ii	any two from MP1. It has a metal case; MP2. Metals/the case conducts (electricity); MP3. to prevent (user getting) a shock;		1 1

(Total for question 4 = 12 marks)

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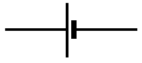
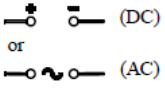
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Question number	Answer	Notes	Marks
16 (a)	Any FOUR from: MP1. Current in <u>coil</u> ; MP2. (Creates) magnetic field (around the wires of the coil); MP3. Interaction of (this) field with that of (permanent) magnets; MP4. There is a force on the wire(of coil); MP5. Reference to left hand rule; MP6. force up on one side and down on other side;	current in circuit is not enough coil becomes an electromagnet allow field cutting as the interaction idea of catapult field reference to moment/turning effect on the coil	4
b i	one of • Reverse supply polarity (however described); • reverse current direction (however described); • swap magnets over(however described);		1
ii	any one from: • Reduce current (however described); • Reduce voltage (however described); • increase resistance of circuit (however described); • weaker magnetic field (however described);	Allow : less turns on coil Condone: fewer coils	1

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Question number	Answer	Notes	Marks
(i) 17 (a)	symbols for circuit components; • cell, battery, 'box' labelled power supply, a.c. symbol, component ends for battery • ammeter or milliammeter • thermistor  a series circuit;	Acceptable power supply symbols    ignore all other symbols	2
(ii)	voltmeter in parallel with thermistor;	ecf from 'thermistor' in ai	1

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(iii)	any FIVE from: MP1. measure current at any known/fixed temperature; MP2. measure voltage at any known/fixed temperature; MP3. measure temperature; MP4. vary temp and take new readings ; MP5. idea of allowing temp to equalise between readings; MP6. either change temp by heating water OR start at 100ºC and allow to cool; MP7. either start from ice OR use ice cubes to take temp down below room temp; MP8. calculate V/I; MP9. repetition/averaging (at any stage); MP10. use of stirrer/digital thermometer;		5

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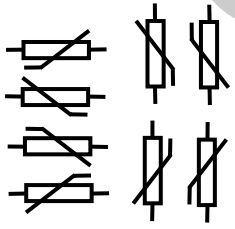
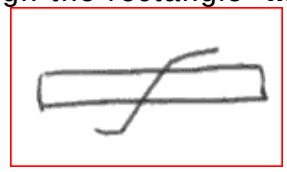
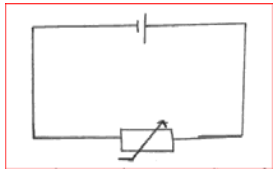
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Question number	Answer	Notes	Marks
(b) (i)	no mark for the choice any valid explanation (dependant on choice of line or curve); e.g. A/curve it fits more points/all the points are closer to the line / eq; OR B /straight line it has 4 points above the line, 4 points below the line/eq;	 accept theory says it should be a curve the resistance will not be zero at 100 °C	1
(ii)	One of the following ideas:- • the new point could be nearer to one line than the other; • the lines are furthest apart at 10°C;	accept this measurement would give more data	1
(c)	Any one correct ; All three correct;; L etal wire at constant temperature K diode J filament lamp		1

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Question number	Answer	Notes	Marks
18 (a)	 Symbol can be in any orientation, e.g. 	the line through the rectangle **must** be correct  =0 Ignore the size Ignore the rest of the circuit e.g.  =0 as the line through is incorrect Allow without the connection leads  =1	1
(b) (i)	Voltage = current x resistance;	Allow V = IR Allow rearrangements ignore a bald 'triangle'	1
(ii)	Convert milliamps to amps OR kilo-ohms to ohms; Substitution into *correct* equation & rearrangement; Calculation to greater than 1SF; 2.6 mA = 0.0026 A (R) = $\frac{13.2}{0.0026}$ = 5077 (Ω)	'show that' question, working must be shown for full mark Allow 5080, 5076 (truncation) 5.080 with working is worth 2 marks 5.08 with no working is worth 1 mark	3

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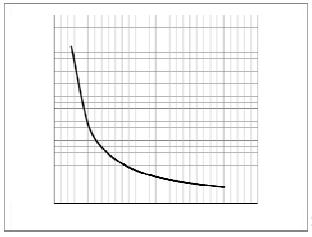
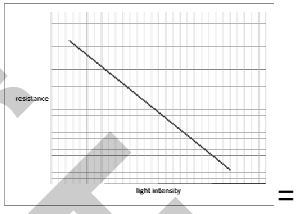
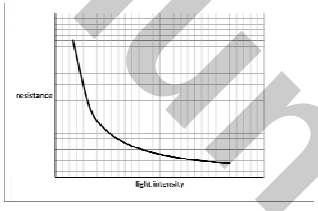
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Question number	Answer	Notes	Marks
(c)	Any **five** of *ABOUT A* 1. Resistance of A decreases with temperature; 2. For A, {largest slope / rate of change} is at lower temperature ORA {smallest slope /rate of change} is at higher temperature; 3. A is a thermistor (ntc); *ABOUT B* 4. Resistance of B increases with temperature; 5. For B, {largest slope / rate of change} is at higher temperature(s) ORA {smallest slope /rate of change} is at lower temperature; 6. For B, resistance is constant below 50 °C; *ABOUT BOTH* 7. More results for B/ fewer results for A; 8. stated both relationships are non-linear; 9. Range of (temperature/resistance) values for both is similar; 10. data comparison e.g. both have the same resistance at 80 °C;	**Accept** • (MP1) for A, when the temperature is low, the resistance is high, ORA • (MP4) for B, when the temperature is low, the resistance is low, ORA **Allow** component B is a ptc thermistor ORA Up to 60 °C **Ignore:** inversely proportional positive/negative correlation Do **not** take implication of MP8 when MP 1,2,4,5 is given	5
		Total	**10**

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Question number	Answer	Notes	Marks
19	Bright light low resistance/Dim light high resistance; Idea of an inverse relationship between R and intensity; e.g. 'bright at lower resistance' ORA =2 marks Idea of non-linear relationship;	ACCEPT Correct answers shown on a labelled sketch graph (light / intensity / light intensity acceptable for one axis, resistance for the other)  = 0 (axis/axes not labelled)  = 2 (first two marking points)  = 3 marks If diagram and text contradict, use list principle REJECT Negative values of resistance or light intensity in sketch graph for 1 mark	3

Total 3 Marks

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Question number	Answer	Notes	Marks
20 (a)	Any two of braking force; air resistance / drag; (road or tyre) friction;	ACCEPT Headwind/wind resistance in this case	2
(b) (i)	force = mass x acceleration;	ACCEPT mass = force ÷ acceleration ACCEPT acceleration = force ÷ mass ACCEPT standard symbols, F = m x a	1
(ii)	Substitution in correct equation; Calculation; e.g. 1400 x 5.5 = 7700 (N) or 7.7 k(N)	correct answer = 2 marks	2
(c)	Attempt at area under the graph (e.g. ½ x base x height); ½ x 4 x 22; Correct answer 44 (m); OR distance = (average) speed x time; 11 x 4; correct answer 44 (m)	correct answer = 3 marks first mark implied in correct substitution first mark implied in correct substitution	3
(d) (i)	(graph is a) curve(d line) /gradient changes / slope changes / (graph is) not a straight line / graph levels off;		1
(ii)	Any two of <u>Increase</u> in air resistance / drag / wind resistance; <u>Increase</u> in road resistance / (tyre) friction; <u>Decrease</u> in resultant force; Road becomes <u>steeper</u> / goes uphill;	IGNORE references to terminal velocity IGNORE 'more weight in the car' IGNORE 'driver changed gear' IGNORE 'driver turned corner'	2

Total 11 Marks

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Question number	Answer	Notes	Marks
21 (a)	A carbon;		(1)
(b)	A negatively charged electrons;		(1)
(c)	D steel;		(1)
(d)	C 2 N poles facing;		(1)

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Question number	Answer	Notes	Marks
22 (a) (i)	step-down (transformer);		1
(ii)	MP1. soft material **loses** magnetism **quickly** / **easily**; MP2. idea that magnetic field (in core) alternates / changes;	ignore unqualified references to losing magnetism	2
(b) (i)	$\frac{\text{input / primary voltage}}{\text{output / secondary voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$	allow • equa ion in words with turns ratio shown as a fraction • sta dard abbreviations :- s, p, in, out, 1, 2 • N or n for number of turns (condone T for number of turns) • "numb r of coils" for number of turns rearrangements also to include turns ratio as a fraction $(V_S/V_P) = (N_S/N_P)$ [equation inverted] $V_S = (V_P)(N_S/N_P)$ [V_S as subject] $V_P = (V_S)(N_P/N_S)$ [V_P as subject]	1
(ii)	substitution into a correct equation; evaluation (including rearrangement); e. 44 / V = 520 /30 (V =) 2.5 (V)	allow 3, 2.53, 2.54, 2.538	2

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(c)	(i)	idea of a (frequency) limit / range to (human) hearing OR (frequency) is {too high / ultrasound}; mention of upper limit as 20 000 Hz;	ignore references to lower limit allow 20 kHz ignore references to lower limit	2
	(ii)	conversion of unit; substitution and evaluation; e. t = 1.5 ms = 0.0015 s (f =) 1/0.0015 = 670 (Hz)	allow 1000 or 0.001 in working, if no other mark can be given allow correct rounding only e.g. 700, 667, 666.7, 666.6 (recurring) 1 mark max for POT error e.g. 0.67, 6.7, 67 etc.	2

Total 10 marks

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Question number	Answer	Notes	Marks
23 (a) i	Step down (transformer);		1
ii	$(V_P/V_S) = (N_P/N_S)$; $\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$ $\frac{V_P}{V_S} = \frac{n_P}{n_S}$	Allow • equation in words • standard abbreviations :- s, p, in, out, 1, 2 • N, n or T for number of turns • Rearrangements e.g. $(V_S/V_P) = (N_S/N_P)$ $V_S = (V_P)(N_S/N_P)$ $V_P = (V_S)(N_P/N_S)$	1
iii	Substitution; (rearrangement and) evaluation; e.g. $\frac{230}{25} = \frac{\text{primary turns}}{100}$ 920 (Turns)	Do not credit the equation in words or symbols bald answer gains full marks	2

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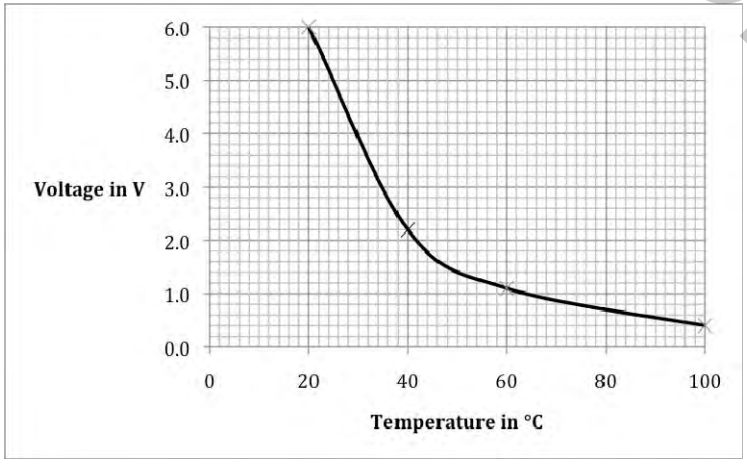
Question number	Answer	Notes	Marks
(b)	Any 5 from MP1. it steps up or steps down the **voltage**; MP2. current in (primary) coil **produces** magnetic field; MP3. the current is changing /has frequency of 50 Hz; MP4. causing a (changing) magnetic field in the core; MP5. the core strengthens the magnetic field; MP6. field lines interact with (secondary) coil; MP7. which **induces** a voltage in the secondary coils; MP8. transformer won't work with (steady) d.c.	allow flux for magnetic field Allow increases or decreases voltage Allow concentrates for strengthens Allow flux changes in secondary coil Allow induces a current/eq NB do not credit repeat of stem	5

(Total for Question 2= 9 marks)

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Question number	Answer	Notes	Marks
24 (a)	Any three of - MP1 use a stirrer / stir with thermometer; MP2 centralise / spread heat source; MP3 move thermistor and thermometer to same level; MP4 move thermistor and thermometer closer together; MP5 Use thermometer with finer scale / digital thermometer;	Ignore repeat readings Assume horizontal separation meant	Max 3
(b)	(milli)Ammeter;	Allow ampmeter	1
(c) (i)	Scale; (at least half the grid) Axes labelled including units; Plotting ±½ small square;; Line of best fit;  	Accept axes reversed -1 each plotting error, minimum 0 for plotting Curve through either (80, 0.2) or (100, 0.4) Allow line bisecting these two points Temperature in °C / Voltage in V 20 / 6.0 40 / 2.2 60 / 1.1 80 / 0.2 100 / .4	5
(c) (ii)	DOP (80, 0.2) circled (if supported by line of best fit)	Allow (100, 0.4) circled if supported by line of best fit	1

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Question number	Answer	Notes	Marks
(d) (i)	voltage = current x resistance;	Accept rearrangements and symbols e.g. current = voltage ÷ resistance, V=IR, R=V/I	1
(ii)	Substitution into correctly rearranged equation; Conversion between amps and milliamps; Calculation yielding value correct to at least 2 s.f.; e. I = 5.9 ÷ 680 = 0.00868 (A) = 8.7 (mA)	 Accept x 1000 in calculation Allow 1 mark max if response is only a successful reverse argument leading to 5.8 V or 5.78 V	3

Total 14 marks

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Question Number	Answer	Notes	Marks
25 (a) (i)	input power = output power; OR $I_pV_p = I_sV_s$; OR $I_{in}V_{in} = I_{out}V_{out}$;	A dimensionally correct power equation is required. Accept - Power in = Power out $I_1V_1 = I_2V_2$ **input power = output power** $V_P I_P = V_S I_S$	1
(ii)	Substitution in correctly rearranged equation; Calculation; e.g. $I_s = \frac{(2 \times 230)}{110}$ 4 (A)	Full marks for bald correct answer Accept more s.f. e.g. 4.2, 4.18, 4.1818	2
(b) (i)	$(V_P/V_S) = (N_P/N_S)$; $\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$ $\frac{V_P}{V_S} = \frac{n_P}{n_S}$	Allow • equation in words with turns ratio shown as a fraction • standard abbreviations :- s, p, in, out, 1, 2 • N, n or T for number of turns • "number of coils" for number of turns Rearrangements also to include turns ratio as a fraction $(V_S/V_P) = (N_S/N_P)$ [equation inverted] $V_S = (V_P)(N_S/N_P)$ [V_S as subject] $V_P = (V_S)(N_P/N_S)$ [V_P as subject]	1

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(ii)	Substitution into correctly rearranged equation; Calculation; e.g. $N_S = \frac{(110 \times 1200)}{230}$ 570	Accept • 2 or more s.f. e.g. 574, 573.9 • Answers which round to 570	2
(c)	Any 5 from MP1. it steps up or steps down the voltage; MP2. current in (primary) coil produces magnetic field; MP3. the current is changing /has frequency of 50 Hz; MP4. causing a (changing) magnetic field in the core; MP5. the core strengthens the magnetic field; MP6. field lines interact with (secondary) coil; MP7. which induces a voltage in the secondary coils; MP8. transformer won't work with (steady) d.c.	allow flux for magnetic field Allow increases or decreases voltage Allow concentrates for strengthens Allow flux changes in secondary coil Allow induces a current/eq	5

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Question number		Answer	Notes	Marks
26 (a) (i)		C (the same speed in free space)		1
(ii)		B (there must be a current in the circuit)		1
(b) (i)		Voltmeter connected in **parallel** with any circuit component; Component chosen is the **LED**;	Ignore a line through the voltmeter symbol	2
(ii)		**Axes labelled**- quantity and unit ;	voltage in V (or V/V) AND all bars (or points) labelled	4
		Linear scale such that longest bar occupies at least half the grid;	Ignore orientation Allow non-zero origin	
		Plotting---ignore order of bars 5 bars correctly plotted;; If only 3 bars correctly plotted allow 1 mark for plotting	Bar length plotted to nearest ½ small square ALL data plotted correctly as floating "x's" gets only one mark for plotting Reject both **plotting** marks if a **line** graph is drawn (only scale and axes marks are available in this case)	
		Colour of light from LED / Minimum voltage in V Red 1.7 Blue 3.6 Yellow 2.1 Orange 2.0 Green 3.0		
(iii)		Student is right/wrong – no mark		
		Any two of MP1 idea that the visible spectrum is a sequence, with the end colours identified; MP2 Colour correctly related to wavelength (e.g. red has longest wavelength); MP3 Colour correctly related to voltage (e.g. blue needs highest voltage);	Red to blue (start either end) Allow ROYGBIV etc Wavelength (or frequency) correctly related to voltage = 2 marks, e.g. f increases with V λ increases with 1/V	2

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Question number	Answer	Notes	Marks
27 (a)	C (132 000 V);		1
(b)	B (efficiency of transmission);		1
(c)	C (transformer);		1

Total 3 marks

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Question number	Answer	Notes	Marks
28 (a) (i)	voltage = current x resistance	ACCEPT equivalent rearrangement ACCEPT suitable abbreviations e.g. V = I x R REJECT V = I x REJECT equation 'triangles' alone	1
(ii)	1.2 x 4.0; 4.8 (V);		2
(iii)	12 – 4.8; 7.2 (V);	ECF on (ii)	2
(iv)	E = VIt (NO MARK) time conversion to seconds (5.0 x 60); 7.2 x 1.2 x (5.0 x 60); 2600 (J);	ECF on (iii) Allow 2592 or 2590 ALLOW 2500/2520 (J) for full marks (using 7 V) ALLOW 42 (J) or 43.2 (J) for 2 marks (using 5 mins)	3
(v)	idea of energy losses rate of energy loss = rate of energy supply (at steady temp)	 NB this statement alone scores (2) as it includes idea of energy loss	2

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Question number	Answer	Notes	Marks
(b) (i)	X – series, Y – parallel	BOTH REQUIRED for the mark	1
(ii)	THREE SUITABLE, e.g.- series advantage – fewer wires; series advantage – lower resistance values; series disadvantage – one fails, circuit fails; series disadvantage – no independent control;	ALLOW REVERSE ARGUMENTS in terms of parallel circuits but do not award the same mark twice IGNORE refs to efficiency ACCEPT correct answers that link to battery voltage / current, etc	Max 3

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Question number	Answer	Notes	Marks
29 (a)	any 2 of: MP1. so that lamps work independently; MP2. so that they all get mains/same voltage/230V; MP3. so that different areas/rooms can have different brightness/power/light intensities of lamps;	 so that can light some rooms without all being on or off/each lamp has its own switch/if 1 lamp blows the others will still work allow no reduction in light output for main voltage allow different currents	2
(b)	D 1.38 A;		1
(c)	any 3 of: MP1. **current** increases over max value of fuse; MP2. fuse wire melts; MP3. cuts off current; MP4. prevents wire(s) in circuit from overheating;	 allow **current** gets too high blows/breaks breaks circuit ignore 'stops electricity' ignore electric shocks	3
(d) (i)	power = voltage x current	allow in standard symbols or in words	1
(ii)	substitution into correct equation; evaluation; e. 0.26 X 230 60 (W)	allow 240 V for mains but not incorrect current (62.4 W) allow 59.8 (W) condone 317(.4) (W) for 1 mark	2
(iii)	 answer from (d)(ii) x **180** ; evaluation; unit; e. 60 X 180 11000 joules/J	accept correct use of E = V x I x t allow ecf from (d)(ii) mark independently allow 10800, 10764	3

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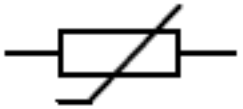
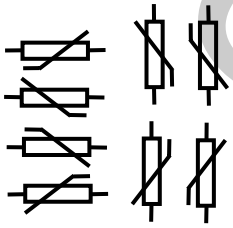
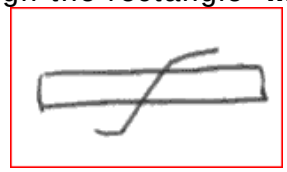
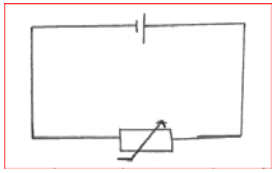
(e) (i)	<table><tr><th>S_1 position</th><th>S_2 position</th><th>lamp is lit</th></tr><tr><td>W</td><td>X</td><td>(yes)✓</td></tr><tr><td>W</td><td>Y</td><td>(no) ×</td></tr><tr><td>Z</td><td>X</td><td>(no) ×</td></tr><tr><td>Z</td><td>Y</td><td>(yes)✓</td></tr></table> any three correct; all 4 correct;;	allow 1 mark when middle two rows blank, but otherwise correct allow 1 mark when top and bottom rows blank but otherwise correct	2
(ii)	any sensible suggestion of 2 way switching; e. on a corridor on stairs basement/cellar bedroom/kitchen light room with 2 doorways	allow clear description of 2 switches controlling the same light	1

Total 15 marks

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Question number	Answer	Notes	Marks
30 (a)	 Symbol can be in any orientation, e.g. 	the line through the rectangle **must** be correct  =0 Ignore the size Ignore the rest of the circuit  e.g. =0 as the line through is incorrect Allow without the connection leads  =1	1
(b) (i)	Voltage = current x resistance;	Allow V = IR Allow rearrangements ignore a bald 'triangle'	1
(ii)	Convert milliamps to amps OR kilo-ohms to ohms; Substitution into *correct* equation & rearrangement; Calculation to greater than 1SF; 2.6 mA = 0.0026 A (R) = $\frac{13.2}{0.0026}$ = 5077 (Ω)	'show that' question, working must be shown for full mark Allow 5080, 5076 (truncation) 5.080 with working is worth 2 marks 5.08 with no working is worth 1 mark	3

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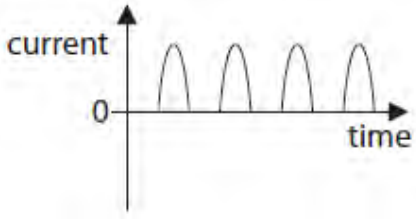
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Question number	Answer	Notes	Marks
(c)	Any **five** of *ABOUT A* 1. Resistance of A decreases with temperature; 2. For A, {largest slope / rate of change} is at lower temperature ORA {smallest slope /rate of change} is at higher temperature; 3. A is a thermistor (ntc); *ABOUT B* 4. Resistance of B increases with temperature; 5. For B, {largest slope / rate of change} is at higher temperature(s) ORA {smallest slope /rate of change} is at lower temperature; 6. For B, resistance is constant below 50 °C; *ABOUT BOTH* 7. More results for B/ fewer results for A; 8. stated both relationships are non-linear; 9. Range of (temperature/resistance) values for both is similar; 10. data comparison e.g. both have the same resistance at 80 °C;	**Accept** • (MP1) for A, when the temperature is low, the resistance is high, ORA • (MP4) for B, when the temperature is low, the resistance is low, ORA **Allow** component B is a ptc thermistor ORA Up to 60 °C **Ignore:** inversely proportional positive/negative correlation Do **not** take implication of MP8 when MP 1,2,4,5 is given	5
		Total	**10**

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Question number	Answer	Notes	Marks
31 (a)(i)	MP1. series circuit containing lamp and some form of power supply; MP2. ammeter in series (with lamp/battery); MP3. voltmeter in parallel across lamp;	correct symbols only condone cell for battery	(3)
(ii)	V=I.R;	accept in words rearrangements NOT the 'triangle'	(1)
(iii)	current reading from graph; calculation; unit; e.g. 1.5 (A) 4 Ω /ohms	 do not accept V/A for Ω	(3)
(iv)	correct shape; correct end position/size;		(2)
(b)	 D ;		(1)

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Question number	Answer	Notes	Marks
32 (a)	CIRCUIT DIAGRAM – Correct symbols for ammeter, voltmeter and battery;	ALLOW three separate cells in series	1
	Ammeter in series with cells;	ALLOW anything reasonable for the wire (e.g. straight line, variable resistor, resistor)	1
	Voltmeter in parallel with wire / as shown in photograph;		1
(b) (i)	(independent variable) – length (of wire) (dependent variable) - resistance	BOTH NEEDED	1
(ii)	ANY FIVE APPROPRIATE, e.g. Connect the circuit / connect (crocodile) clip to wire; Read ammeter; Read voltmeter; For known /particular / quoted value length; measure length with a ruler; Repeat readings / average (in different places along the wire); Take readings for different lengths; Check meters for zero errors; Disconnect/switch off between readings; To avoid heating the wire;	IGNORE references to calculating resistance, plotting graphs –	5

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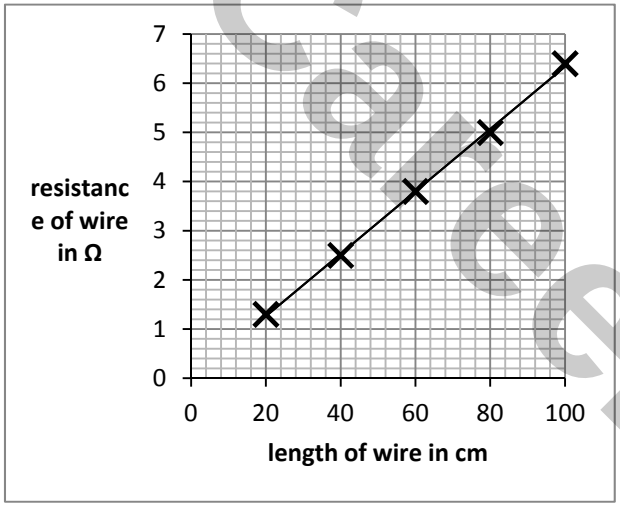
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Question Number	Answer		Marks
(c) (i)	Voltage = current x resistance;	ALLOW standard symbols, V = I X R ALLOW correct rearrangements DO NOT ALLOW equation given as unit symbols	1
(ii)	6.4;	ALLOW correct answer if it follows an equation given in unit symbols IGNORE s.f. BUT must be correctly rounded from 6.4285...	1

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Question Number	Answer		Marks
(d) (i)	Sample graph –  scale; at least half the paper axes labelled including units; Plotting; Plotting; Best fit line;	<table><tr><td>20</td><td>1.3</td></tr><tr><td>40</td><td>2.5</td></tr><tr><td>60</td><td>3.8</td></tr><tr><td>80</td><td>5.0</td></tr><tr><td>100</td><td>.4)</td></tr></table> Points to plot IF AXES REVERSED, LOSE THE AXES MARK Ignore (100 cm, 6.4) ALLOW as length increases resistance increases ALLOW conclusions in terms of resistance per metre etc	5

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Question Number	Answer		Marks
(d (ii)	MARK (ii) and (iii) together, credit points wherever seen (directly) proportional;	IGNORE 'as length increases current decreases' / conclusions relating to current	1
MARK tog With			
(iii)	any TWO of Straight line; Through (0,0); line slopes upwards; quoting appropriate values from the graph;	ALLOW constant gradient ALLOW positive correlation	1 1
		Total	**19**

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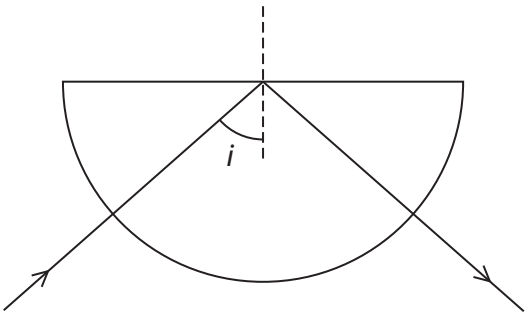
Chapter 3: Wave
Question

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1 A student watches a demonstration of the total internal reflection of light in a semicircular glass block.



i = angle of incidence

(a) He takes notes, but some of his notes are wrong.

Place a tick (✓) or a cross (✗) in the table to show which statements are right or wrong.

The first statement is right and has been done for you.

(2)

Notes about the total internal reflection of light	Right or wrong
the angle of incidence equals the angle of reflection	✓
light changes speed when it is internally reflected	
every ray entering the semicircular glass block is reflected by total internal reflection	
if $i = 0$ then the ray does not deviate	
the refractive index of glass is bigger than the refractive index of air	

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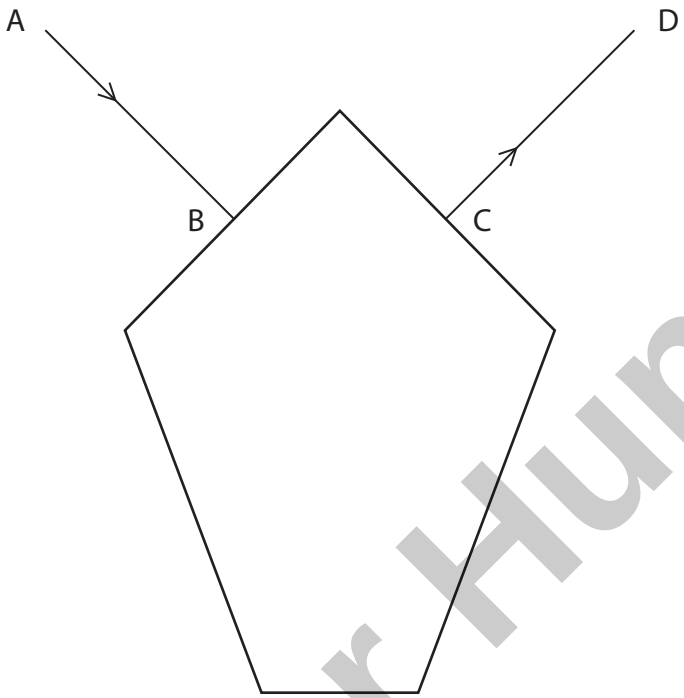
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(b) Jewellers cut jewels so that total internal reflection is more likely.

Light enters a jewel along the normal AB and leaves along the normal CD as shown.

Between B and C there are **two** total internal reflections.



Complete the path of the light through the jewel.

(3)

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(c) (i) Show, by calculation, that the critical angle for a refractive index of 1.5 is about 42°.

(3)

(ii) Explain why the quantity called refractive index has no unit.

(2)

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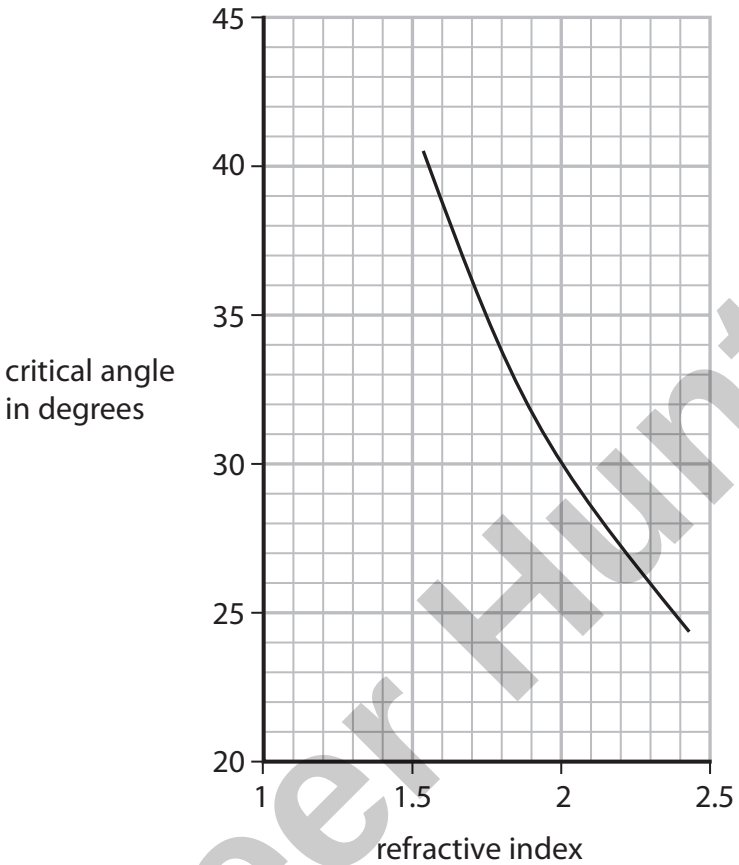
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(d) The graph shows how critical angle varies with refractive index.

(i) Add the point (1.5, 42°) to the graph.

(1)



(ii) How can you tell that the point (1.5, 42°) is **not** anomalous?

(1)

.....

.....

(iii) Suggest two reasons why the axes of the graph do not start from zero.

(2)

1 .....

.....

2 .....

.....

(Total for Question 1 = 14 marks)

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2 A student uses a semicircular glass block to investigate refraction in glass.

(a) List three other pieces of equipment that he needs for this investigation.

(3)

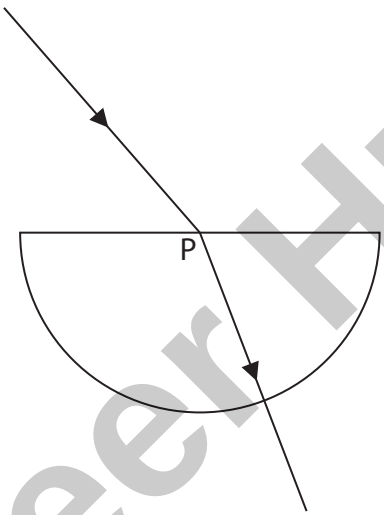
1 .....

2 .....

3 .....

(b) He shines a ray of light into the block at point P, as shown.

P is the middle of the flat surface.



(i) On the diagram, draw the normal at P.

(1)

(ii) Measure the angle of incidence and the angle of refraction.

(2)

angle of incidence .....

angle of refraction .....

(iii) Explain why the ray of light changes direction at P.

(2)

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(c) The student varies the angle of incidence and obtains this table of results.

Angle of incidence *i*	Angle of refraction *r*	sin *i*	sin *r*
11°	7°	0.19	0.12
24°	15°	0.41	0.26
47°	28°	0.73	0.47
65°	36°	0.91	0.59
90°	40°	1.00	0.64

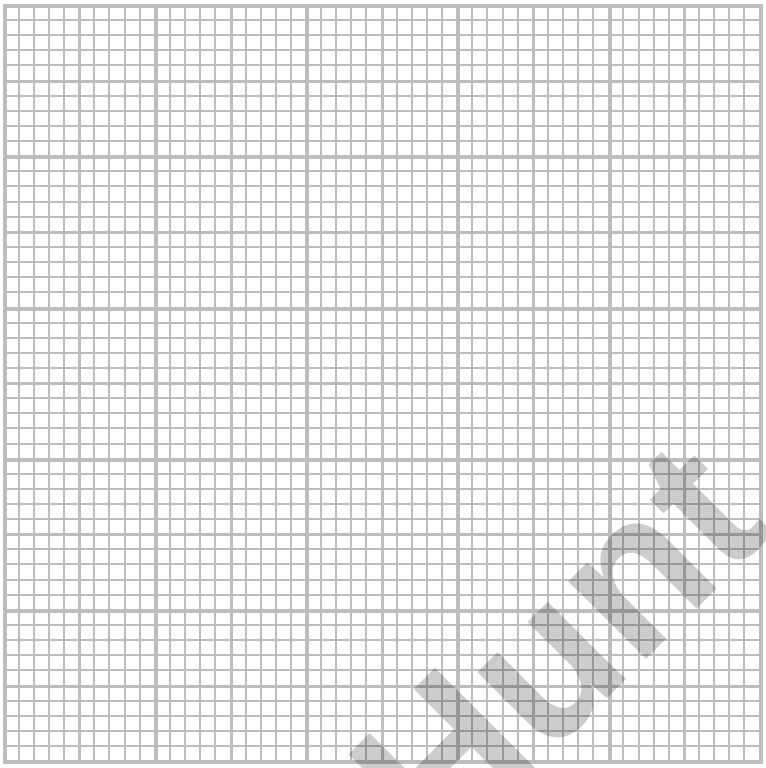
(i) Plot a graph of sin *i* against sin *r*.

(4)

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(ii) Draw the straight line of best fit.

(1)

(iii) State the relationship between refractive index, angle of incidence and angle of refraction.

(1)

(iv) Use your graph to find the refractive index of glass.

(2)

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refractive index = ...

(Total for Question 2 = 16 marks)

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3 A light ray can undergo total internal reflection.

(a) (i) What is meant by the term **total internal reflection**?

(2)

.....

.....

.....

.....

(ii) State two uses of total internal reflection.

(2)

1 .....

.....

.....

2 .....

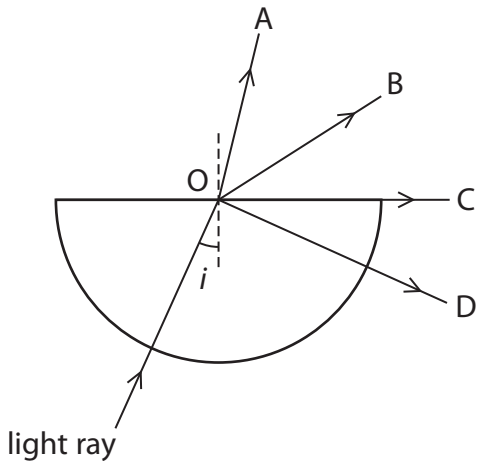
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(b) The diagram shows a light ray entering a glass block and travelling towards point O.



The angle *i* is 25°.

The critical angle of the glass is 42°.

(i) Which path does the ray take after reaching point O?

(1)

☒ **A** OA

☒ **B** OB

☒ **C** OC

☒ **D** OD

(ii) State the equation linking critical angle and refractive index.

(1)

(iii) Calculate the refractive index of the glass.

(2)

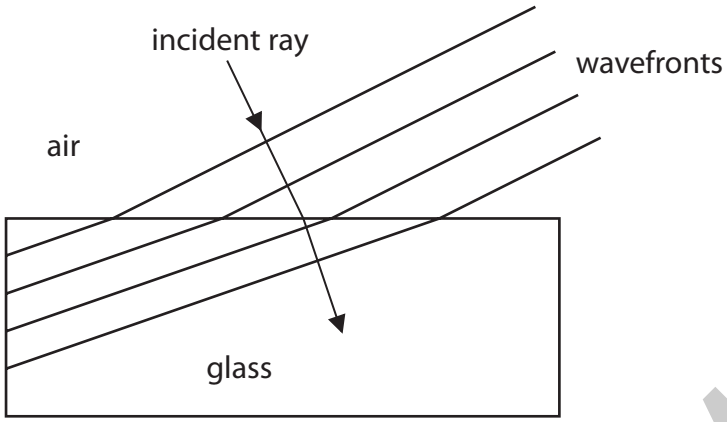
refractive index = ...

(Total for Question 3 = 8 marks)

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4 The diagram shows changes to light waves passing from air into glass.



(a) (i) The effect shown in the diagram is

(1)

- ☒ **A** diffraction
- ☒ **B** dispersion
- ☒ **C** reflection
- ☒ **D** refraction

(ii) State two ways in which the light waves change as they pass into the glass.

(2)

1 .....

2 .....

(b) (i) Draw the normal to the incident ray on the diagram.

(1)

(ii) Label the angle of incidence on the diagram.

(1)

(Total for Question 4 = 5 marks)

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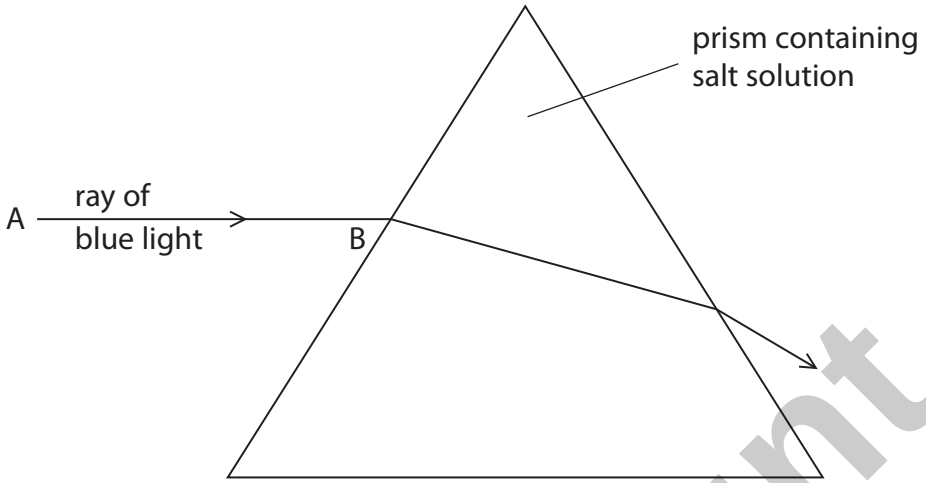
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5 (a) A student investigates refraction of light by using a salt solution in a hollow prism.

He shines a ray of blue light from A to B and traces the path of the ray through the prism.

The diagram shows the path of the ray of blue light.



(i) Explain what is meant by the term **refraction**.

(1)

.....

.....

.....

(ii) On the diagram, draw the normal at B and measure the angle of incidence.

(3)

angle of incidence = ...

(iii) The student then shines a ray of red light from A to B.

The refractive index of the salt solution is lower for red light than it is for blue light.

On the diagram, sketch a possible path for the red light through the solution and out of the prism.

(3)

(iv) Suggest what would happen to the path of the blue light if the student used a salt solution with a higher refractive index.

(2)

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(b) echnician working in a soft drinks factory uses refraction of light to measure sugar concentration in drinks.

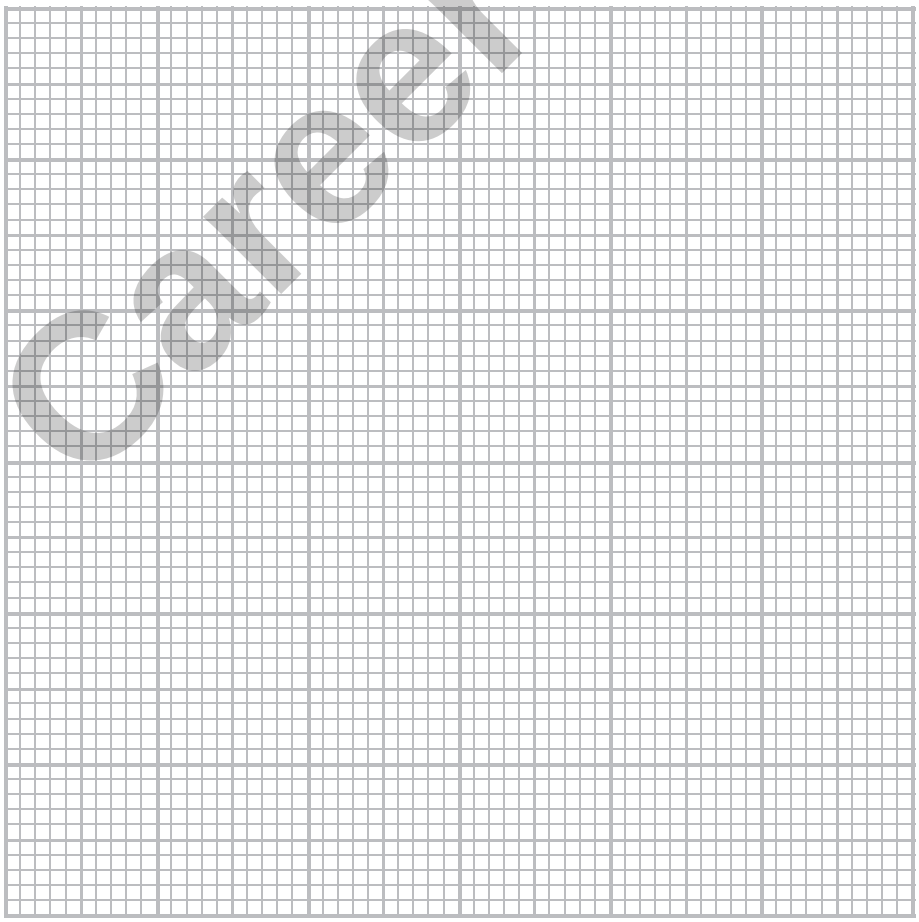
She takes readings using a refractometer. Different sugar concentrations give different scale readings on the refractometer.

The table shows her results.

Sugar concentration (%)	Refractometer reading
0	48
10	60
30	57
50	69
70	86
90	108

(i) Plot a graph of the refractometer reading against sugar concentration and draw the curve of best fit.

(5)



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(ii) Circle the anomalous point on your graph and suggest what the correct refractometer reading should be.

(2)

refractometer reading = ...

(iii) Use your graph to find the sugar concentration when the refractometer reading is 80.

(1)

sugar concentration = ... %

(iv) Describe the pattern shown by your graph.

(2)

.....

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(Total for Question 5 = 19 marks)

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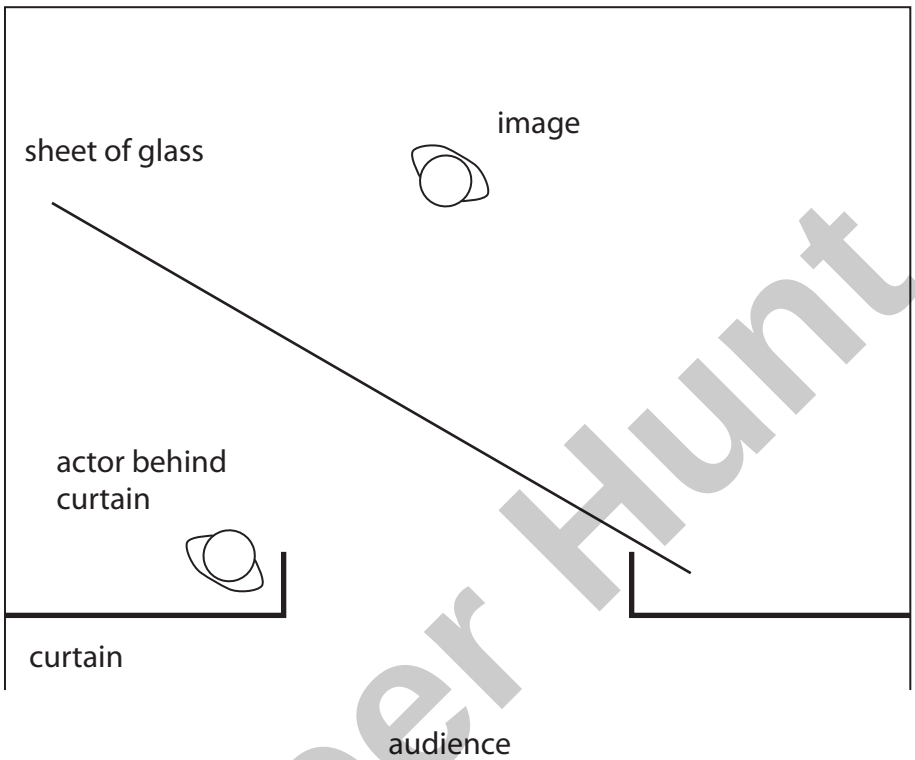
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6 Pepper's Ghost is a theatre effect used to make it appear that there is an image on stage.

The diagram shows a theatre viewed from above.

A sheet of glass is placed on the stage. A brightly lit actor stands behind a curtain at the side of the stage.

The audience sees the reflection of this actor in the glass.



(a) Add a ray diagram to show how light from the actor appears to come from the image.

(3)

(b) The image formed by the glass is a virtual image.

State what is meant by the term **virtual image**.

(1)

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(c) Light travels as a transverse wave.

Some waves travel as longitudinal waves.

(i) Give an example of a wave that travels as a longitudinal wave.

(1)

.....

(ii) Describe the difference between transverse waves and longitudinal waves.

You may draw diagrams to help your answer.

(3)

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7 Echo sounding is used to detect fish in the sea.

Sound waves are emitted from a fishing boat. Some of the sound waves are reflected by fish and detected back at the boat.

(a) The shortest time between the sound waves being emitted and detected is 0.26 s.

The speed of sound in water is 1.5 km/s.

Calculate the distance between the boat and the nearest fish.

(4)

distance = ... m

(b) Each sound wave is emitted for a very short time.

The reflected sound wave received at the boat lasts for a longer time.

Suggest a reason for this difference in time.

(2)

.....

.....

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8 This question is about the reflection of light.

(a) Light reflects from a plane mirror.

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

(1)

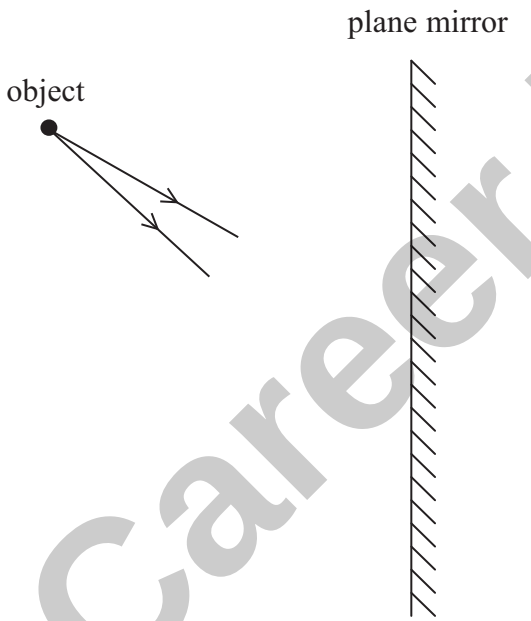
less than **eq** **to** **eater than**

When light reflects from the surface of a plane mirror, the angle of incidence is ..... the angle of reflection.

(ii) The diagram shows two rays of light coming from an object.

Continue the two rays and add further lines to the diagram to show how an image is formed by a plane mirror.

(2)



(iii) The image in a plane mirror is a **virtual image**.

How can you tell this from your diagram?

(1)

.....

.....

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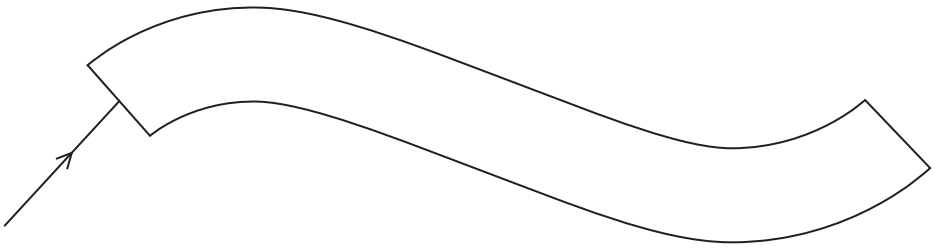
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(b) Light can also reflect along optical fibres by total internal reflection.

(i) Complete the diagram to show the path of the ray of light as it enters and passes through the optical fibre.

(2)



(ii) State **two** conditions required for total internal reflection to happen.

(2)

1 .....

.....

2 .....

.....

(iii) Telephone signals can be sent along optical fibres using light. In earlier systems the signals were sent using electric currents in copper wires.

Suggest **one** advantage of sending signals using optical fibres.

(1)

.....

.....

.....

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9 A student is investigating refraction of light.

(a) What is **refraction**?

(1)

.....

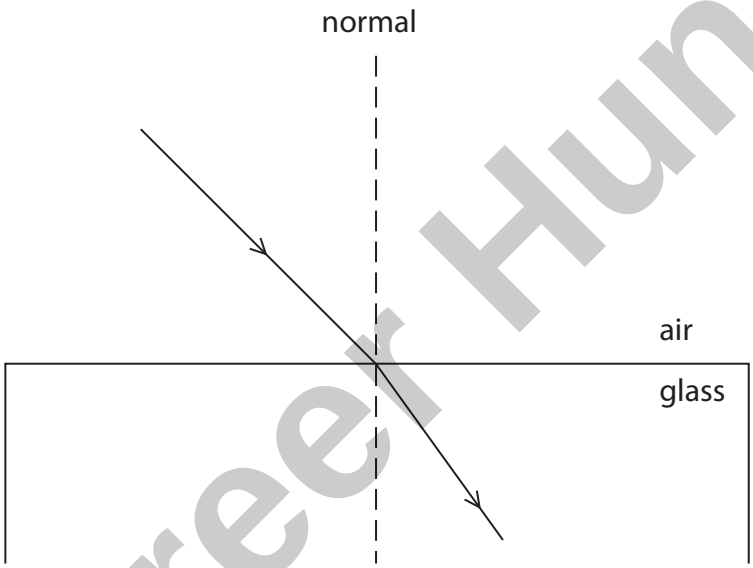
.....

.....

(b) The diagram shows a ray of light travelling from air to glass.

Add labels to show the angle of incidence, *i*, and the angle of refraction, *r*.

(2)



(c) The student wants to find the refractive index of the glass.

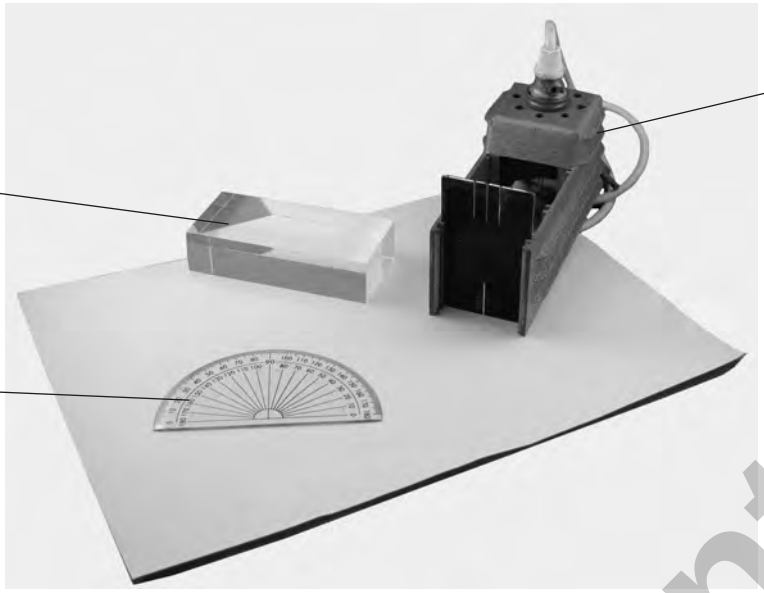
(i) State the equation linking refractive index, angle of incidence and angle of refraction.

(1)

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(ii) The photograph shows the apparatus the student has available.



Describe how the student should carry out the experiment.

You should include:

- what the student should measure
- how the measurements should be made
- how the student should use a graph to find the refractive index.

(6)

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10 A teacher and two students are measuring the speed of sound.



The teacher makes a loud sound by hitting two cymbals together.

Each student starts a stopwatch when they see the teacher hit the cymbals. They each stop their stopwatch when they hear the sound.

(a) Describe how a sound wave moves through the air.

(3)

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(b) The students repeat the experiment and record their readings in a table.

Student	Time in s
Andrew	0.44, 0.46, 0.44, 0.48, 0.43
Kefe	0.5, 0.6, 0.4, 0.4, 0.6

(i) State the precision of Andrew's readings.

(1)

.....

(ii) State the equation linking speed, distance travelled and time taken.

(1)

(iii) The teacher was standing 150 m from the students.

Use the experimental data recorded by each student to complete the table below.

Give your answers to an appropriate number of significant figures.

(3)

Student	Mean (average) time in s	Speed of sound in m/s
Andrew		
Kefe		

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(c) The students look in a data book and find that the speed of sound in air is given as 341 m/s.

The students discuss their results.



My experiment was more accurate because my answer was closest to 341 m/s.

No, you didn't allow for reaction time. My result is the best that you can get with this method.

No, reaction time didn't matter because I had to react twice and it cancelled out.



Andrew

Kefe

Evaluate these conclusions.

(5)

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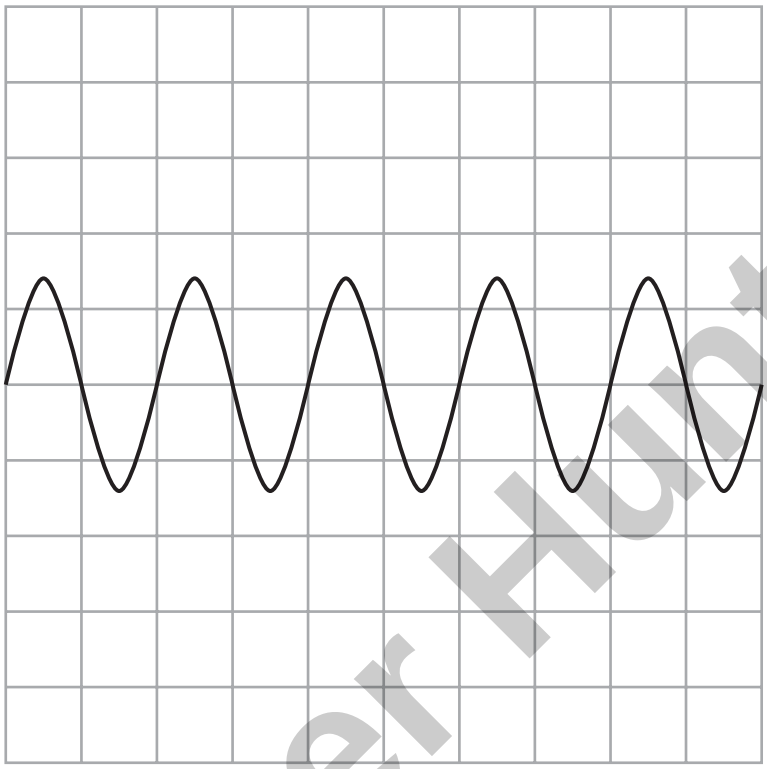
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11 Waves can travel on water, through air or in a vacuum.

(a) The diagram shows the side-view of a wave on the surface of water.

Each square on the grid represents 1 cm x 1 cm.



(i) State the wavelength of the wave shown.

(1)

wavelength = ... cm

(ii) On the grid sketch the trace of a wave travelling at the same speed, but with a larger amplitude and a lower frequency.

(2)

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(b) Two students investigate the speed of sound waves in air.

They use a stopwatch that shows times to the nearest 0.1 s.

They use an outdoor running track as their measure of distance.

The track is straight and 100 m long.

Describe what else they must do to obtain a value for the speed of sound.

(5)

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(c) (i) State the equation linking wave speed, frequency and wavelength.

(1)

(ii) The speed of radio waves is 300 000 000 m/s.

A radio wave has a frequency of 31 MHz.

Calculate the wavelength of this radio wave.

(3)

wavelength = ... m

(d) A sound wave and a radio wave have the same wavelength.

State why they have different frequencies.

(1)

.....

.....

.....

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12 The Astra satellite is in an orbit around the Earth.

(a) The satellite uses microwave signals for communication.

Microwaves are part of the electromagnetic spectrum.

(i) Which part of the electromagnetic spectrum has longer wavelengths than microwaves?

(1)

- ☒ **A** gamma rays
- ☒ **B** radio waves
- ☒ **C** ultraviolet light
- ☒ **D** visible light

(ii) Which of these statements is correct?

(1)

- ☒ **A** Microwaves always travel faster than radio waves.
- ☒ **B** Microwaves always travel slower than radio waves.
- ☒ **C** Microwaves and radio waves travel at the same speed in a vacuum.
- ☒ **D** Microwaves and radio waves travel at the same speed in all materials.

(iii) State one property of electromagnetic waves that makes microwaves suitable for communications with a satellite in space.

(1)

.....

.....

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(b) The Astra satellite takes 24 hours to orbit the Earth once.

It travels at a speed of 3.1 km/s.

Calculate the orbital radius of the satellite and give the unit.

(4)

orbital radius = ... unit .....

(c) The Astra satellite orbits above the equator and travels in the same direction as the rotation of the Earth.

Suggest why this type of 24-hour orbit is an advantage for communications.

(1)

.....

.....

.....

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13 A student is listening to a radio.



(a) The radio is powered by batteries that provide a direct current (d.c.).

What is **direct current**?

(1)

.....

(b) Radio waves are part of the electromagnetic spectrum.

(i) Suggest a property of radio waves that makes them suitable for use in communication.

(1)

.....

(ii) Complete the table to show uses and possible harmful effects of some other parts of the electromagnetic spectrum.

(4)

Part of electromagnetic spectrum	Use	Possible harmful effect on people
microwaves		
ultraviolet		

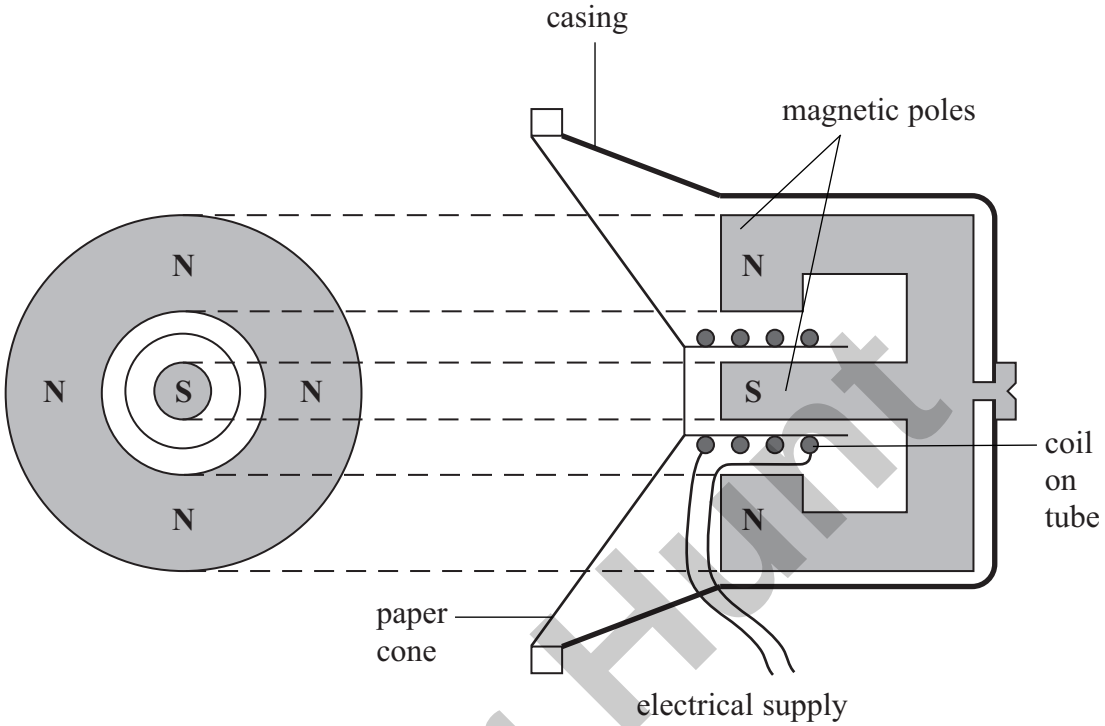
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(c) In the radio, sound is produced by a loudspeaker.

The diagram shows the construction of a loudspeaker.



Describe how a loudspeaker uses an electrical supply to produce sound waves.

(5)

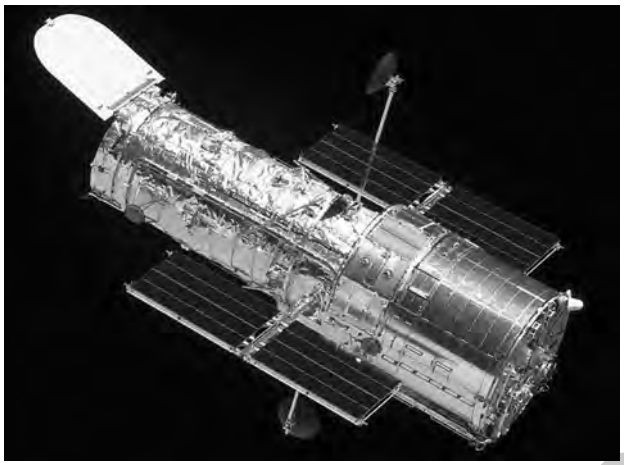
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14 The Hubble Space Telescope is in orbit around the Earth.

It detects visible light from distant objects.



(a) Name the force that keeps the telescope in orbit around the Earth.

(1)

.....

(b) The Hubble Space Telescope moves in a circular orbit.

Its distance above the Earth's surface is 560 km.

(i) The radius of the Earth is 6400 km.

Calculate the radius of the orbit of the Hubble Space Telescope.

(1)

Radius = ... km

(ii) The Hubble Space Telescope completes one orbit in 96 minutes.

Calculate its orbital speed in m/s.

(3)

Orbital speed = ... m/s

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(c) The Chandra Telescope also orbits the Earth, but does not move in a circular orbit.

Its distance from the Earth and its speed change as it orbits the Earth.

It travels fastest when it is closest to the Earth.

Use ideas about energy to explain why.

(3)

(d) The Chandra Telescope detects X-rays from distant objects.

(i) State the name of the type of wave that includes X-rays and visible light.

(1)

(ii) Describe **two** differences between X-rays and visible light.

(2)

1

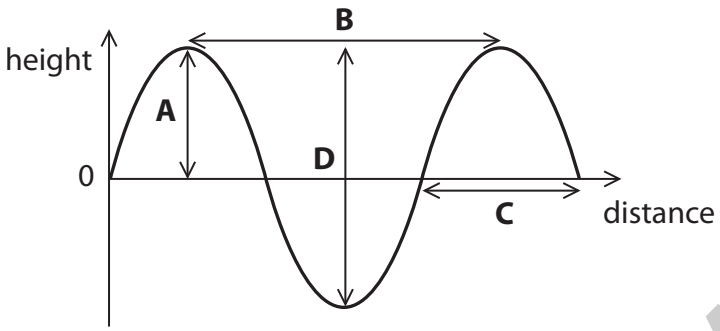
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15 The diagram shows part of a water wave.



(a) (i) Which letter represents the wavelength?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(ii) Which letter represents the amplitude?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(iii) This water wave is transverse. Other waves can be longitudinal.

State a similarity and a difference between a transverse wave and a longitudinal wave.

(2)

similarity .....

.....

difference .....

.....

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(b) A student writes some sentences about electromagnetic waves.

His teacher circles a mistake in each sentence.

In the table, write a suitable correction for each mistake.

The first one has been done for you.

(5)

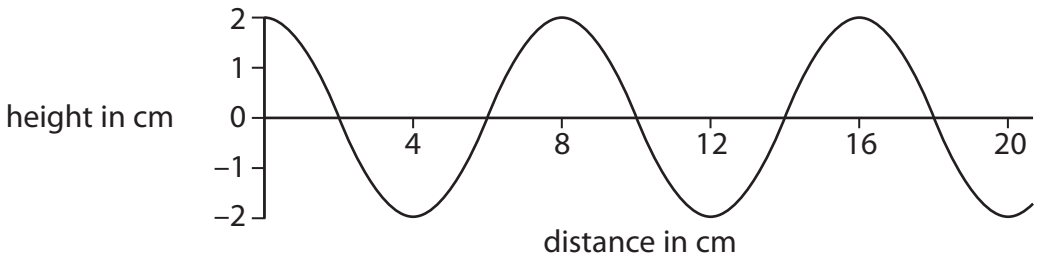
Sentence	Correction
Electromagnetic waves travel at $3 \times (10^2)$ m/s in a vacuum.	10^8
(Sound) waves are electromagnetic.	
(Infra-red) waves are the most harmful to people.	
(Gamma) waves are used for heating up food.	
(Radio) waves have the highest frequency.	
(Gamma) waves have a very long wavelength.	

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16 The diagram shows a water wave.



(a) (i) The amplitude of the wave is

(1)

- ☒ **A** 1 cm
- ☒ **B** 2 cm
- ☒ **C** 4 cm
- ☒ **D** 8 cm

(ii) The wavelength of the wave is

(1)

- ☒ **A** 2 cm
- ☒ **B** 4 cm
- ☒ **C** 8 cm
- ☒ **D** 20 cm

(b) Describe one difference between transverse and longitudinal waves.

Draw a labelled diagram to help your answer.

(3)

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(c) State two properties that are the same for all electromagnetic waves.

(2)

1 .....

2 .....

(d) Some types of wave are used in hospitals.

(i) A scanner uses one type of wave to check for broken bones.



The type of wave emitted by the scanner is

(1)

☒ **A** infrared

☒ **B** microwaves

☒ **C** sound

☒ **D** X rays

(ii) An image of the bone is seen because the waves from the scanner are

(1)

☒ **A** absorbed by the bone

☒ **B** reflected by the bone

☒ **C** refracted by the bone

☒ **D** transmitted by the bone

(iii) Name one type of wave that is used in cancer treatment and explain what it does during the treatment.

(2)

Type of wave .....

Explanation of what it does .....

.....

.....

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17 A student investigates how air vibrates in a plastic pipe.

She blocks one end of the pipe and blows across the other end.

The pipe emits a sound with a steady pitch.

The student uses a microphone to monitor the sound.

(a) Explain the meaning of the **pitch** of a sound.

(2)

.....

.....

.....

.....

(b) The student measures the length of the pipe and the frequency of the microphone signal for two different lengths of pipe.

(i) Name two instruments that she will need for these measurements.

(2)

1 .....

2 .....

(ii) Name the dependent and independent variables in her investigation.

(2)

dependent variable .....

independent variable .....

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(c) The student collects this data.

Length of pipe in m	Frequency of signal in Hz
2	42
1½	57

Suggest three ways to improve this investigation.

(3)

1 .....

.....

2 .....

.....

3 .....

.....

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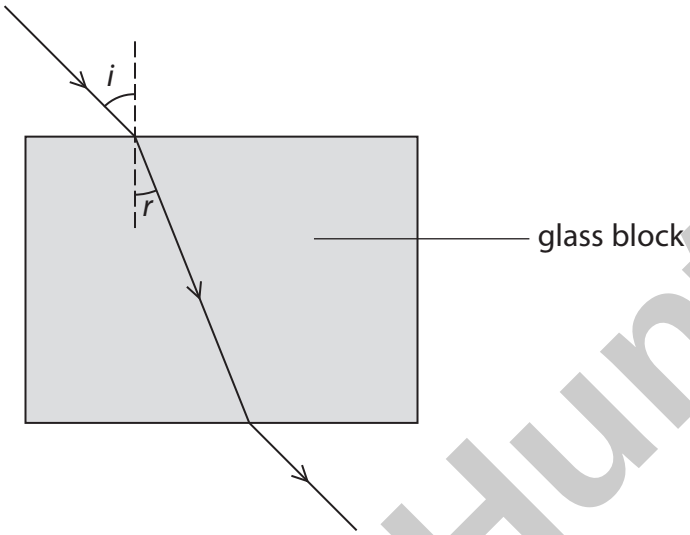
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18 A student investigates refraction using a glass block.

She wants to find the refractive index of the glass.

She sends rays of light into the block at different angles and measures the angle of incidence and the angle of refraction.



The table shows her results.

Angle of incidence, *i*	Angle of refraction, *r*	sin *i*	sin *r*
0°	0°	0.00	0.00
15°	10°	0.26	0.17
25°	16°	0.42	
35°	22°	0.57	
45°	28°	0.71	0.47

(a) (i) Complete the table by calculating the missing values of sin *r*.

(1)

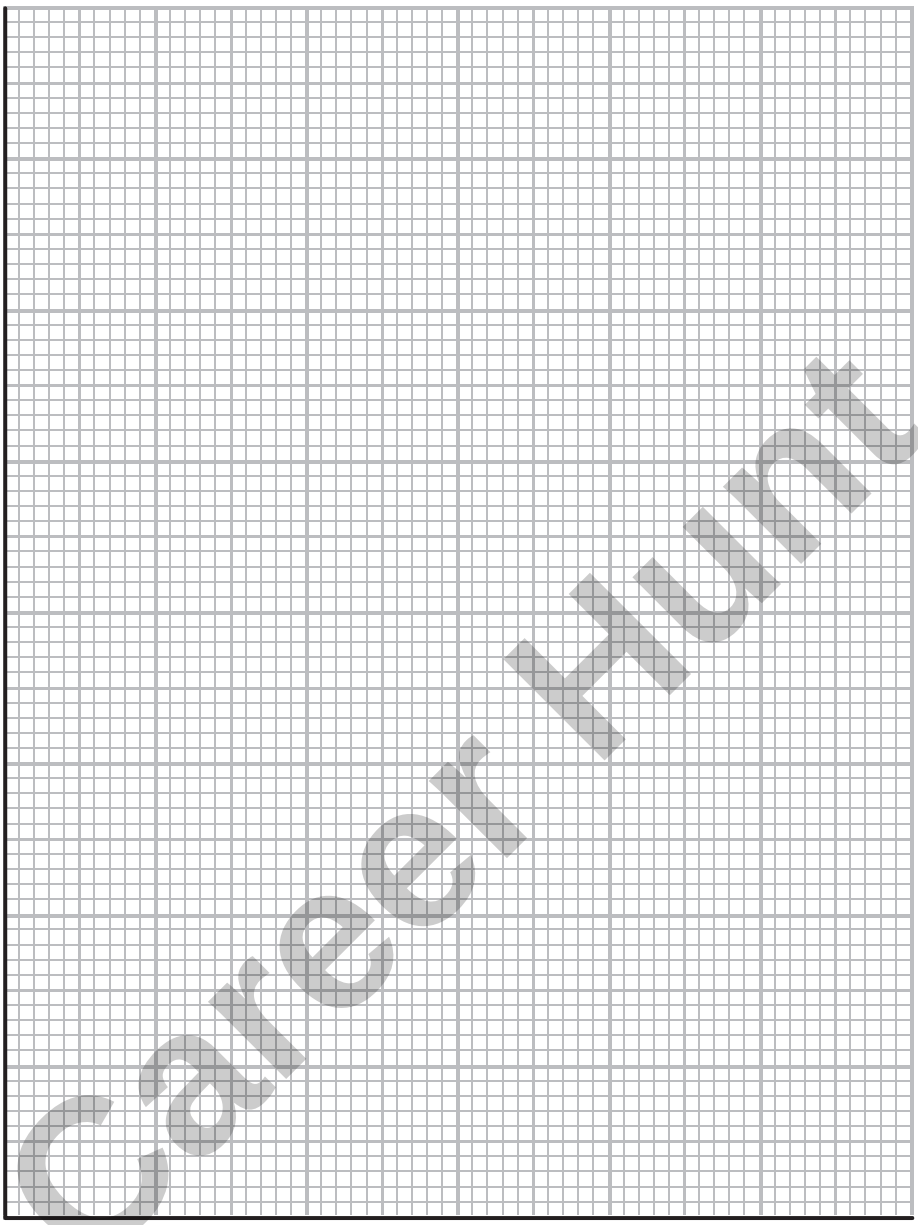
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(ii) Draw a graph of sin *i* (*y*-axis) against sin *r* (*x*-axis).

(5)



(iii) Use your graph to find the refractive index of the glass.

(2)

refractive index = ...

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(b) Suggest two reasons why using a graph to find the refractive index is a better method than simply calculating it using a pair of angles from the table.

(2)

1 .....

.....

2 .....

.....

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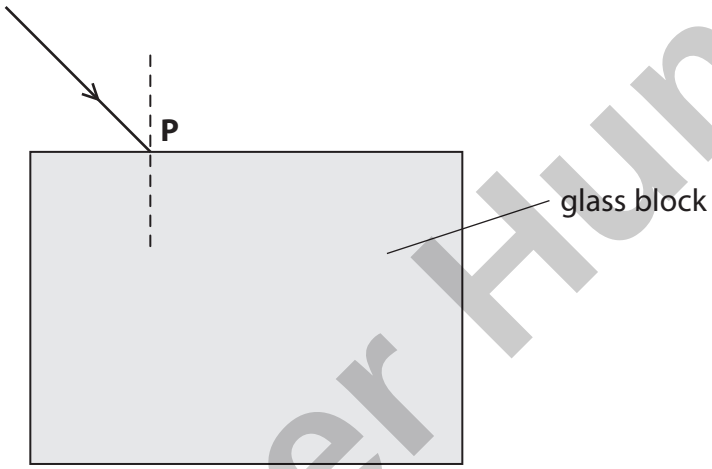
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19 A student uses a rectangular glass block to determine the refractive index of glass.

The diagram shows a ray of red light in air as it enters the glass block at **P**.

The normal at **P** is shown as a dotted line.



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(a) Complete the diagram by

- drawing the ray that continues inside the block
- labelling the angle of incidence (*i*) and the angle of refraction (*r*)
- drawing the ray that leaves the block.

(4)

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(b) The student measures values for the angle of incidence (*i*) and the angle of refraction (*r*).

i	60°
r	34°
sin *i*	
sin *r*	

(i) Complete the table by inserting values for sin *i* and sin *r*.

(1)

(ii) State the equation that links refractive index, angle of incidence (*i*) and angle of refraction (*r*).

(1)

(iii) Calculate the refractive index of the glass.

(2)

Refractive index = ...

(c) How should the student continue the investigation to obtain a more accurate value for the refractive index of glass?

(3)

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20 (a) A student wants to find the refractive index of a glass block.

(i) Draw a diagram to show how the student should set up the apparatus needed to find the refractive index of a glass block.

Label your diagram.

(2)

(ii) What measurements should the student take to find the refractive index of the glass block?

(2)

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(iii) Describe how the student should use these measurements to find the refractive index of the glass block.

(2)

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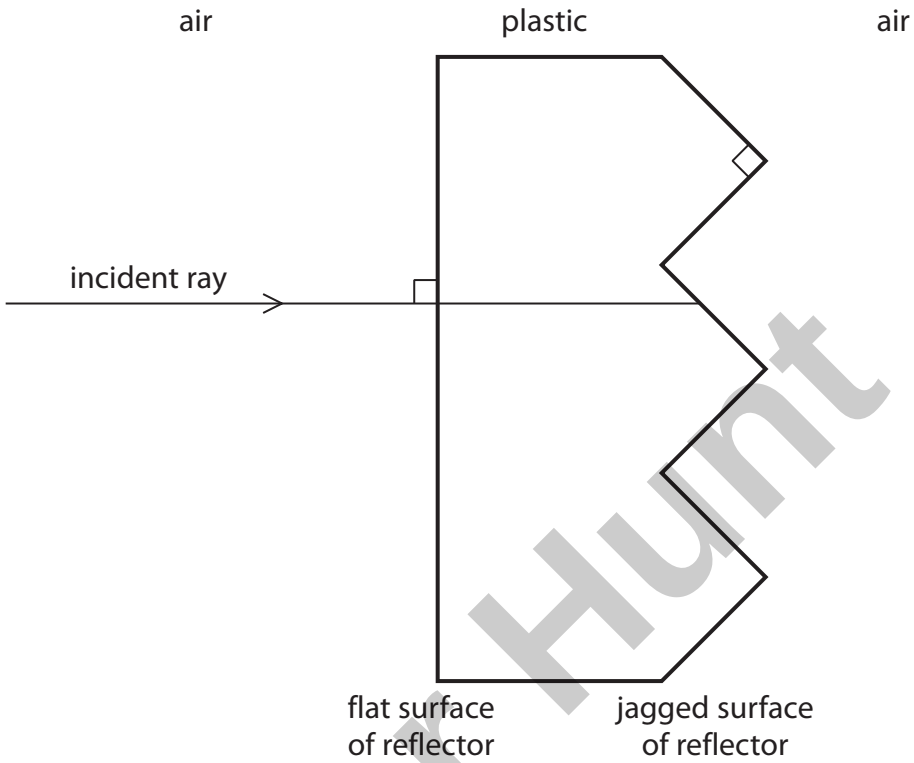
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(b) The diagram shows a section through a bicycle reflector.

A ray of light is incident on the flat surface of the reflector.



(i) The critical angle for the plastic of the reflector is less than 45°.

Continue the incident ray on the diagram to show the path of the ray until it emerges from the plastic.

(2)

(ii) What happens to the incident ray as it enters the plastic?

(1)

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.....

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21 The chart lists some electromagnetic radiations.

radio	microwave	infrared	visible light	ultraviolet	X-ray	gamma

(a) Complete the table by giving one radiation from the chart for each use.

You may give each type of radiation once, more than once or not at all.

(3)

Use for radiation	Type of radiation
cooking	
treating cancer	
identifying broken bones	

(b) All types of electromagnetic radiation from the Sun are emitted with

(1)

☒ **A** the same amplitude

☒ **B** the same frequency

☒ **C** the same speed

☒ **D** the same wavelength

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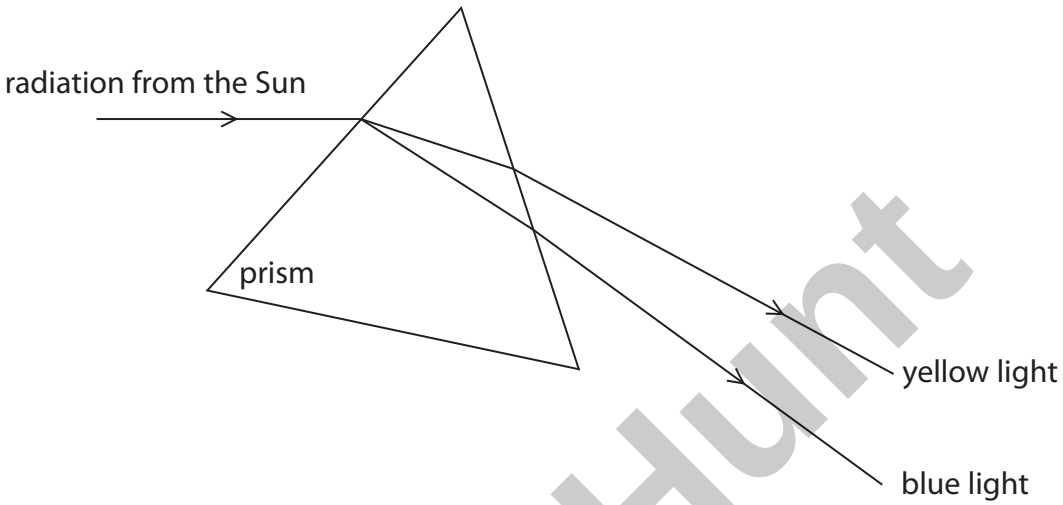
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(c) William Herschel was a scientist who investigated infrared radiation.

He passed electromagnetic radiation from the Sun through a triangular glass prism.

The prism refracted different radiations by different amounts.

The paths of yellow and blue visible light rays are shown in the diagram.



(i) Add to the diagram to show how the prism refracts an infrared ray.

(2)

(ii) William Herschel used a thermometer to detect infrared radiation.

He coloured the surface of his thermometer to make it more effective.

Which colour surface would work best?

(1)

☒ **A** black

☒ **B** red

☒ **C** silver

☒ **D** white

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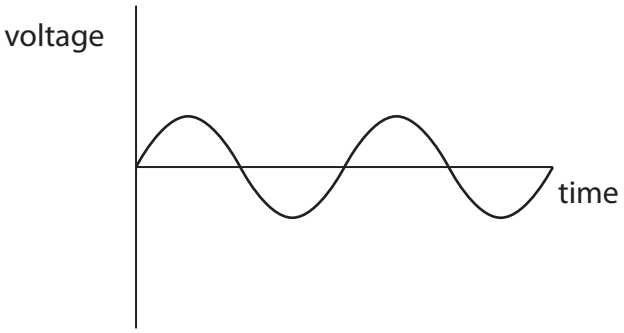
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22 (a) The graphs show oscilloscope traces produced by four different sounds. The oscilloscope settings are the same for each trace.

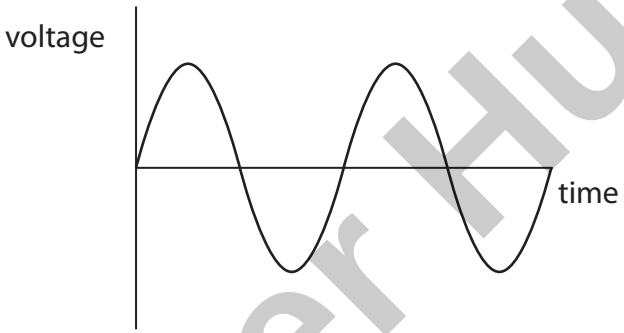
Which graph shows the trace for the loudest sound at the lowest frequency?

(1)

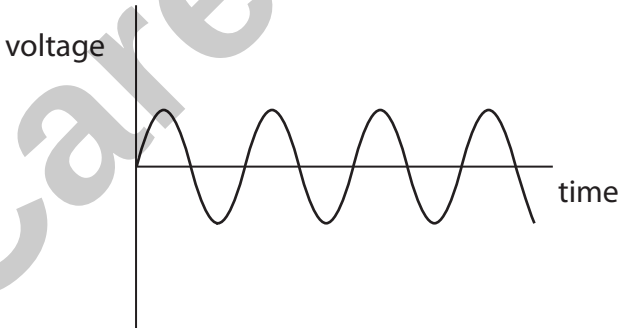
☒ **A**



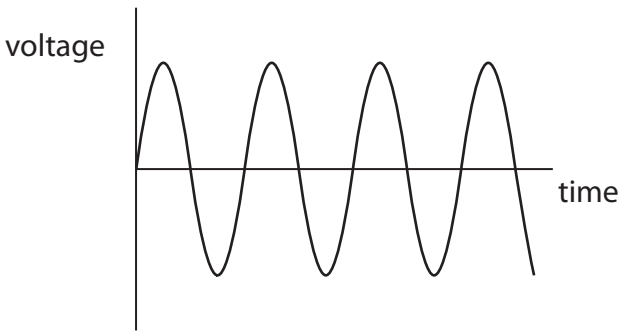
☒ **B**



☒ **C**



☒ **D**

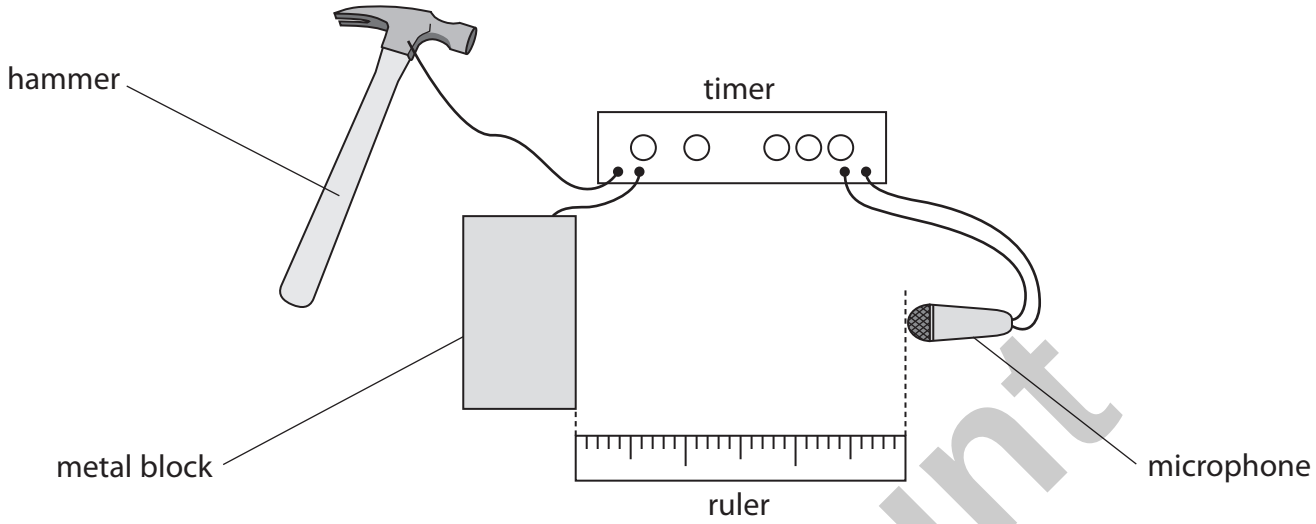


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(b) The diagram shows the equipment used by a student to measure the speed of sound in air.



The student measures the distance between the front of the metal block and the microphone.

She then uses this method to measure the time taken for sound to travel from the metal block to the microphone.

- start the timer by hitting the metal block with the hammer
- stop the timer when the sound produced reaches the microphone
- record the time taken for sound to reach the microphone in milliseconds

The student repeats the experiment six times, changing the distance between the metal block and the microphone for each experiment.

The table shows her results.

Distance in m	Time in ms
0.62	1.8
0.80	2.4
1.00	3.0
1.20	3.8
1.38	4.2

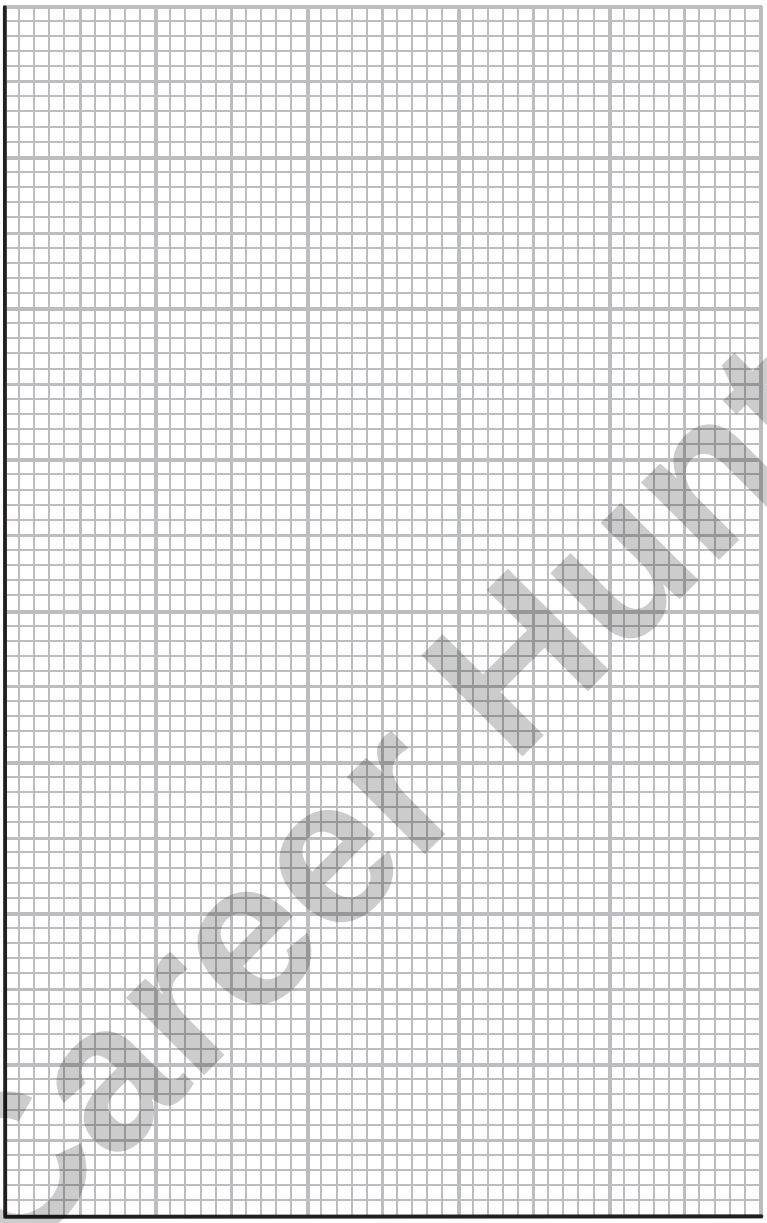
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(i) Use the student's results to plot a graph of distance against time and draw the straight line of best fit.

(5)



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(ii) Use your graph to find the speed of sound in air and give the unit.

(3)

speed = ... unit .....

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(iii) Suggest how the student could make this experiment valid (a fair test).

(1)

.....

.....

.....

(iv) Suggest two ways that the student could improve the quality of her data.

(2)

1 .....

.....

2 .....

.....

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23 Somewaves travel across the sea. They all have the same wavelength.

a) What is meant by the term wavelength?

(1)

.....

.....

(b) The waves travel across the sea at 3.0 m/s and have a frequency of 1.5 Hz.

(i) State the equation linking wave speed, frequency and wavelength.

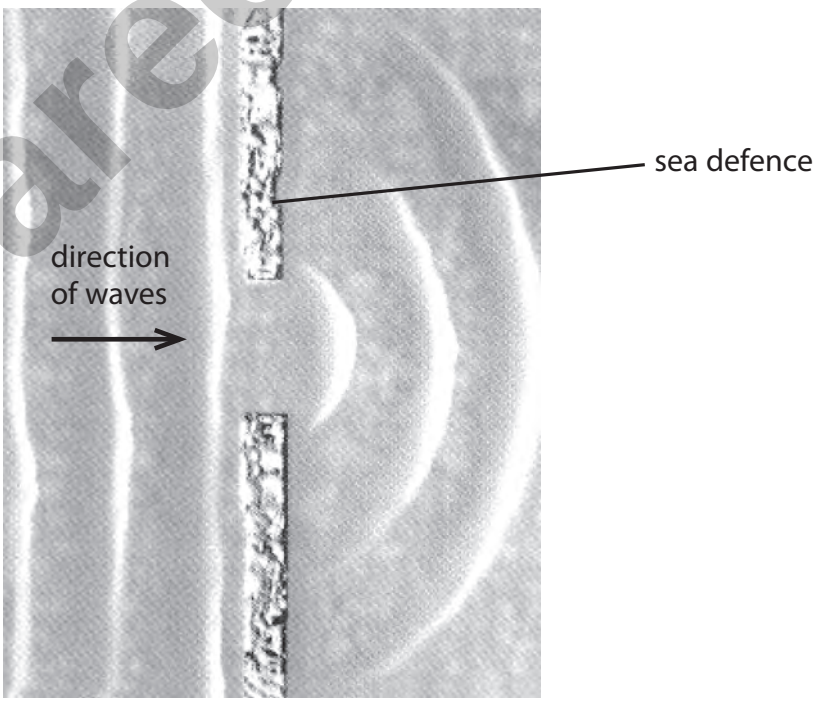
(1)

(ii) Calculate the wavelength of the waves.

wavelength ..... m

(2)

(c) This photograph was taken from an aeroplane. It shows a sea defence, with a gap in the sea wall.



Parallel waves pass through the sea defence at the gap in the sea wall, making the curved pattern shown in the photograph.

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(i) Explain how this wave pattern is produced.

(2)

(ii) Explain why light waves do not make a similar pattern as they pass through the same gap.

(2)

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24 A foghorn makes a loud, low-pitched warning sound when a ship is moving in fog.



(a) What is the relationship between the frequency of a sound wave and the pitch of the sound?

(1)

.....

.....

(b) The foghorn emits sound waves with a frequency of 160 Hz.

The speed of sound is 340 m/s.

(i) State the equation linking wave speed, frequency and wavelength.

(1)

(ii) Calculate the wavelength of these sound waves.

(2)

wavelength = ... m

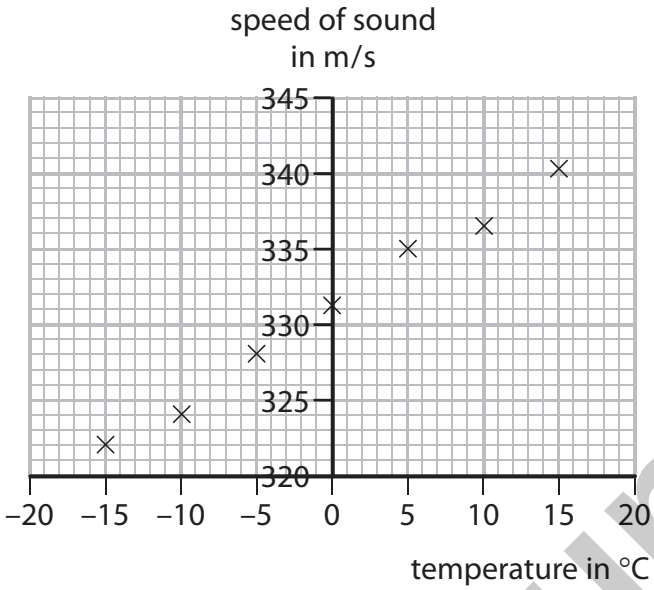
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(c) A student investigates how the speed of sound in air varies with temperature.

The student's results are shown on the graph.



(i) Draw a straight line of best fit on the graph.

(1)

(ii) Use the graph to find the speed of sound when the air temperature is 20 °C.

(2)

speed of sound = ... m/s

(d) The air temperature decreases while the foghorn continues to emit sound waves with a frequency of 160 Hz.

Explain how this decrease in temperature affects the wavelength of the sound waves.

(2)

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25 A remote control emits infrared waves to operate a television.



Source: www.lemon-digital.co.uk



©science.howstuffworks.com

(a) The television receives infrared waves and radio waves.

It emits light waves and sound waves.

Which type of wave has the highest frequency?

(1)

☒ **A** infrared

☒ **B** light

☒ **C** radio

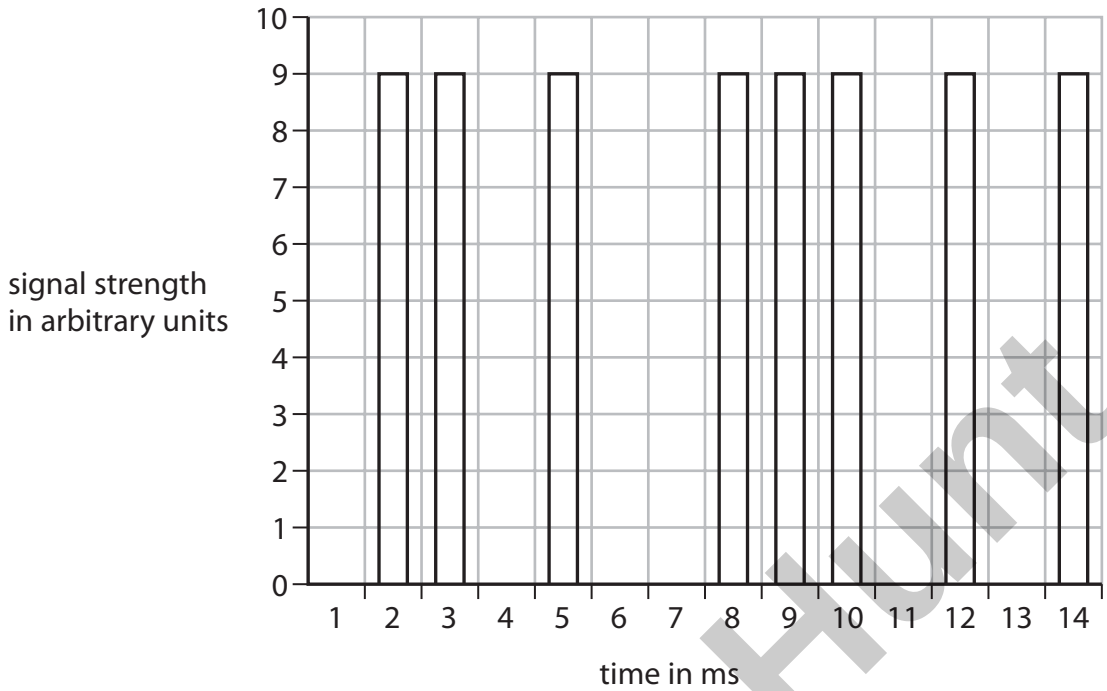
☒ **D** sound

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(b) The graph shows how the strength of the infrared signal from the remote control varies with time.



(i) Explain how the graph shows that the infrared signal is digital.

(1)

.....

.....

(ii) Suggest two ways that this signal could be made to carry more information.

(2)

1 .....

.....

2 .....

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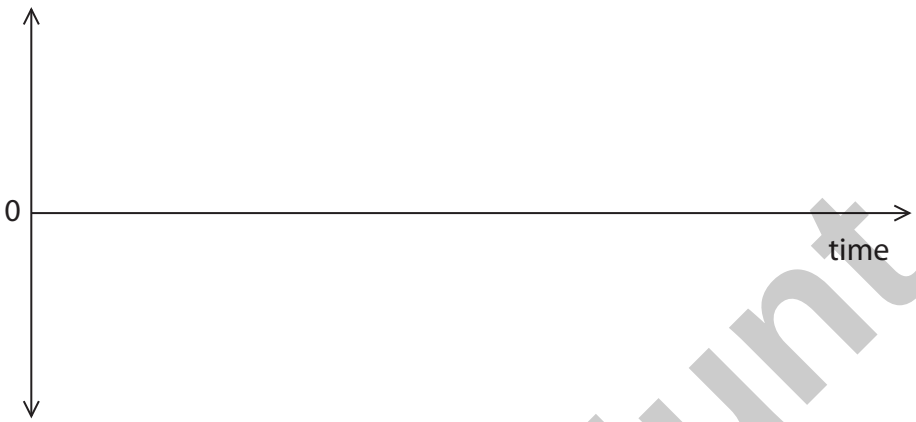
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26 Communicaton signals are often transmitted in digital form.

(a) Sketch a graph to show how a digital signal varies with time.

(2)



(b) Describe the advantages of using digital signals rather than analogue signals.

(2)

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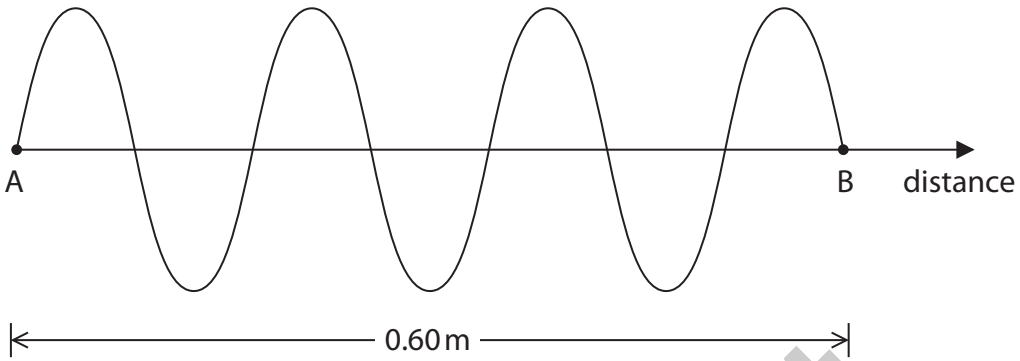
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27 (a) The diagram represents a microwave travelling in free space from point A to point B.



(i) The distance from A to B is 0.60 m.

Calculate the wavelength of this microwave.

(2)

wavelength = ... m

(ii) State the equation linking wave speed, frequency and wavelength.

(1)

(iii) Calculate the frequency of this microwave.
[speed of microwave in free space = 3.0×10^8 m/s]

(3)

frequency = ... Hz

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(b) The diagrams show what happens to radio waves and microwaves as they move past a hill.

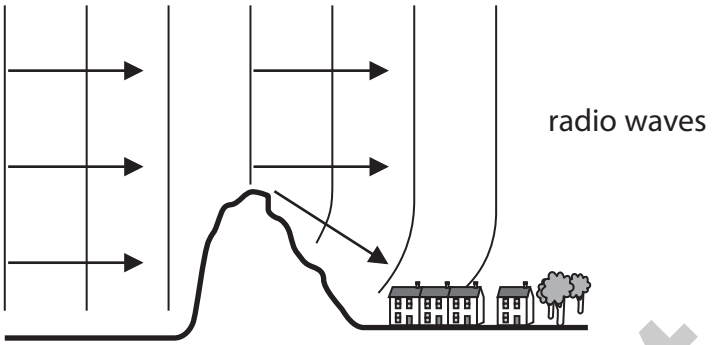


Diagram 1

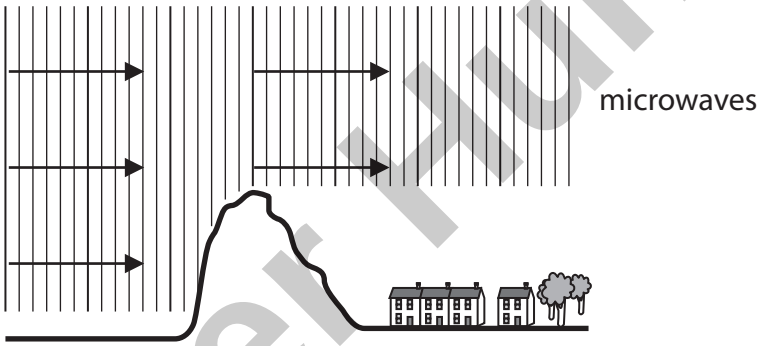


Diagram 2

(i) Name the effect shown by the radio waves in diagram 1.

(1)

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(ii) Suggest why this effect is not shown by the microwaves in diagram 2.

(2)

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28 A signal generator produces sounds from a loudspeaker.

(a) (i) Which property of the sound wave should be increased in order to make the sound louder?

(1)

- ☒ **A** amplitude
- ☒ **B** frequency
- ☒ **C** speed
- ☒ **D** wavelength

(ii) Which property of the sound wave should be increased in order to make a higher pitched sound?

(1)

- ☒ **A** amplitude
- ☒ **B** frequency
- ☒ **C** speed
- ☒ **D** wavelength

(b) Sound waves travel as longitudinal waves.

Other waves are transverse.

(i) Give an example of a transverse wave.

(1)

.....

(ii) Describe how the vibrations of longitudinal waves and transverse waves differ.

(2)

.....

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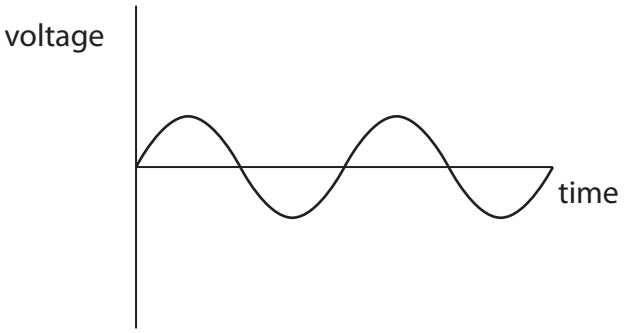
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29 (a) The graphs show oscilloscope traces produced by four different sounds. The oscilloscope settings are the same for each trace.

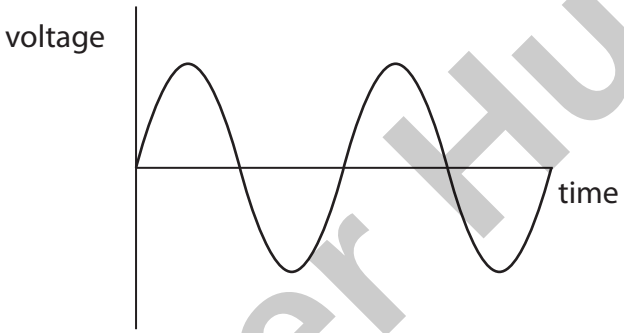
Which graph shows the trace for the loudest sound at the lowest frequency?

(1)

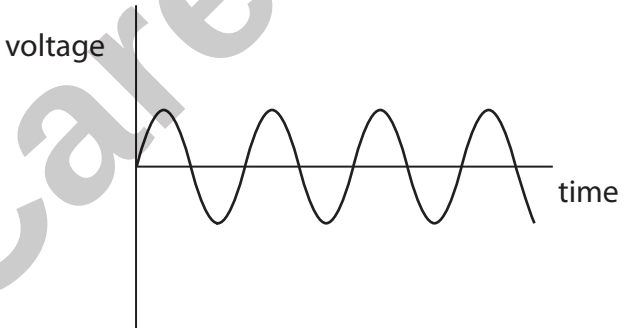
☒ **A**



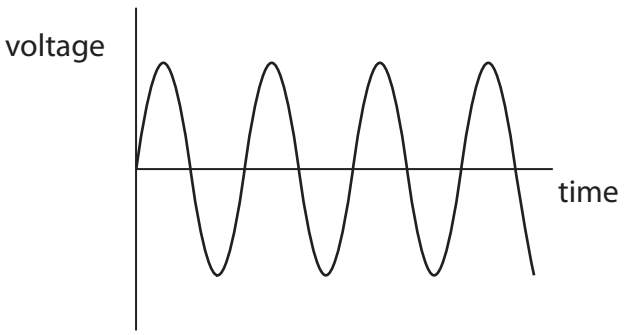
☒ **B**



☒ **C**



☒ **D**

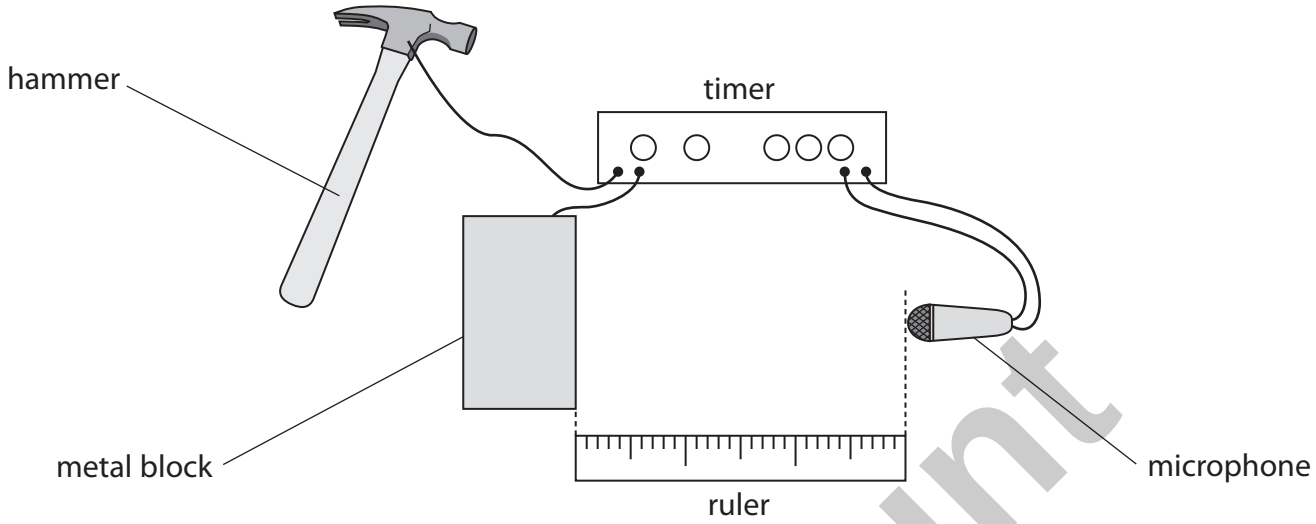


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(b) The diagram shows the equipment used by a student to measure the speed of sound in air.



The student measures the distance between the front of the metal block and the microphone.

She then uses this method to measure the time taken for sound to travel from the metal block to the microphone.

- start the timer by hitting the metal block with the hammer
- stop the timer when the sound produced reaches the microphone
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The table shows her results.

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1.38	4.2

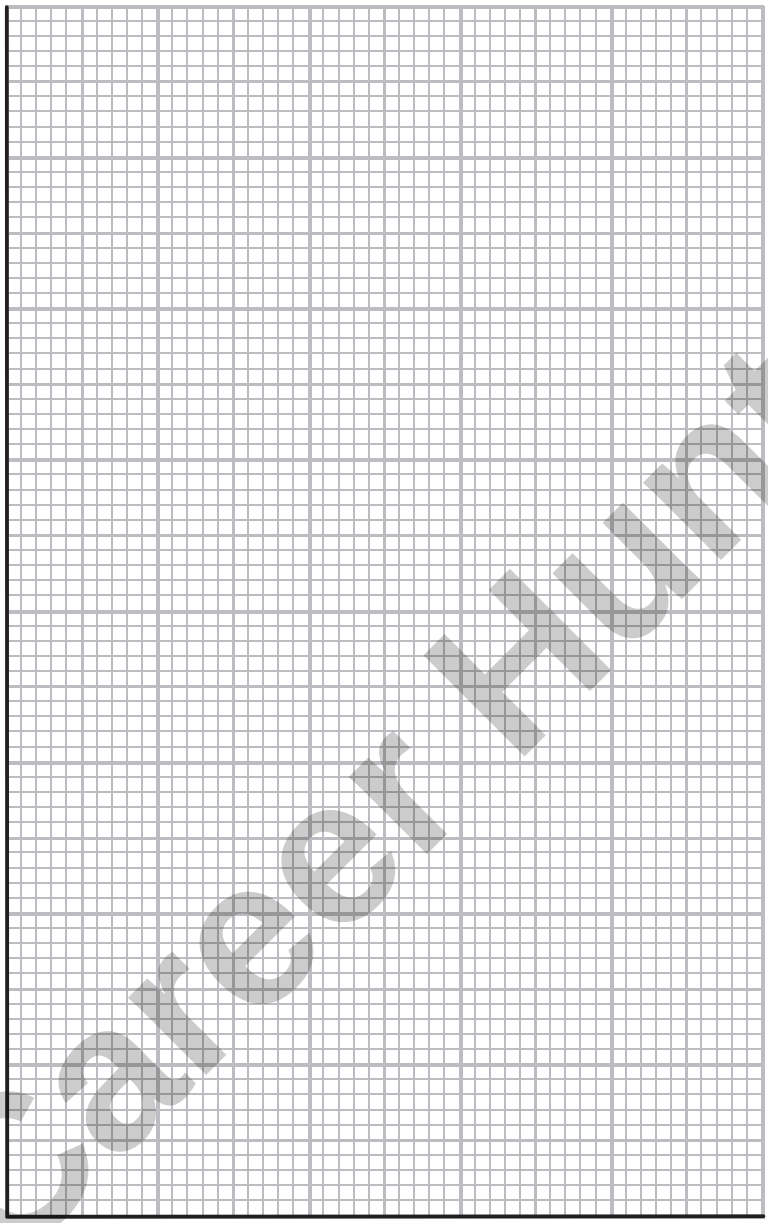
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(i) Use the student's results to plot a graph of distance against time and draw the straight line of best fit.

(5)



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(ii) Use your graph to find the speed of sound in air and give the unit.

(3)

speed = ... unit .....

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(iii) Suggest how the student could make this experiment valid (a fair test).

(1)

.....

.....

.....

(iv) Suggest two ways that the student could improve the quality of her data.

(2)

1 .....

.....

2 .....

.....

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30 Somewaves travel across the sea. They all have the same wavelength.

a) What is meant by the term wavelength?

(1)

.....

.....

(b) The waves travel across the sea at 3.0 m/s and have a frequency of 1.5 Hz.

(i) State the equation linking wave speed, frequency and wavelength.

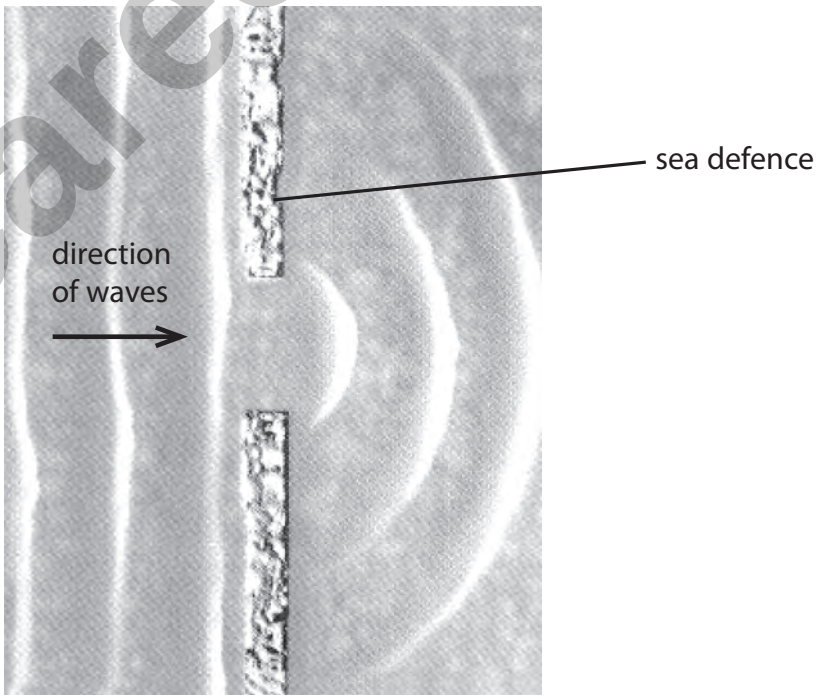
(1)

(ii) Calculate the wavelength of the waves.

wavelength ..... m

(2)

(c) This photograph was taken from an aeroplane. It shows a sea defence, with a gap in the sea wall.



Parallel waves pass through the sea defence at the gap in the sea wall, making the curved pattern shown in the photograph.

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(i) Explain how this wave pattern is produced.

(2)

(ii) Explain why light waves do not make a similar pattern as they pass through the same gap.

(2)

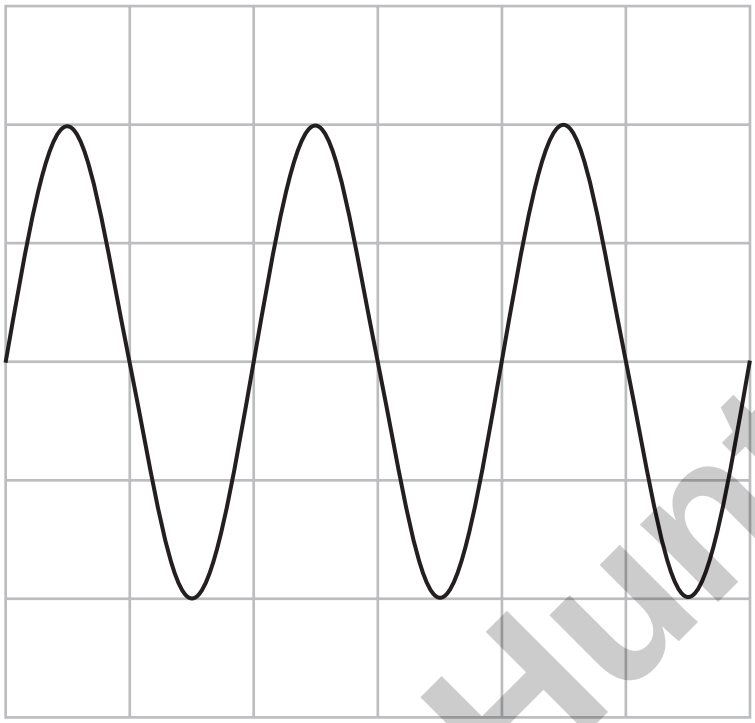
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31 A microphone is connected to an oscilloscope to display a sound wave.

The diagram shows the trace on the oscilloscope screen.



The oscilloscope settings are:

Y direction: 1 square = 1 V

X direction: 1 square = 0.001 s

(a) (i) How many time periods are shown on the trace?

(1)

.....

(ii) What is the frequency of the sound wave?

(2)

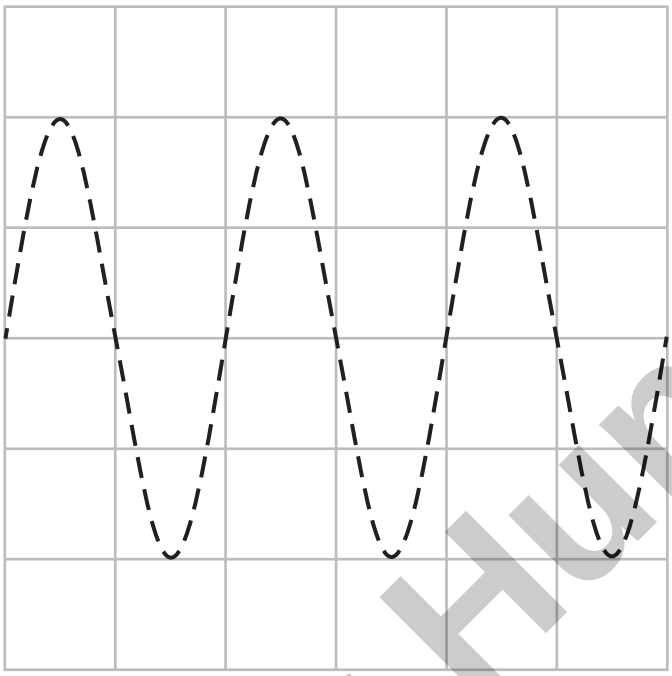
Frequency = ... Hz

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(b) On the grid below, sketch the trace of a sound wave with a smaller amplitude and a higher frequency than the wave shown by the dotted line.

(2)



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32 A foghorn makes a loud, low-pitched warning sound when a ship is moving in fog.



(a) What is the relationship between the frequency of a sound wave and the pitch of the sound?

(1)

.....

.....

(b) The foghorn emits sound waves with a frequency of 160 Hz.

The speed of sound is 340 m/s.

(i) State the equation linking wave speed, frequency and wavelength.

(1)

(ii) Calculate the wavelength of these sound waves.

(2)

wavelength = ... m

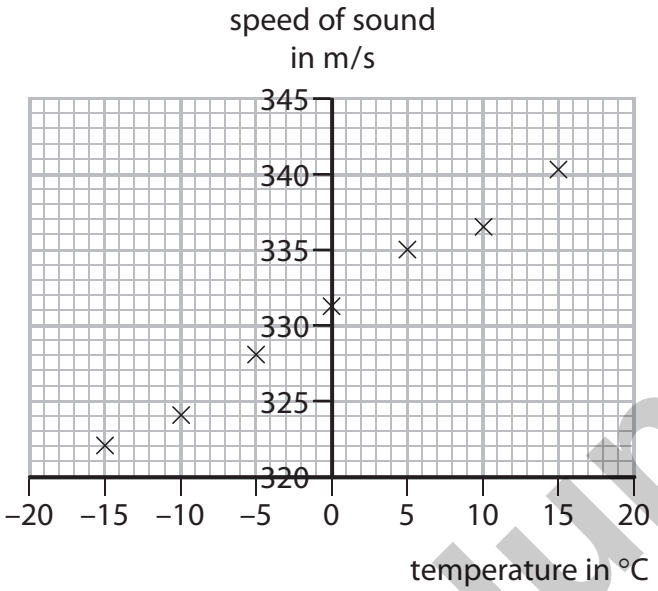
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(c) A student investigates how the speed of sound in air varies with temperature.

The student's results are shown on the graph.



(i) Draw a straight line of best fit on the graph.

(1)

(ii) Use the graph to find the speed of sound when the air temperature is 20 °C.

(2)

speed of sound = ... m/s

(d) The air temperature decreases while the foghorn continues to emit sound waves with a frequency of 160 Hz.

Explain how this decrease in temperature affects the wavelength of the sound waves.

(2)

.....

.....

.....

.....

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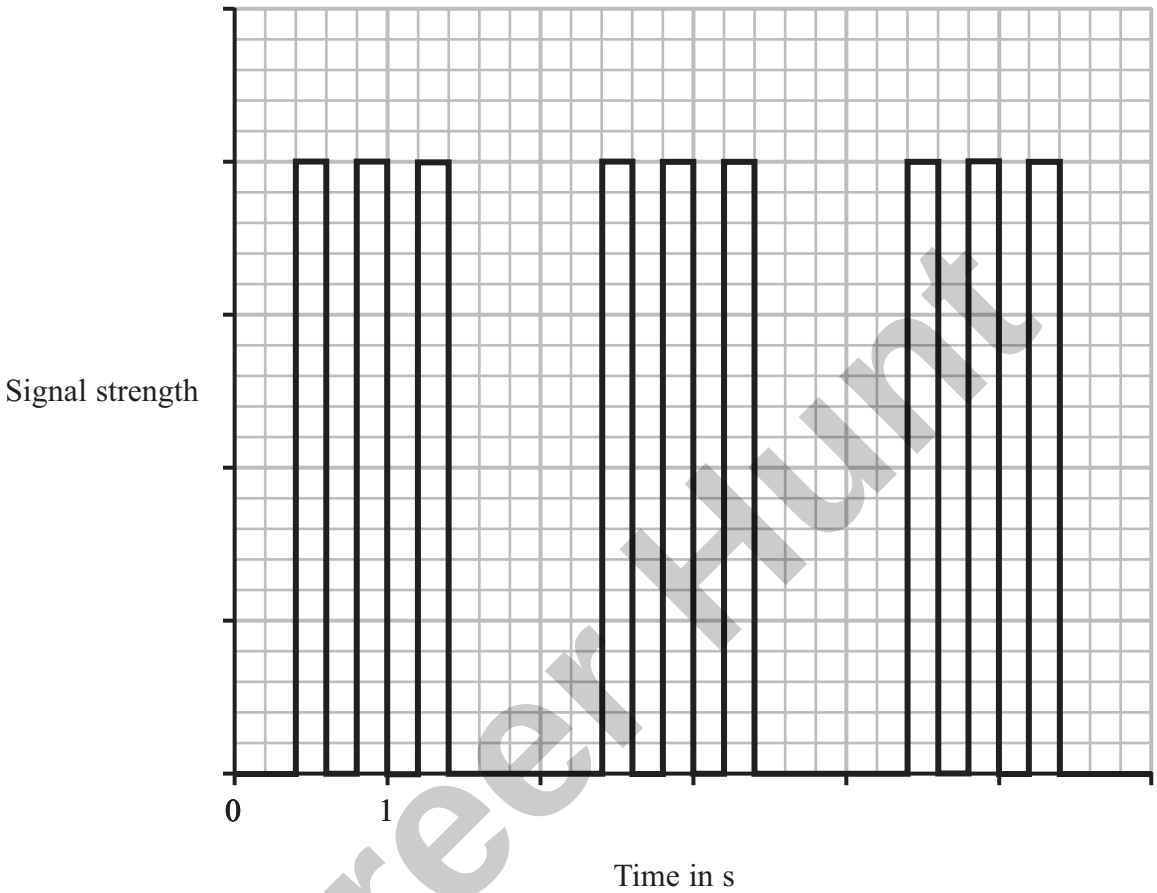
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33 In 1901, Marconi received the first radio signal across the Atlantic Ocean.

The signal was the letter S in Morse code (three 'dots') sent over and over again.

Each letter S was produced by quickly turning an electric spark on and off three times.

The graph shows how the strength of the signal changed with time.



(a) (i) The graph shows a digital signal.

Explain what is meant by a digital signal.

(2)

.....

.....

.....

.....

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(ii) Suggest **two** ways that this signal could be made to carry more information.

(2)

1 .....

.....

2 .....

.....

(b) The frequency of Marconi's radio wave was 820 kHz and the wavelength was 366 m.

(i) State the equation linking wave speed, frequency and wavelength for radio waves.

(1)

(ii) Calculate the speed of the radio waves Marconi received.

(2)

Speed of radio waves ..... m/s

(c) Some people do not believe that Marconi received 820 kHz radio waves.

They think that the frequency was really twice as much: 1640 kHz.

If these people are correct, what wavelength radio waves did Marconi receive?

(1)

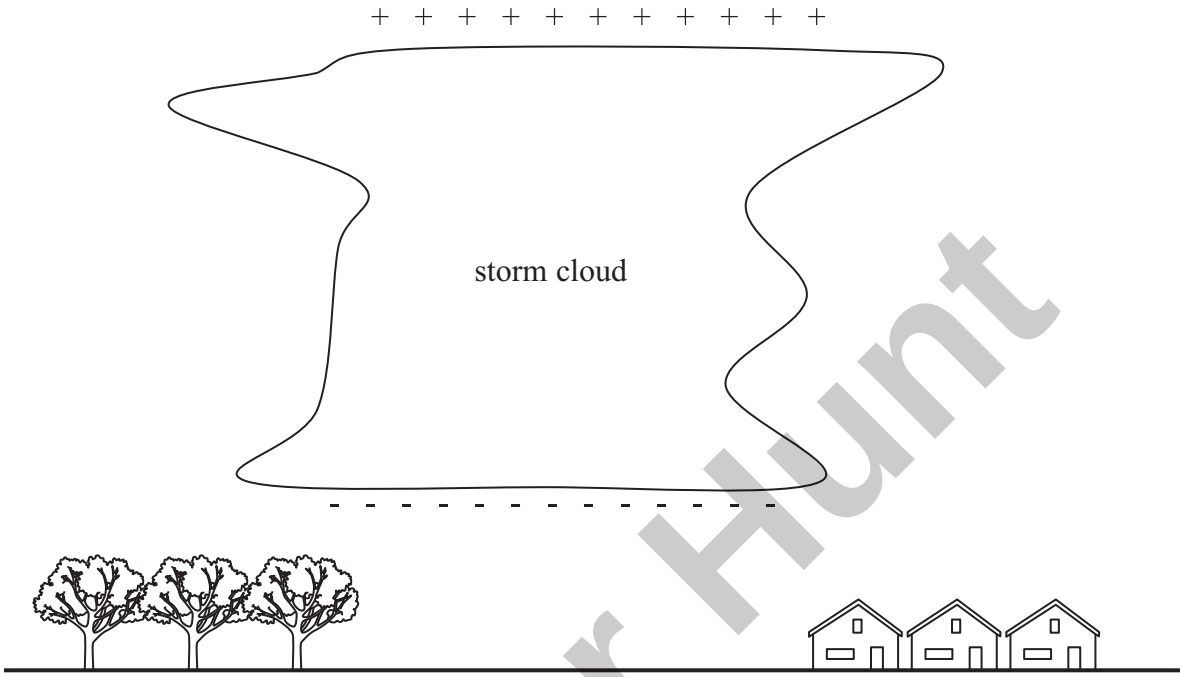
Wavelength ..... m

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(d) Other people do not think Marconi received a radio signal across the Atlantic Ocean at all.

They think the radio waves he received were really caused by electrostatic discharges from storm clouds.



Explain what happens when a storm cloud discharges.

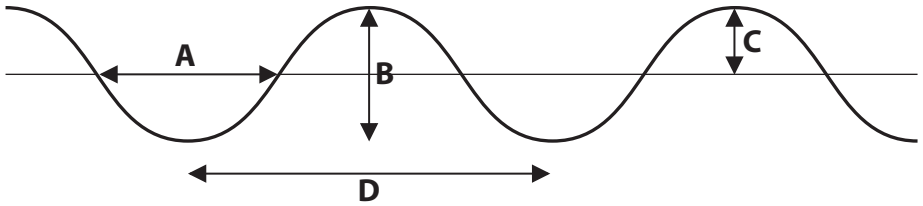
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34 The diagram shows a wave on the sea.



(a) (i) Which letter shows the wavelength of the wave?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(ii) Which letter shows the amplitude of the wave?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b) A man watches some waves pass his boat.

He sees the crest of the waves pass him every 5 s.

Calculate the frequency of these waves.

(2)

Frequency = ... Hz

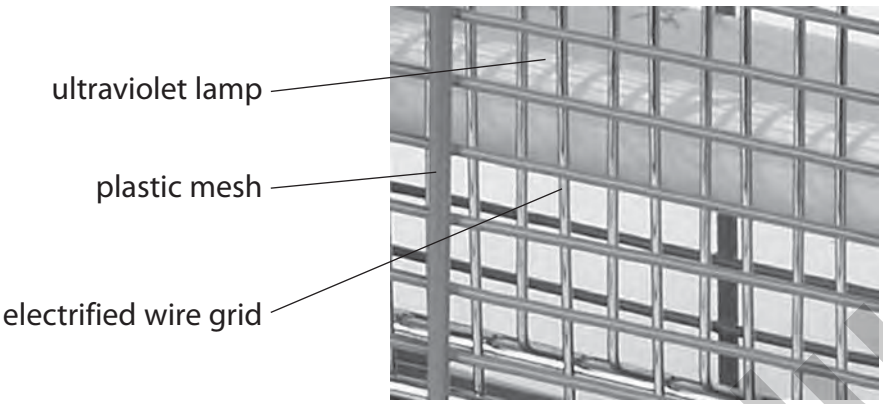
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35 Many food shops have devices that attract and kill flying insects.

The devices consist of

- an ultraviolet lamp
- a plastic mesh on the outside
- an electrified wire grid below the plastic mesh
- a transformer that is connected to the wire grid



(a) The ultraviolet lamp attracts many flying insects towards the device.

Ultraviolet is an electromagnetic wave.

(i) State two properties of electromagnetic waves.

(2)

1 .....

.....

2 .....

.....

(ii) Which of these electromagnetic radiations has a frequency greater than ultraviolet?

(1)

☒ **A** infrared

☒ **B** gamma rays

☒ **C** radio waves

☒ **D** visible light

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(b) The transformer supplies an output voltage of 2000 V a.c. to the wire grid.

The input voltage to the transformer is 230 V a.c.

(i) Give the name of this type of transformer.

(1)

.....

(ii) State the relationship between input (primary) voltage, output (secondary) voltage, primary turns and secondary turns.

(1)

(iii) There are 110 turns on the primary coil.

Calculate the number of turns on the secondary coil.

(3)

number of turns .....

(iv) Suggest a reason why there is a plastic mesh on the outside of the device.

(1)

.....

.....

.....

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36 The chart lists some electromagnetic radiations.

radio	microwave	infrared	visible light	ultraviolet	X-ray	gamma

(a) Complete the table by giving one radiation from the chart for each use.

You may give each type of radiation once, more than once or not at all.

(3)

Use for radiation	Type of radiation
cooking	
treating cancer	
identifying broken bones	

(b) All types of electromagnetic radiation from the Sun are emitted with

(1)

☒ **A** the same amplitude

☒ **B** the same frequency

☒ **C** the same speed

☒ **D** the same wavelength

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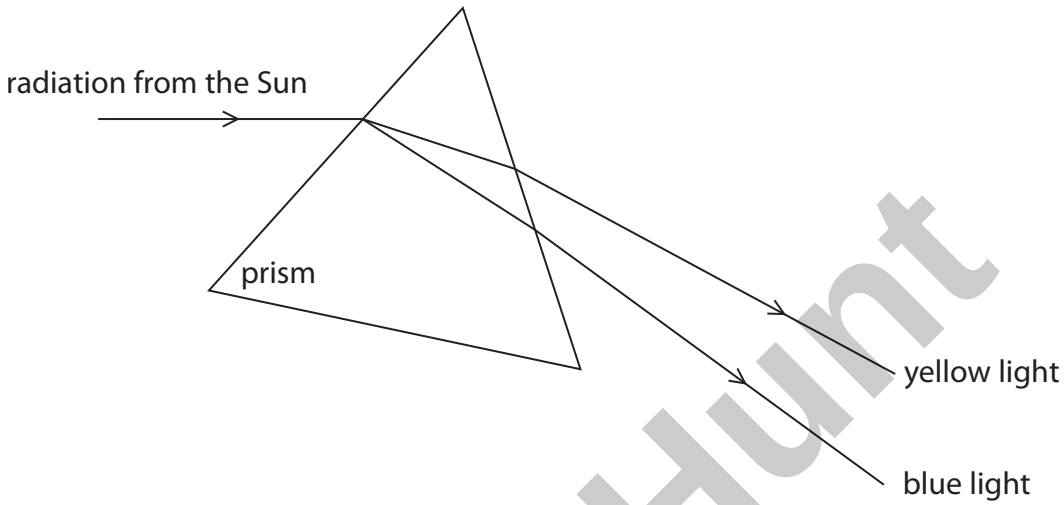
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(c) William Herschel was a scientist who investigated infrared radiation.

He passed electromagnetic radiation from the Sun through a triangular glass prism.

The prism refracted different radiations by different amounts.

The paths of yellow and blue visible light rays are shown in the diagram.



(i) Add to the diagram to show how the prism refracts an infrared ray.

(2)

(ii) William Herschel used a thermometer to detect infrared radiation.

He coloured the surface of his thermometer to make it more effective.

Which colour surface would work best?

(1)

☒ **A** black

☒ **B** red

☒ **C** silver

☒ **D** white

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37 A pulsar is a type of star.

We receive radiation from a pulsar in regular short bursts called pulses.

(a) Some pulsars emit radio waves. Other pulsars emit x-rays.

(i) State a property of waves that is the same for radio waves and x-rays.

(1)

.....

.....

(ii) State two properties of waves that are different for radio waves and x-rays.

(2)

1 .....

.....

2 .....

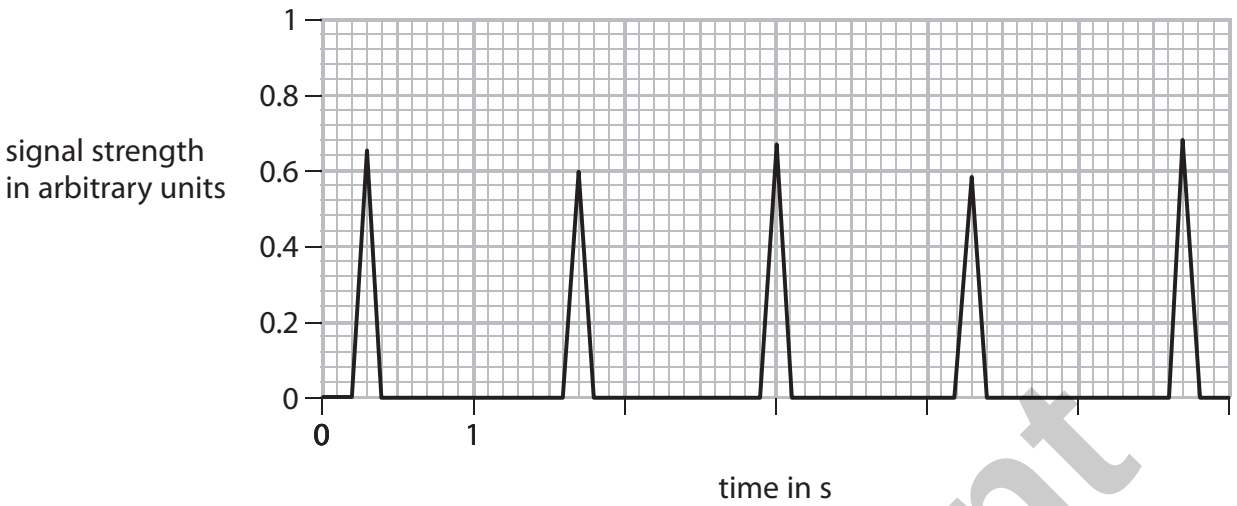
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(b) The graph shows five pulses of the signal from a pulsar.



(i) Explain how the graph shows that the signal is not digital.

(2)

.....

.....

.....

.....

(ii) Use the graph to estimate the average time between each pulse.

(2)

time = ... s

(iii) Calculate the frequency of the pulses in the signal.

Give the unit.

(2)

frequency = ... unit .....

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Chapter 3: Wave
Answer

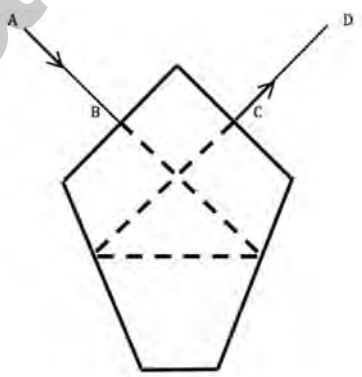
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Question number	Answer	Notes	Mar
1 (a)	3 or more correct lines = 2 marks Any two correct lines = 1 mark		

Notes about the total internal reflection of light	Right or wrong
the angle of incidence equals the angle of reflection	✓
light changes speed when it is internally reflected	×
every ray entering the semicircular glass block is reflected by total internal reflection	×
if i = 0 then the ray does not deviate	✓
the refractive index of glass is bigger than the refractive index of air	✓

(b)	MP1 only **two** internal reflections attempted; MP2 horizontal line from first TIR to second TIR; MP3 ray does not deviate on exit;  	horizontal line by eye ignore arrows	3

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Question number			Answer	Notes	Marks
1	(c)	(i)	Statement of sin c = 1/n; Substitution; Calculation; e.g. sin c = 1/n ……..worth 1 sin c = 1/1.5……..worth 2 (= 0.667) so c = 41.8º …….worth 3	 Value of c (or n) to at least 3 s.f. Allow reverse argument for max 2. Sin 42º = 0.669, giving n = 1.49 (“about 1.5”) Sin 42 x 1.5 =1.0036 ≈1 (sin 42 =1/1.5) Beware spurious maths that gives about 42 degrees	3
		(ii)	Any two of the following ideas:- • RI = sin i /sin r • RI(n) is (only) a <u>number /ratio</u>; • a sine is a number /ratio;	allow n = speed $_1$/speed$_2$ n = 1/sin c proportion for ratio units cancel out	2
	(d)	(i)	Plot at 1.5, 42;	no tolerance	1
		(ii)	Any one of - Fits the trend/pattern; (point is on) an extrapolation of line to;	 May be shown on graph OR e.g. “where the line would go”	1
		(iii)	Any two of - MP1. Idea that a reduced scale gives full(er) use of grid; MP2. RI is always more than 1 (for incidence in air) MP3. angle c greater than ~20°;	 allow reduced scale fits the data ranges (of RI or c) ignore RI >0 allow angle c never zero	2

Total 14 marks

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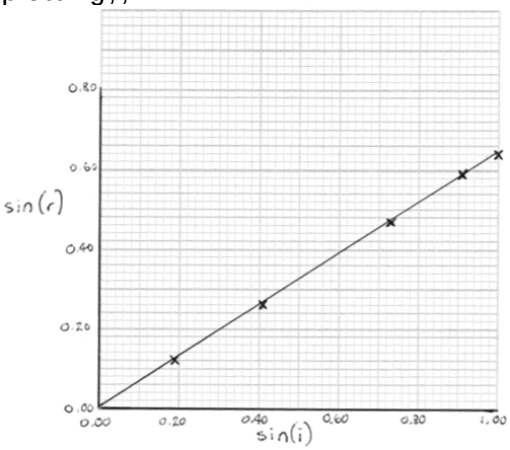
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Question number	Answer	Notes	Marks
2 (a)	any three from: paper / pen / pencil; protractor; ruler / straight edge; light source (& power supply); (optical) pins;	 allow cork board ignore unqualified 'light' allow needles	3
(b) (i)	line drawn at P at 90° to the flat surface;	judge by eye	1
(ii)	41(°); 21(°);	tolerance +/- 3° no ECF	2
(iii)	change of medium / eq; change in speed / wavelength;	allow change of refractive index / (optical) density ignore changes direction reject second mark if contradiction seen	2

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(c)	(i)	label on both axes; scale on both axes; plotting;;  	ignore orientation ignore any units linear scale using ≥50% of the grid tolerance is +/- 0.5 square -1 for each error sin *i* / sin *r*: 0.19 / 0.12; 0.41 / 0.26; 0.73 / 0.47; 0.91 / 0.59; 1.00 / 0.64	4
	(ii)	straight line of best fit (towards zero);	points should be evenly distributed about the line	1
	(iii)	n = sin i ÷ sin r	accept sine for sin	1
	(iv)	correct use of data from graph or table seen; value in range 1.54-1.60;		2
			total marks = 16	

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Question number	Answer	Notes	Marks
3 (a) (i)	Any two of - MP1. Idea that the reflection is (from a surface) **inside** the material; MP2. Idea that **all** of the light is reflected; MP3. Idea that reflection occurs inside the optically more dense medium; MP4. light incident at angle greater than critical angle	NB do not credit repeat of 'totally', 'internally' within Allow inside the higher refractive index medium	2
(ii)	Any two sensible uses – e. • **optical fibres** for communication; • in endoscopes; • **optical fibres** in decorative lamps/eq; • in safety reflector; • (Rectifying) **prism** in binoculars/telescope; • (Viewing) **prism** in camera; • (Reflecting) **prism** in periscope; • (Reflecting) **prism** in rangefinder;	allow only allow bald 'optical fibre' if no other O.F. mark given description of use e.g bicycle/car reflector, cat's eye	2
(b) (i)	**B** - OB		1
(ii)	sin c = 1/n	Allow rearrangements and abbreviations μ for n condone sin i for sin c	1
(iii)	Substitution and rearrangement in correct equation; Evaluation; e.g. n=1/sin 42° = 1/0.6691 n= 1.5	 1.49, 1.50 (1.4945)	2

Total 8 marks

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Question number	Answer	Notes	Marks
4 (a) (i)	D refraction;		1
(ii)	any 2 of: MP1. waves **slow down**; MP2. waves change direction/bend/angle; MP3. wavelength **decreases**;	allow 'light' for waves do not allow 'curved' allow wavefronts closer together	2
(b) (i)	line at 90° to the surface at point of contact;	judge by eye label not required	1
(ii)	angle between normal and incident ray clearly indicated;	allow ecf from normal line drawn in (b)(i) allow measured value in degrees	1

Total 5 marks

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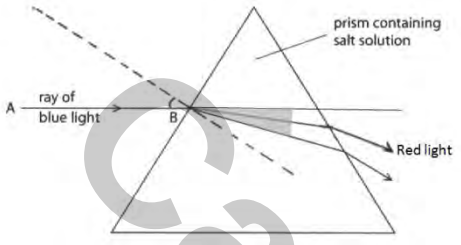
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Question number	Answer	Notes	Marks
5 (a) (i)	change of direction of a wave (as it changes from 1 medium to another);	allow definition in terms of change of speed condone 'bending of light'	1
(ii)	MP1. right angle by eye; MP2. incident angle marked; MP3. incident angle value in range 31° to 34°;	allow normal labelled with right angle (90° or symbol) Give 2 marks (MP2 and MP3) for answer in range without a marked incident angle	3

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iii	 MP1. $r_r > r_b$; MP2. $r_r < i$; MP3. less refraction than for blue light on emergence;	red line above blue line inside prism refraction at first surface (inside grey area) exit rays diverge downwards	3

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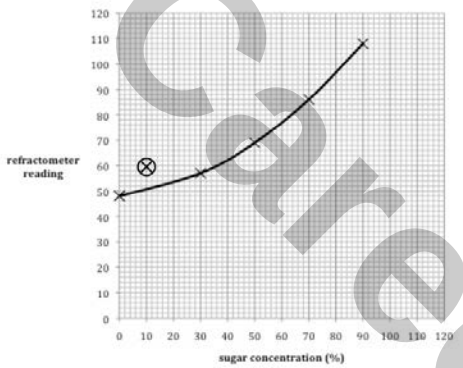
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iv	what happens inside the prism ONE mark from:- MP1. (blue light will) refract more (at the first surface); MP2. it will be nearer the normal; MP3. 'r' will be smaller; what happens on emergence:- ONE mark from:- MP4. it will bend even more; MP5. so larger deviation than previously;	allow for MP1 it will go slower;	2

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Question number	Answer	Notes	Marks
5 b i	 **Sugar concentration (%)** / **Refractometer reading** 0 / 48 10 / 60 30 / 57 50 / 69 70 / 86 90 / 108 axes labelled with units; scales correct and linear to cover at least half the grid on one of the axes; points;; (-1 for each incorrect point to a maximum of 2) curve of best fit drawn;		5

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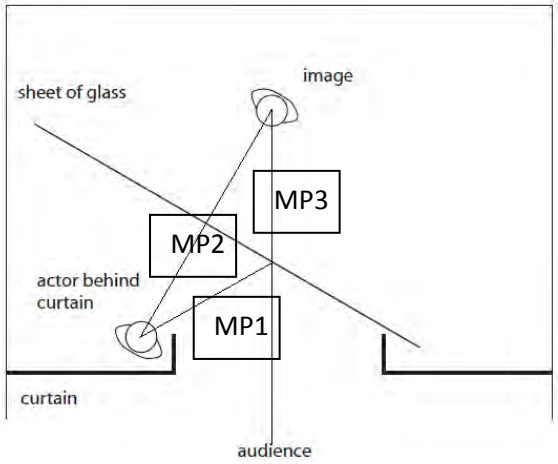
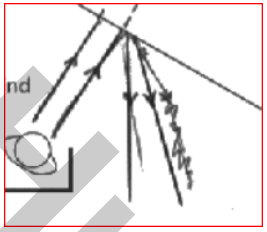
(ii)	point 10, 60 circled; (10,)50;	 allow 49-52	1 1
(iii)	63 / ans from candidates graph;	 ans in range 62-66	1
(iv)	Any two from • pattern sentence / positive correlation / positive slope; • gradient changes/nonlinearity discussed; • not through the origin;	 as one increases the other increases allow • refractometer readings increase faster than % sugar concentration • attempted mathematical description e.g. exponential or similar	2

(Total for Question 5 = 19 marks)

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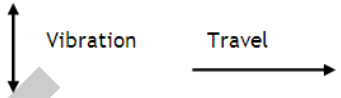
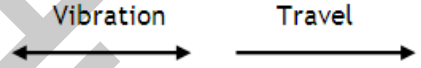
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Question number			Answer	Notes	Marks
6	(a)		MP1. Ray <u>reflects</u> correctly (by eye, any ray straight down the page (allow +/- 10°), ignore horizontal displacement); MP2. Normal shown / construction line between actor and image; MP3. Reflected ray projecting back to image;	  not spread out from 1 point for MP1	3
	(b)		any **one** from: cannot be formed on a screen/eq ; rays do not actually come from there ; rays {diverge/don't actually cross} after reflection; image formed by extension (backwards) of light rays	ignore what is seen in a mirror not real properties of image in mirror, e.g. inverted, same distance	1

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	(c)	(i)	Any suitable example; e. sound, ultrasound, deep water waves	Allow seismic (P-) waves, waves in a (slinky) spring	1
		(ii)	vibrations/oscillations are parallel or perpendicular; To direction of energy transfer/ direction of travel; Correct identification of both types;	allow vibrations up and down for perpendicular vibrations back and forward for parallel Accept suitably labelled diagrams a correct description of either wave = 2 marks e. Transverse:  Longitudinal:  ignore: examples of either type of waves if no other mark, accept descriptions of pressure changes or clear diagram(s) showing compression and rarefaction for 1 mark only	3

Total 8 marks

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Question number			Answer	Notes	Marks
7	(a)		MP1. Substitution into correct equation; MP2. Rearrangement; MP3. Divide by 2; MP4. Conversion between km and m; e. 1.5 x 1000 = 1500 Speed = $\frac{\text{distance}}{0.26}$ Distance = 1500 x 0.26 = 390 (m) So distance to fish = 195 m	Accept x 1000 at any point in calculation 0.39 gets 2 marks 390 gets 3 marks	4
	(b)		Any **two** of MP1. Reflected from different depths within shoal; MP2. So (reflected pulse(s)) travels different distances; MP3. Fish move; MP4. Reflection from sea bed;		2

Total 6 marks

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Question number	Answer	Notes	Marks
8 (a) (i)	Equa to		1
(ii)	Any TWO of - Rays continued and reflected correctly from mirror; Projected back behind mirror (to reasonably the right place) Line perpendicular to the mirror joining object and image positions (roughly equal distances in front and behind);	Judged by eye to be i = r rays should diverge after reflection Judged by eye ACCEPT (for the second mark) projection back to image even if reflected rays not drawn in front of the mirror Rays do not need to have arrows Dotted lines no required behind mirror Image does not have to be labelled Accept dotted lines in front of mirror if meaning is clear Use of ruler not essential, but candidates will find it difficult to draw a convincing diagram freehand	2
(iii)	'rays do not actually meet at the image'		1

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Question Number	Answer		Marks
(b) (i)	Added to diagram - Reflection inside fibre; At least three (with reasonable angles);	Continuous path shown inside fibre	1 1
(ii)	Must be more (optically) dense to less (optically) dense change; Angle of incidence > critical angle;	IGNORE angle of incidence = critical angle DO NOT ALLOW angle of incidence greater than 42^0	1 1
(iii)	Any ONE sensible point – e.g. Less prone to noise; less prone to heating; send more information (per second); more data (per second);	IGNORE references to cost IGNORE references to speed	1
		Total	**9**

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Question number	Answer	Notes	Marks
9 (a)	change in direction of waves at a boundary	ALLOW change in speed ALLOW idea of 'boundary' such as changing medium, or examples such as 'going from air into a glass block'	1
(b)	correct label for *i* correct label for *r*	ALLOW labels written out in full as "incidence" or "angle of incidence" etc REJECT if angles are the wrong way around	2
(c) (i)	refractive index = sin *i* / sin *r*	ALLOW 'n' for refractive index REJECT speed in 1/speed in 2	1
(ii)	Method max 4 marks: draw around block; mark positions of incident and emergent rays; (remove block and) draw refracted ray; measure i; measure r; measure angle(s) to the normal; range of values; Data max 2 marks: (graph of) sin i against sin r; graph is straight line; DOP gradient gives refractive index; DOP	 Accept pin or pencil method Ignore mention of protractor i.e. different values of i not just repeating	MAX 6

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<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>10 (a)</td><td>ANY THREE
vibration / oscillation of (air) molecules / particles;
longitudinal;
directions of vibration and propagation are parallel;
compression / rarefaction /pressure wave;</td><td>need to include what is vibrating

no need to mention molecules / particles</td><td>3</td></tr>
<tr><td>(b) (i)</td><td>0.01 s</td><td>ALLOW 2 s.f. / 2 sig figs / 2 significant figures</td><td>1</td></tr>
<tr><td>(ii)</td><td>speed = distance / time</td><td>ACCEPT equivalent rearrangement
ACCEPT suitable abbreviations e.g. s = d/t or v = s/t
REJECT equation ‘triangles’ alone</td><td>1</td></tr>
<tr><td>(iii)</td><td><table><tr><th>Student</th><th>Mean time in s</th><th>Speed of Sound in m/s</th></tr><tr><td>Andrew</td><td>0.45</td><td>330</td></tr><tr><td>Kefe</td><td>0.5</td><td>300</td></tr></table></td><td>1 mark each correct COLUMN (ignoring sf);;
mean time values as shown in mark scheme
speed = 150/mean time (allow ecf)

1 mark for all significant figures correct;
(i.e. 2 s.f. in first row, 1 s.f. in second row)</td><td>3</td></tr>
</table>

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Question number	Answer	Notes	Marks
(c)	ANY 5 relevant points, e.g. Explanation of what reaction time is; Reaction time affects readings / reaction time does matter; Reaction times vary; Reaction times do not cancel out; Reaction time should be considered / allowed for; Kefe is right (about reaction times); reaction time typically at least 0.1 s; which is large compared to measured times / large % error; time should only be to 1 s.f.; so final value should also be to 1 s.f. / Kefe's value more suitable; 3 s.f. inappropriate; closer to accepted value does not mean more accurate;	Answers should ideally relate to how *appropriate* the precision of the measurements was, linking this to the number of significant figures merited Consideration of reaction time and its measurement may score a number of marks	MAX 5

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Question number	Answer	Notes	Marks
11 (a) (i)	(cm)		1
(ii)	Sketched wave (at least 1 cycle) with a larger amplitude; Sketched wave (at least 1 cycle) with a longer wavelength;	Shape of wave and position of axis unimportant (i.e. ignore conditions of wind and tide)	2
(b)	Any five of - MP1. A method to make a loud enough sound; MP2. Speed = $\frac{\text{distance}}{\text{time}}$; MP3. Need for still air; MP4. Repeat AND average; MP5. Need to check/reset stopwatch zero reading; MP6. Idea of clear visual signal; MP7. measurement of time **interval** (between visual signal and sound); MP8. Idea of reaction time(s) (could be a problem);	ignore measurement of distance bald 'clap' • wooden blocks • noise has to heard over 100m RA allow repeat AND sort out anomalies e. • when the sound is seen to be made • smoke from starting pistol (because) light travels faster than sound	5

Continued

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Question number	Answer	Notes	Marks
(c) (i)	wave speed = frequency × wavelength	Allow abbreviations and rearrangements, e.g. $v=f\lambda$	1
(ii)	Conversion to Hz; Substitution into correct equation and rearrangement; Evaluation; e.g. 31 MHz = 31 000 000 Hz wavelength = 300 000 000 ÷ 31 000 000 9.7 m	Allow 10^6 seen at any stage allow answers which round to 9.7 (9.6774)	3
(d)	Any one of the following ideas - MP1. the two waves travel at different speeds; MP2. the two waves travel the same distance (or 1 wavelength) in different times;	ignore references to • transverse and longitudinal • em spectrum	1

Total 13 marks

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Question number			Answer	Notes	Marks
12	(a)	(i)	B radio waves		1
		(ii)	C Microwaves and radio waves travel at the same speed in a vacuum.		1
		(iii)	any one sensible property; e. travels (very) fast travel at speed of light can be coded can travel in vacuum	Allow can penetrate the ionosphere, can carry more information (than radio) higher frequency /shorter wavelength (than radio) minimal diffraction	1
	(b)		Quantities substituted in the correct equation; Rearrangement; Calculation; Conversion from hours/days to s at any point (implicit if correct ans in km); e. $3.1 = \frac{2 \times \pi \times r}{(24 \times 3600)}$ $r = \frac{3.1 \times 24 \times 3600}{2\pi}$ r = 42 600 km	No credit for quoting the equation as $v = 2\pi r/T$ is given on page 2. sub and rearrange in either order allow 3600 or 86 400 seen Allow 42630, 42628 Allow 42622 (from π = 3.142)	4

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	(c)		any suitable point; e. Satellite always appears in same part of sky satellite always about the same point on the Earth no need (for satellite dish) to track because it orbits in the same time the earth rotates	Allow idea of geostationary orbit	1

Total 8 marks

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Question number	Answer	Notes	Marks
13 (a)	(Current / Electron/particle movement) in a single direction;		1
(b) (i)	ANY SUITABLE, e.g. Travel quickly / at the speed of light; Can code information; Can travel long distances / through buildings / walls / objects; Not harmful/dangerous; can diffract / reflect;		1
(ii)	(microwaves) use - communication / cooking ; harmful effect - heating ; (ultraviolet) use - fluorescent lamps / kill bacteria / harden fillings ; harmful effect - <u>skin</u> cancer / eye damage / sunburn;	ALLOW correct alternatives	4
(c)	ANY FIVE RELEVANT POINTS, e.g. current in coil; changing current/alternating current; produces magnetic field; (constantly) changing (field); which interacts with field of permanent magnet / reference to Fleming's LHR; force on coil /coil moves; vibration in (coil / cone / air); making longitudinal wave;	DO NOT ALLOW 'coil spins'	5
		Total	**11**

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Question number	Answer	Notes	Marks
14 (a)	gravity		1
(b) (i)	6960 (km)		1
(ii)	equation quoted (NO MARK) conversion of km OR min; v = (2 x π x 6 960 000) / (96 x 60); 7600;	 ECF on (i) Allow for rounding errors	3
(c)	EITHER grav pe reduces when closer; (so) ke increases; because total energy conserved; OR gravitational attraction / field strength increases when closer; mass remains constant; so accelerates;	 Grav force increases so ke increases = 1 (mixing arguments) REJECT 'gravity higher' 'gravity stronger' ACCEPT 'pull of gravity' 'force of gravity'	3
(d) (i)	electromagnetic (spectrum)	Accept transverse (waves)	1
(ii)	Any **two** from X-rays have shorter wavelength; ORA X-rays have higher frequency; ORA X-rays have higher energy; ORA X-rays have greater penetration range; ORA X-rays have greater effects on living tissue; ORA	Idea of comparison must be there REJECT 'visible light can be seen' / eq	2

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Question number	Answer	Notes	Marks
15 (a) (i)	B;		1
(ii)	A;		1
(iii)	Similarity:- any wave property e.g. transfer energy, reflection, refraction, vibration;	Allow diffraction carry energy	1
	Difference:- any one of • longitudinal particles oscillate in {same direction/ parallel to} the direction of travel; • transverse {particles oscillates/vibration} at right angles to the direction of travel;	Allow • direction of energy transfer for direction of travel • only transverse waves can be polarised • transverse waves cannot travel through a liquid Ignore mention of vacuum/ medium	1

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(b)

circle the mistake in this sentence	the correct word(s) is
They all travel at 3×10^2 m/s in a vacuum.	10^8 GIVEN
Sound waves are electromagnetic.	any of radio, micro(wave), infrared (IR), visible, ultraviolet (UV), X-ray or gamma
Infra-red waves are the most harmful to people.	gamma
Gamma waves are used for heating up food.	micro(waves)/ Infrared (IR)
Radio waves have the highest frequency.	Gamma (γ)
Gamma waves have a very long wavelength.	radio (waves)

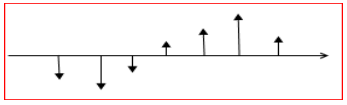
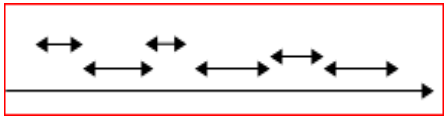
each line for 1 mark;;;;;

5

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Question number		Answer	Notes	Marks
16 (a) (i)		B- 2		1
(ii)		C- 8		1
(b)		Idea that in a transverse wave the direction of vibration is perpendicular to the direction of the wave; (May be shown with labels on the diagram) Idea that longitudinal wave the direction of vibration is parallel to the direction of the wave; (May be shown with labels on the diagram) A named freehand sketch of either wave indicating the two directions; e.  transverse  Longitudinal	Allow (for vibration) oscillation / displacement / disturbance (for direction of wave) direction of travel / energy / transfer (for perpendicular) at right angles, is ⊥ to (for parallel) the same as, // the minimum labeliing is to name of the type of wave they have drawn. Allow sine waves with appropriate arrows Allow diagrams indicating compression and rarefaction e.g. in a spring Allow for 1 mark (but only if other mark is scored) a comparison of the directions of vibration of both waves without relating them to the direction of the wave e.g. transverse vibrates up and down but longitudinal vibrates back and forward	3
(c)		any two of		2

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			MP1 can travel through vacuum OR needs no medium; MP2 speed (in a vacuum) OR speed = 3 X10^8 (m/s); MP3 obeys laws of reflection / refraction; MP4 obeys wave equation OR speed = frequency × wavelength; MP5 carries energy/ information; MP6 they are transverse	"speed in a vacuum" where seen, scores 2 marks (MP1 and MP2) Accept reflect, refract, diffract	
(d)	i		D - X-rays		1
	ii		A – absorbed by the bone		1
	iii		X-rays OR gamma rays idea of causing damage to cancer cells e.g. cells killed/mutated/ionised/destroys;	allow symbol γ do not allow UV Independent mark	2

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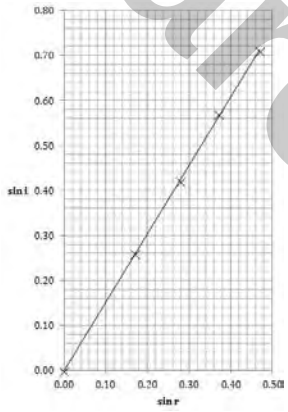
Question number	Answer	Notes	Marks
17 (a)	MP1. pitch is <u>frequency</u>; MP2. any one of: • whether sound/note sounds high or low; • high sound has high frequency ORA;	allow 'it' for pitch ignore references to amplitude, wavelength allow vibrates more often / with shorter time period 'high pitch has high frequency' ORA gains 2 marks	2
(b) (i)	ruler / measuring tape; oscilloscope / mobile phone app / data logger / (guitar) tuner;	 ignore microphone frequency meter frequency gauge frequency counter	2
(ii)	dependent – frequency / pitch; independent – length (of pipe);		2
(c)	any three of: MP1. repeat AND average the readings; MP2. (measure a) larger range of values; MP3. (measure some) intermediate values; MP4. improved precision of a named variable / instrument; MP5. control a named variable (e.g. temperature); MP6. plot a graph of frequency and length; MP7. deal with anomalies;	 accept 'measure more values' for 1 mark if NEITHER MP2 nor MP3 awarded e.g. 'use a cm ruler', 'measure frequency in mHz' etc. ignore references to accuracy allow 'blow with controlled apparatus' allow 'plot a graph of the results' allow 'identify anomalies'	3

Total 9 marks

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Question number	Answer	Notes	Marks
18 (a) (i)	0.28 0.37	(both for 1 mark)	1
(ii)	suitable scales; axes labelled; plotting of second and fifth points ;; line of best fit;  	Must use > half width and half height of grid no units on axis labels ignore orientation of graph to nearest ½ square, up to two marks available for this line – allow ecf from candidate's third and fourth points If incorrect graph plotted (i◦ against r◦) the only scales and line mark can be awarded (NB in this case can only get first MP in (a)(iii))	Max 5
(iii)	Attempt at gradient of line, seen on graph or in working; Value in range 1.48 to 1.54;	e.g. triangle or equivalent drawn on graph, rise/run bald correct answer is 1 mark only	2

sin i	sin r
0.00	0.00
0.26	0.17
0.42	**0.28**
0.57	**0.37**
0.71	0.47

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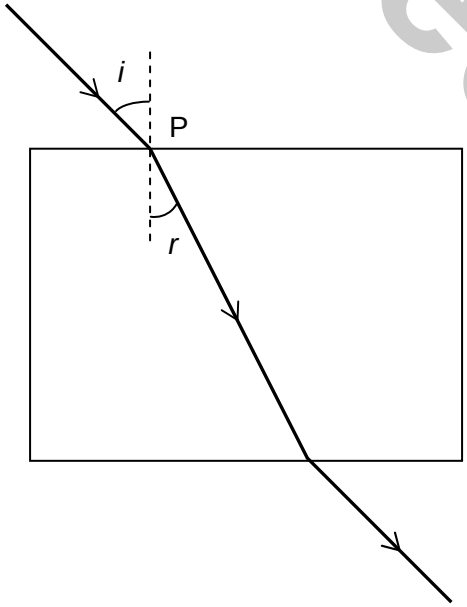
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b	Any two of - MP1. Idea that value relates to all the data collected; MP2. Idea that method allows for anomalies; MP3. Idea that effects of uncertainty/error can be reduced or accounted for;	Method checks reliability, anomalies can be seen graph is an averaging technique Ignore comments about accuracy	2

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Question number	Answer	Accept	Reject	Marks
19 (a)	Refraction into glass towards the normal (r > 0); Angle of incidence <u>and</u> angle of refraction both labelled correctly at the same surface; Refraction at the lower surface into air away from the normal; Emergent ray parallel to incident ray after correct refraction (by eye);  	Accept dotted lines Ignore any reflections Ignore a second incorrectly labelled pair		4

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Question number	Answer	Accept	Reject	Marks

(b) (i)	One mark for **either** sin i or sin r correct;
	
	i = 60°
	r = 34°
	sin *i* = **0.87**
	sin *r* = **0.56**
		sin i = 0.866;
		sin i = 0.8660;
		sin r = 0.559;
		sin r = 0.5592;
		
		Ignore degree sign
		
		Ignore any other values
				1

(ii)	n = sin i ÷ sin r;	Accept refractive index = sin i ÷sin r		1
(iii)	Two marks for correct answer Refractive index = 1.55;; Or Refractive index = 1.6;; Or Refractive index = 1.5;;	Accept for one mark only any other value in the range 1.5 < n < 1.6; Any power of 10 error, e.g. 155.3		2

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Question number	Answer	Accept	Reject	Marks
(c)	Any three of: MP1 any mention of repetition / take an average of readings; MP2 vary *i* to obtain more values ; MP3 plot a graph of <u>sin i against sin r</u> ; OR Calculate/work out/ find n; MP4 find gradient of graph ; OR Calculate average of n; MP5 sensible experimental precaution / improvement to method (e.g. mark lines on paper, thinner beam, fix block firmly in position, remove anomalies, sharper pencil, use a more precise protractor e.g. ½º);	Ignore reference to critical angle Ignore second glass block Ignore different colours		3

Total 11 marks

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Question number		Answer	Notes	Marks
20(a)	(i)	set-up showing any **two** from- clear indication of equipment needed; correct refraction at one surface of glass block shown; protractor shown in use;	 ray-box or pins Allow ruler for apparent depth method	2
	(ii)	angle of incidence; angle of refraction; OR critical angle; idea of grazing emergence;	Allow apparent depth method, i.e. real depth; apparent depth;	2
	(iii)	find sin i and sin r; refractive index is the ratio of sines; OR find sin c; refractive index is 1/ sin c;	Accept for two marks • (n =) sin i/sin r • (n =) 1/ sin c • graph of sin i vs sin r Allow refractive index = real depth ÷ apparent depth for two marks	2
(b)	(i)	Diagram – reflection at first back surface; reflection at second back surface;	judge by eye • straightness of ray and correctness of angle • emergent ray parallel to incident ray	2
	(ii)	Refracted / slows down / wavelength decreases	Ignore: direction change ideas it does nothing / nothing happens	1

Total 9 marks

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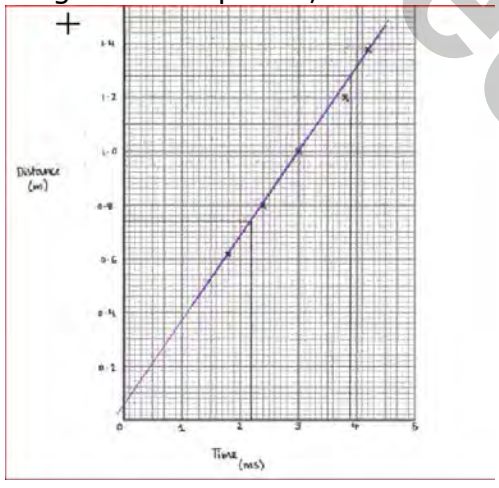
Question number	Answer	Notes	Marks
21 (a)	cooking – micro(waves) OR infrared (waves); treating cancer – ultraviolet OR x-rays OR gamma (rays); identifying broken bones - x-rays;	if more than one example given for each use then reject mark if any incorrect	3
(b)	C - the same speed;		1
(c) (i)	drawn ray shows refraction in the correct direction (downwards) at **both** surfaces; drawn ray is above yellow ray and diverges from it (if ray had entered at the original point);	judge by eye ignore arrows and labels dependent on previous allow if ray drawn enters **parallel** to original ray	2
(ii)	A- black;		1

Total 7 marks

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Question number	Answer	Notes	Marks
22 (a)	B;		1
(b) (i)	MP1. Axes labelled with units; MP2. Correct scales (to occupy at least ¼ of the area of the graph and in sensible intervals); MP3. Plotting; MP4. Plotting; MP5. straight line of best fit which extends beyond given data points;  **Distance in m / Time in ms** 0.62 / 1.8 0.80 / 2.4 1.00 / 3.0 1.20 / 3.8 1.38 / 4.2	• ignore orientation of graph • scale intervals on axes should be 2 or 5 or 10 • points should be less than 0.5 sq in diameter • -1 each incorrect plot to max of -2 • tolerance = +/- ½ square • if zero is not included, then line should go through all points except 3rd or 4th • if zero included, look for balance of points	5

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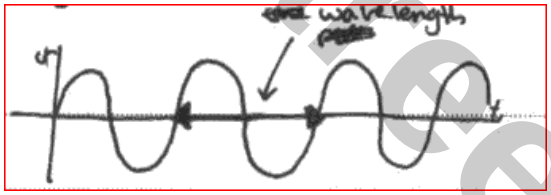
(ii)	Attempt to find slope or gradient of line ; AND evaluation of value; matching unit; e.g. = 0.6/0.0018 = 333 m/s	Δ seen or two lines from same axis seen or rise/run seen value in range of 310-350 allow 0.333 km/s 0.333 m/ms	3
(iii)	Any one specific variable from the experiment; e.g. hitting the block in the same place Use the same microphone/timer/wires Ensure there is no 'hammer bounce'	These must be specific to the experiment Accept same • temperature • humidity • density • draughts • force • block ignore • 'keep everything the same' • use control variables • repeat experiment	1
(iv)	Any 2 suggestions from MP1. repeat the time readings (for each distance); MP2. measure the distance to the sensor of the microphone; MP3. use wider range of distance readings (<0.62 or >1.38); MP4. use intermediate distances (between points);	ignore imprecise suggestions e.g. • 'be careful with timer' • 'change the distance'	2

(Total for Question 6 = 12 marks)

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Question number	Answer	Notes	Marks
23 (a)	standard definition of wavelength; e. • distance between two points on a wave/ two peaks/ two troughs • distance between each wavefront • distance travelled by wave in one time period 	allow: from clear diagram crest for peak ignore: • 'the length of a wave' • 'distance taken for 1 cycle' • distance between one wave and the next one	1
(bi)	Speed of wave = frequency x wavelength;	allow: in any rearrangement $v = f.\lambda$	1
(bii)	substitution into any form of the equation ; evaluation; e. $3(m/s) = 1.5(Hz) \times \lambda$ $(\lambda) = 2(m)$;	accept for 1 mark $\frac{3}{1.5}$	2

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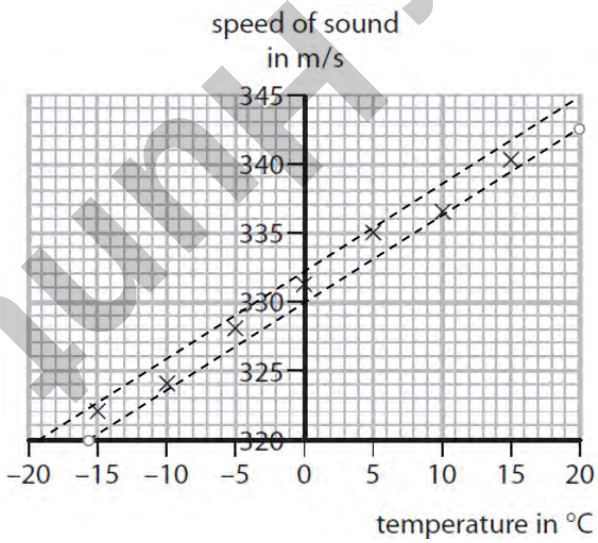
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Question number	Answer	Notes	Marks
(ci)	Diffraction; And one of • The incoming wave spreads out at the gap; • The energy carried by the wave spreads out ;	allow: • diffraction seen in (cii) • recognisable spelling for 'diffraction' ignore: • the wave gets bigger • wave is bent • (wavefront is) curved	2
(cii)	idea that (diffraction only apparent when) λ and size of gap comparable/RA; wavelength of light is very small / smaller than water waves /smaller than the gap;	Allow RA	2
		Total	**9**

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Question number	Answer	Notes	Marks
24 (a)	idea that higher frequency gives higher pitch;	allow reverse argument condone idea of proportionality / linearity	1
(b) (i)	(wave) speed = frequency × wavelength	allow abbreviation, e. v = f × λ or rearrangements	1
(ii)	substitution into correctly rearranged equation; evaluation; e. (v =) 340 / 160 (v =) 2.1 (m)	allow 2.125, 2.12, 2.13 or 2 (if supported)	2
(c) (i)	straight line of best fit drawn within indicated area;  	line does not need to be extended beyond data range for this mark	1
(ii)	line of best fit extended to 20°C; student's own value from graph ± half a square;		2

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(d)	any 2 from: MP1. speed (of sound) decreases (with temperature); MP2. frequency is constant; MP3. so wavelength decreases (with temperature);	 allow 'sound slows down' ignore references to particle speed allow λ is smaller	2

Total 9 marks

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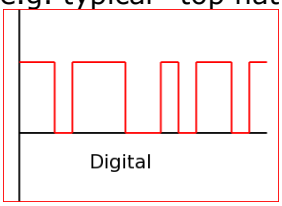
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Question number	Answer	Notes	Marks
25 (a)	B - light;		1
(b) (i)	(signal has) two values;	accept • on or off • 0 and 9 • 0 and 1 • 1 and 9 • two signal strengths/states • binary • it is a square wave(form) ignore • all at 9 • up and down • true and false	1
(ii)	any two of:	ignore references to analogue signals	2
	MP1. (idea of) increasing the bit rate / sending more bits in the same time;	allow more bits / pulses per second condone increase frequency	
	MP2. (idea of) an **additional** level / strength;	allow a named **extra** level e.g. 'use 4.5 as well'	
	MP3. (idea of) increased bandwidth / range of transmission frequencies;	allow wider bandwidth ignore 'broadband'	
	MP4. (idea of) multiplexing;	allow use more than one channel condone add extra signals	
	MP5. (idea of) quantisation (algorithm);	allow compression of data	

Total 4 marks

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Question number	Answer	Notes	Mark
26(a)	2 value line with top line & lower line at constant heights; straight up/down lines; e.g. typical 'top hat' waveform  	ignore spacing of pulses judge by eye allow waveform with 3 distinct values at +X, zero and – X 	2
(b)	any two described **advantages** from:- MP1. information density e.g. digital carry more information (per second); MP2. quality e.g. maintain quality over longer distances; MP3. easier to reduce noise/less affected by noise; MP4. regeneration e.g. able to boost signal to original strength;	accept clearer easier to process total marks = 4	2

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Question number			Answer	Notes	Marks
27	a	i	number of waves/cycles = 3.5; $\frac{0.60}{3.5}$ = 0.17 (m);	3.5 seen or implied 0.1714 (m) 17 cm 17.14 cm For 1 mark only 17 (m), 17.14(m), 0.2 (m), 0.15 (m), 0.085 (m)	2
		ii	wave speed = frequency x wavelength	allow words or accepted symbols and rearrangements	1
		iii	substitution; rearrangement; evaluation; eg. $3.0 \times 10^8 = 0.17 \times f$ (1 mark) $3.0 \times 10^8 / 0.17$ (2 marks) 1.8×10^9 (Hz) (3 marks)	**allow ecf from ai** 1.76×10^9 (Hz) 1.75×10^9 (Hz) POT = -1	3
	b	i	diffraction;		1
		ii	any two from: MP1. microwaves not diffracted as much; MP2. diffraction (only seen) when size of barrier/gap comparable to wavelength; MP3. radio-waves have (much) longer wavelength than microwaves/RA;	 must have quantifier-e.g 'little' ignore 'microwaves not diffracted' wavelength of microwaves (much) smaller than size of barrier allow an implied comparison	2
				total =9 marks	

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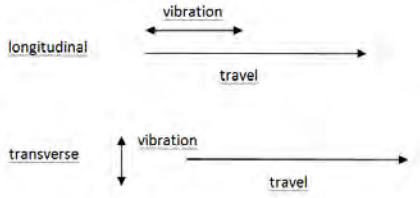
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Question number	Answer	Notes	Marks
28 (a) (i)	A - amplitude;		1
(ii)	B - frequency;		1
(b) (i)	Any of - e.g. Light, (any named) electromagnetic wave, water waves, S(econdary) seismic waves;	Allow • slinky if described correctly • wave on a string Ignore 'heat waves'	1

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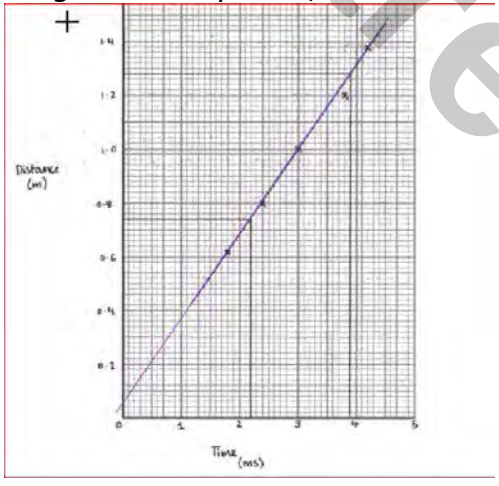
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(ii)	Longitudinal - Idea that vibration is parallel to **energy transfer**; e.g. vibration is in the same direction that the **wave travels** they (vibrations) are in the same direction that the **wave moves** Transverse – Idea that vibration is perpendicular to **energy transfer**; e.g. vibration is at 90º to the direction that the **wave travels** they (vibration) are at right angles to the direction the **wave moves**	Ignore left to right, up and down, to and fro, side to side Accept • oscillation for vibration • information transfer for energy transfer • clear labelled diagrams, e.g.  Condone for longitudinal 'particles oscillate in the same direction that the wave goes'	2

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Question number	Answer	Notes	Marks
29 (a)	B;		1
(b) (i)	MP1. Axes labelled with units; MP2. Correct scales (to occupy at least ¼ of the area of the graph and in sensible intervals); MP3. Plotting; MP4. Plotting; MP5. straight line of best fit which extends beyond given data points;  	• ignore orientation of graph • scale intervals on axes should be 2 or 5 or 10 • points should be less than 0.5 sq in diameter • -1 each incorrect plot to max of -2 • tolerance = +/- ½ square • if zero is not included, then line should go through all points except 3rd or 4th • if zero included, look for balance of points	5

Distance in m	Time in ms
0.62	1.8
0.80	2.4
1.00	3.0
1.20	3.8
1.38	4.2

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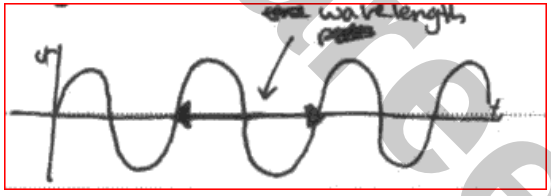
(ii)	Attempt to find slope or gradient of line ; AND evaluation of value; matching unit; e.g. = 0.6/0.0018 = 333 m/s	Δ seen or two lines from same axis seen or rise/run seen value in range of 310-350 allow 0.333 km/s 0.333 m/ms	3
(iii)	Any one specific variable from the experiment; e.g. hitting the block in the same place Use the same microphone/timer/wires Ensure there is no 'hammer bounce'	These must be specific to the experiment Accept same • temperature • humidity • density • draughts • force • block ignore • 'keep everything the same' • use control variables • repeat experiment	1
(iv)	Any 2 suggestions from MP1. repeat the time readings (for each distance); MP2. measure the distance to the sensor of the microphone; MP3. use wider range of distance readings (<0.62 or >1.38); MP4. use intermediate distances (between points);	ignore imprecise suggestions e.g. • 'be careful with timer' • 'change the distance'	2

(Total for Question 5 = 12 marks)

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Question number	Answer	Notes	Marks
30 (a)	standard definition of wavelength; e. • distance between two points on a wave/ two peaks/ two troughs • distance between each wavefront • distance travelled by wave in one time period 	allow: from clear diagram crest for peak ignore: • 'the length of a wave' • 'distance taken for 1 cycle' • distance between one wave and the next one	1
(bi)	Speed of wave = frequency x wavelength;	allow: in any rearrangement $v = f.\lambda$	1
(bii)	substitution into any form of the equation ; evaluation; e. $3(m/s) = 1.5(Hz) \times \lambda$ $(\lambda) = 2(m)$;	accept for 1 mark $\frac{3}{1.5}$	2

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Question number	Answer	Notes	Marks
(ci)	Diffraction; And one of • The incoming wave spreads out at the gap; • The energy carried by the wave spreads out ;	allow: • diffraction seen in (cii) • recognisable spelling for 'diffraction' ignore: • the wave gets bigger • wave is bent • (wavefront is) curved	2
(cii)	idea that (diffraction only apparent when) λ and size of gap comparable/RA; wavelength of light is very small / smaller than water waves /smaller than the gap;	Allow RA	2
		Total	**8**

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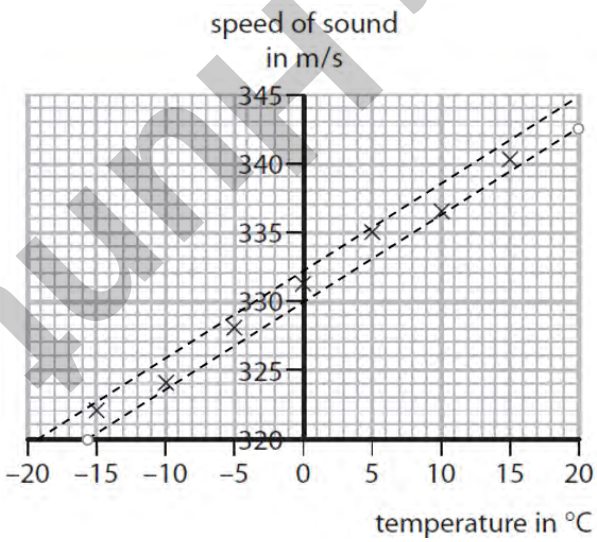
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Question number	Answer	Accept	Reject	Marks
31 (a) (i)	3;	Three /3.0		1
(ii)	0.002 (s) / 2ms ; 500 (Hz) / 0.5kHz	0.001 ecf only if 2ai=6 correct answer without working for 2 marks 1000 ecf only if 2ai =6		2
(b)	All of waves at smaller amplitude (can vary); All of complete waves at higher frequency (can vary);	Any wave form Accept two diagrams that clearly show the candidate's intention		2

Total 5 marks

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Question number	Answer	Notes	Marks
32 (a)	idea that higher frequency gives higher pitch;	allow reverse argument condone idea of proportionality / linearity	1
(b) (i)	(wave) speed = frequency × wavelength	allow abbreviation, e. $v = f \times \lambda$ or rearrangements	1
(ii)	substitution into correctly rearranged equation; evaluation; e. (v =) 340 / 160 (v =) 2.1 (m)	 allow 2.125, 2.12, 2.13 or 2 (if supported)	2
(c) (i)	straight line of best fit drawn within indicated area;  	line does not need to be extended beyond data range for this mark	1
(ii)	line of best fit extended to 20°C; student's own value from graph ± half a square;		2

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(d)	any 2 from: MP1. speed (of sound) decreases (with temperature); MP2. frequency is constant; MP3. so wavelength decreases (with temperature);	 allow 'sound slows down' ignore references to particle speed allow λ is smaller	2

Total 9 marks

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Question number			Answer	Accept	Reject	Marks
33	(a)	(i)	(Signal has) two values; Only;	On or off, 0 or 1, two signal strengths Binary		2
		(ii)	Any two of The idea of increased frequency (of wave or modulation); The idea of regeneration (allowing more data to arrive); The idea of using increased bandwidth; The idea of using additional (signal) level; The idea of multiplexing (e.g. use more than one channel);	send more bits/sparks, send morse code more quickly, send other letters The response should be about the signal, so ignore: idea of just sending a longer message using optical fibre(s)		2
	(b)	(i)	(wave) speed = frequency x wavelength	$v = f \times \lambda$ (accept rearrangements)		1
		(ii)	Substitution; Calculation; e.g.: 820 000 x 366 = 300 120 000 or 300 000 000 or 3 x 10^8 (m/s)	Bald answer;; Power of ten error (for 1 mark) e.g. 300 000 m/s Alternative correct units (for 2 marks) e.g. 300 000 km /s		2

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Question number			Answer	A	Reject	Marks
	(c)		183 (m);			1
	(d)		Any three of: MP1 Electrons move OR there is a current Or negative charge moves; MP2 (Discharge) to earth OR across cloud OR to named object – tree, house, lightning conductor; MP3 Air conducts; MP4 Phenomenon e.g. thunder clap / lightning;	Sparks generate radio waves; Lightning causes (radio) interference; Correct reference to electrostatic attraction / repulsion ;		3
					Total	**11**

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Question number	Answer	Notes	Marks
34 (a)	D		1
(i) (ii)	C		1
(b)	f = 1/T (NO MARK) f= 1/5; 0.2 (Hz);	Bald 0.2 (Hz) scores 2 marks	2

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Question number	Answer	Notes	Marks
35 (a) (i)	any two from:- MP1. travels at speed of 3 x 10^8 m/s; MP2. travels in a vacuum; MP3. transverse wave; MP4. transfer energy / information; MP5. can be reflected/refracted/diffracted;	travel at the same speed /speed of light	2
(ii)	B gamma rays;		1
(b) (i)	step- up;	allow	1
(ii)	$\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$ $\frac{V_P}{V_S} = \frac{n_P}{n_S}$	equation in any rearrangement	1
(iii)	substitution; rearrangement; evaluation; e.g. $\frac{230}{2000} = \frac{110}{n_s}$ $n_s = \frac{110 \times 2000}{230}$ $n_s = 960$	sub and rearrangement in either order 956.52, 957	3
(iv)	to protect user from high voltage/eq;	allow plastic is an insulator to prevent (electric) shock Total 9 marks	1

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Question number	Answer	Notes	Marks
36 (a)	cooking – micro(waves) OR infrared (waves); treating cancer – ultraviolet OR x-rays OR gamma (rays); identifying broken bones - x-rays;	if more than one example given for each use then reject mark if any incorrect	3
(b)	C - the same speed;		1
(c) (i)	drawn ray shows refraction in the correct direction (downwards) at **both** surfaces; drawn ray is above yellow ray and diverges from it (if ray had entered at the original point);	judge by eye ignore arrows and labels dependent on previous allow if ray drawn enters **parallel** to original ray	2
(ii)	A- black;		1

Total 7 marks

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Question number	Answer	Notes	Marks
37 (a) (i)	Any one of- MP1 Speed / velocity (in a vacuum); MP2 Transverse (wave); MP3 Electromagnetic (wave); MP4 A general wave property;	 e.g. reflection, refraction, diffraction, transfer energy	1
(ii)	Any two of- Frequency; Wavelength; Energy;	Any wavelength or frequency relationship if stated must be correct	2
(b) (i)	There are more than two values; Reference to shape/slope/ramp(s);	Accept peaks not all same height not just 1 and 0 Accept RA Ignore “analogue”	2
(ii)	MP1 More than one gap measured / averaging seen; MP2 Value of 1.15 or 1.35 (s);	 Allow 2 marks for bald answers of: 1.15 or 1.35 (s) Allow 1 mark (MP1) for bald answers of: 1.2, 1.25, 1.4, 1.55 (s)	2
(iii)	Calculation of frequency (from f= 1/T); Unit to match value; e.g. f = 1/1.15 = 0.87 Hz	Allow e.c.f from time value given in (b)(ii) 1/1.35 = 0.74	2

Total 9 marks

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Chapter 4: Energy Resources and Transfers Question

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1 The table gives information about some ways to generate electrical power.

Type of power station	Maximum power output in MW	Time to reach maximum power	Relative fuel cost
wind farm	20	variable	none
gas turbine	600	15 minutes	medium
tidal scheme	6000	variable	none
nuclear power station	1200	2 days	low
coal-fired power station	1800	3 hours	high

An electricity supply company has enough power stations to cover the normal demand for electricity but not enough for cold conditions.

On cold days the demand for electrical power can suddenly increase by 20 000 MW.

The company needs to build new power stations to meet this increased demand.

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Using **only** information in the table, evaluate which types of power station would be the most suitable to meet this increased demand.

(5)

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(Total for Question 1 = 5 marks)

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2 An electric kettle is connected to the 230 V mains supply.

The power of the kettle is 960 W.



(a) (i) A power of 960 watts is the same as

(1)

☒ **A** 960 joules per coulomb

☒ **B** 960 joules per second

☒ **C** 960 newtons per metre

☒ **D** 960 newtons per second

(ii) State the equation linking power, current and voltage.

(1)

(iii) Show that the current in the kettle is about 4 A.

(2)

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(b) The 960 W kettle is earthed and fitted with a fuse.

(i) Explain how this can protect the person using the kettle if there is a fault.

(3)

(ii) Another kettle has twice as much power.

It is connected to the same mains supply.

Which of these fuse ratings should be used for this kettle?

(1)

☒ **A** 1 A

☒ **B** 3 A

☒ **C** 5 A

☒ **D** 13 A

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(c) A student has a pack of fuses labelled 2 A.

Explain how she could use one of these fuses to check that the label is correct.

You may draw a circuit diagram to help your answer.

(3)

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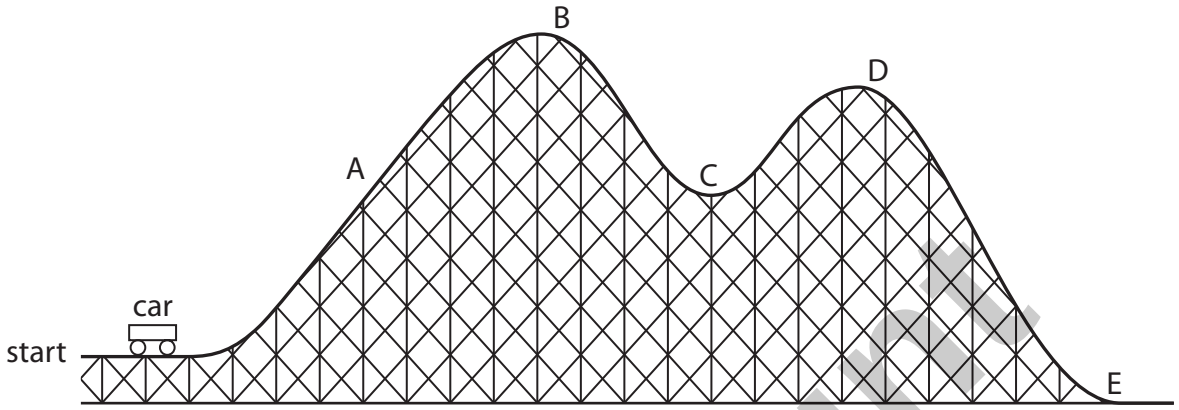
(Total for Question 2 = 11 marks)

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3 The diagram shows a roller-coaster ride.

The car is pulled slowly from the start to point B and then released.



(a) Choose letters from the diagram to complete this sentence.

(2)

The car has the most gravitational potential energy at point .....

and it goes fastest at point ..... .

(b) The mass of the car is 900 kg.

The maximum speed of the car is 15 m/s.

(i) State the relationship between momentum, mass and velocity.

(1)

(ii) Calculate the maximum momentum of the car.

Give the unit.

(3)

maximum momentum = ... unit .....

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(iii) State the equation linking kinetic energy (KE), mass and speed.

(1)

(iv) Calculate the maximum KE of the car.

(2)

maximum KE = ... J

(Total for Question 3 = 9 marks)

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4 An energy company plans to build a new power station.

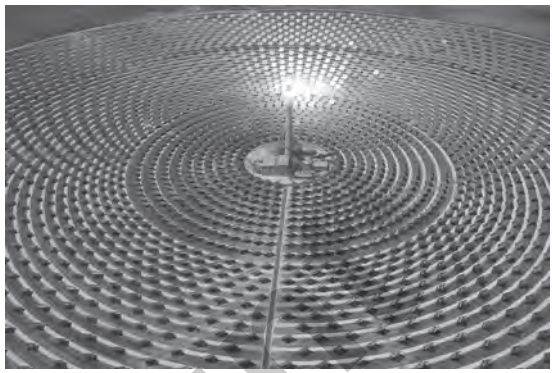
The company must decide between two renewable energy projects, a geothermal power station or a solar power station.

Geothermal power station



(Author: Gretar Ívarsson, geologist at Nesjavellir, 2006)

Solar power station



(Author: Torresol Energy, 2011)

Explain how the location and the climate might affect the type of power station that the company chooses.

(4)

location .....

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climate .....

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(Total for Question 4 = 4 marks)

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5 A coal-fired power station and a wind turbine both produce electrical power.

The power station produces 1200 MW and the wind turbine produces 1.5 MW.



(a) Give **one** advantage of using wind turbines instead of a coal-fired power station to produce electricity.

(1)

.....

.....

(b) Coal-fired power stations are still in general use.

Explain why wind turbines have not replaced them.

(4)

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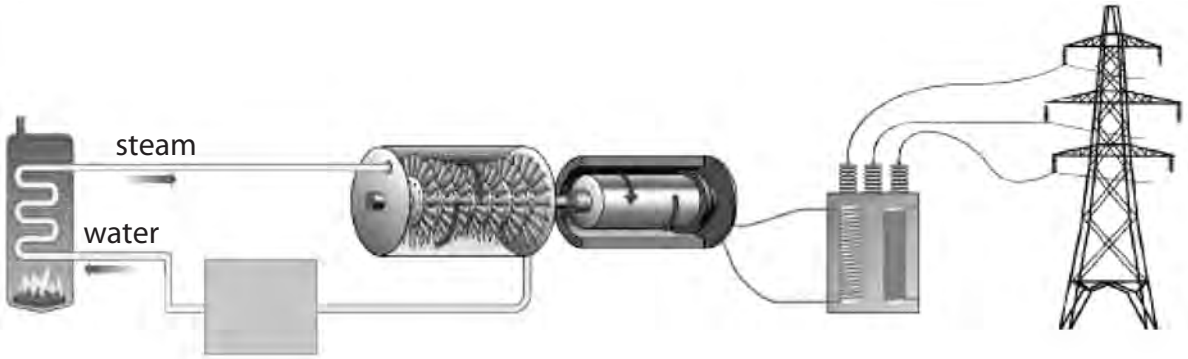
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(Total for Question 5 5 marks)

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6 The diagram shows a coal-fired power station.



(a) (i) In which part of the power station is heat energy usefully converted to kinetic energy?

(1)

- ☒ **A** boiler
- ☒ **B** turbine
- ☒ **C** generator
- ☒ **D** wires

(ii) In which part of the power station is kinetic energy usefully converted to electrical energy?

(1)

- ☒ **A** boiler
- ☒ **B** turbine
- ☒ **C** generator
- ☒ **D** wires

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(b) A transformer is used to convert the 25 kV output from the power station to 115 kV.

(i) State the equation linking power, voltage and current.

(1)

(ii) Compare the input current and the output current of the transformer.

Assume there are no energy losses in the transformer.

(3)

(iii) State one advantage of transmitting electricity at high voltages.

(1)

(c) Some power stations use uranium as a fuel.

Describe the problems that arise from the disposal of waste from this type of power station.

(4)

(Total for Question 6 = 11 marks)

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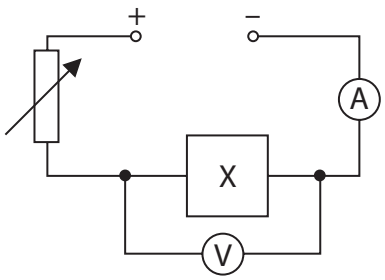
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7 A student is given an unknown electrical component, X.

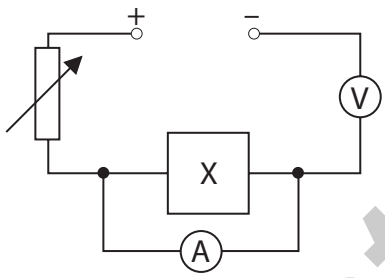
He uses a circuit to investigate how the current in X varies with the voltage across it.

(a) Which of these circuits is correct for his investigation?

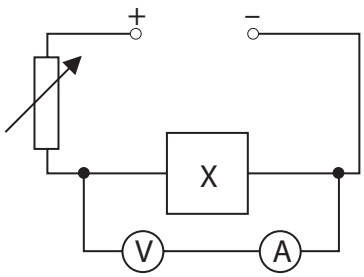
(1)



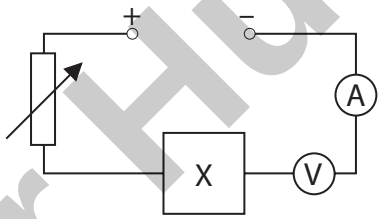
A ☒



B ☒



C ☒



D ☒

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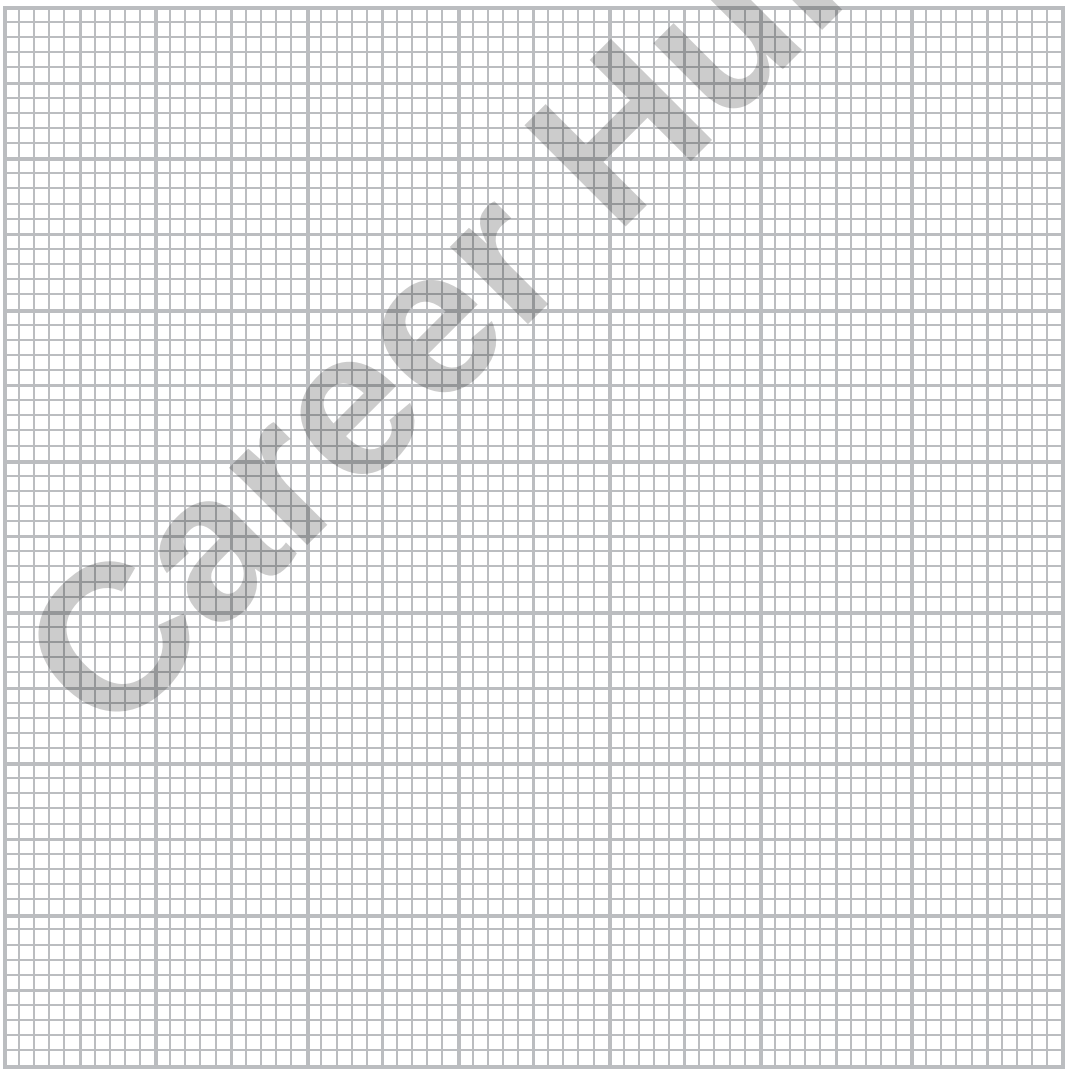
(b) The table shows the student's results.

Voltage across X in V	Current in X in A
0	0
3.0	0.5
14.5	2.3
19.5	2.9
25.0	3.2
29.5	3.3

(i) Plot a graph of these results and draw a curve of best fit.

(4)

current in A



voltage in V

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(ii) State the equation linking voltage, current and resistance.

(1)

(iii) Calculate the resistance of component X when the voltage across it is 10.0 V.

Give the unit.

(4)

resistance = ... unit .....

(iv) Describe the pattern shown by this graph.

(3)

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(v) Suggest a conclusion for the investigation.

(2)

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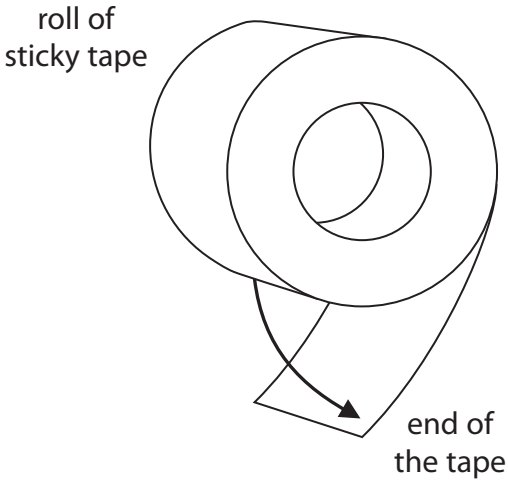
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8 A student holds a roll of sticky tape and pulls the end down as shown in the diagram.



This causes both the roll and the end of the tape to become electrically charged by friction.

(a) Explain how an object becomes charged by friction.

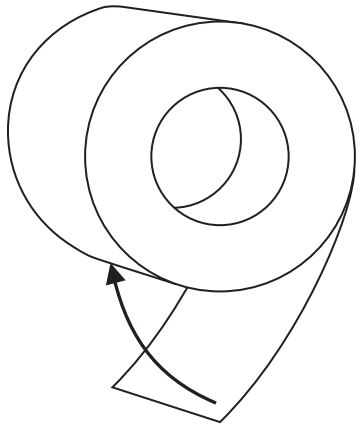
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(b) The student lets go of the end of the tape and the charges cause it to move towards the roll.



Explain why the end of the tape moves back towards the roll.

(2)

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9 A wind turbine generates electricity for the National Grid.



(a) The useful energy transfer in the wind turbine is

(1)

- ☒ **A** chemical energy to electrical energy
- ☒ **B** gravitational potential energy to electrical energy
- ☒ **C** kinetic energy to electrical energy
- ☒ **D** sound energy to electrical energy

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(b) The generator in the wind turbine transfers 39 MJ of energy in 1 minute.

The generator current is 490 A.

(i) Calculate the output voltage of the generator.

(3)

Voltage = ... V

(ii) The generator output voltage is then increased to 132 kV for transmission.

Explain why electrical energy is transmitted using very high voltages.

(4)

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(c) The generator provides a direct current (d.c.).

This d.c. is changed to an alternating current (a.c.).

The frequency of the alternating current is 50 Hz.

(i) Explain the meaning of **50 Hz alternating current**.

(2)

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(ii) Explain why the d.c. from the generator must be changed to a.c. before it is transmitted.

(2)

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10 Some energy sources are renewable and other energy sources are non-renewable.

a) (i) Explain what is meant by the term non-renewable.

(1)

.....

(ii) Give an example of a non-renewable energy source.

(1)

.....

(b) The photograph shows a wind farm that generates electricity for the National Grid.



(i) Some wind farms are in remote areas.

Explain how the electrical energy from a remote wind farm is transmitted to large cities.

(3)

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(ii) Some people think that wind farms are a good idea.

Others disagree.

Discuss the advantages and disadvantages of building more wind farms.

(6)

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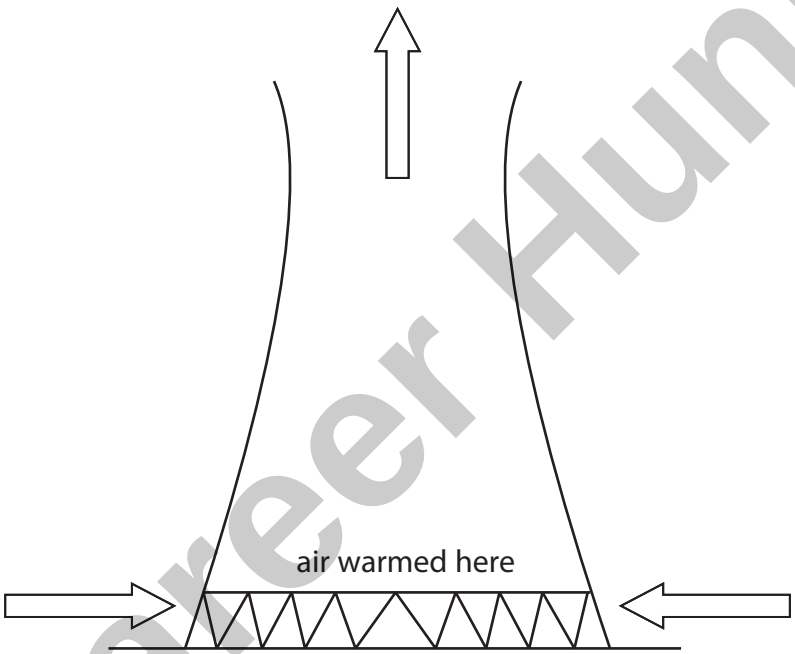
11 A cooling tower is designed to transfer thermal energy away from a power station.



© Copyright Alan Murray-Rust

(a) Thermal energy from the power station warms the air inside the cooling tower.

Air enters through holes at the bottom of the cooling tower and leaves through the top.



Explain why the air moves as shown by the arrows.

(4)

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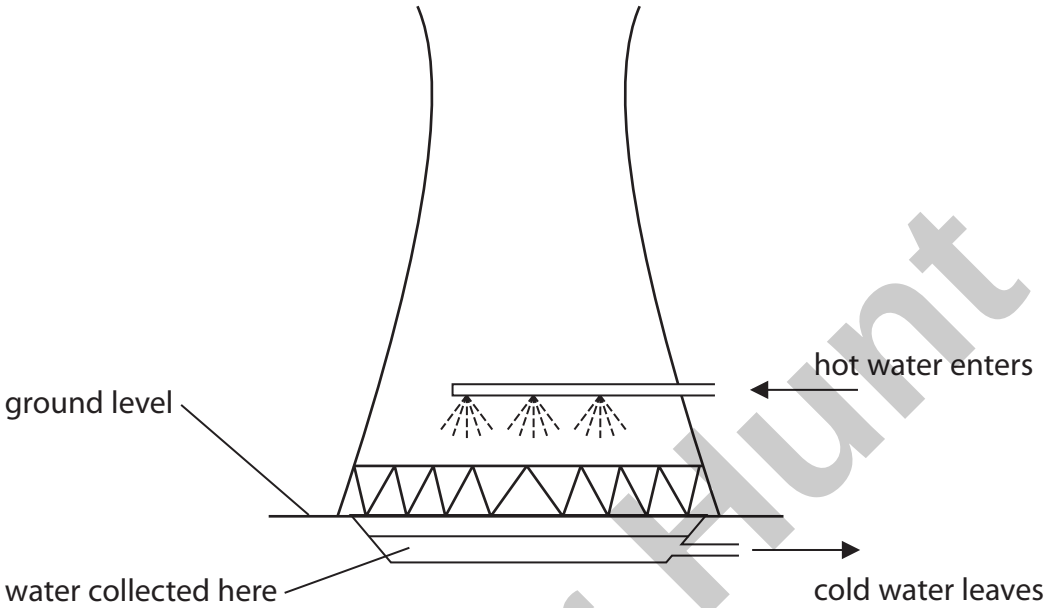
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(b) Hot water from the power station is sprayed into the cooling tower, as shown.

As it falls through the air, some of the hot water evaporates.

The rest of the water is collected and returned as cold water to the power station.



Explain how evaporation cools the water.

(3)

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12 An electric vehicle has a rechargeable battery.

The battery is recharged by connecting it to a charging station.



© Epattloamer

(a) The battery voltage is 385 V.

(i) State the amount of energy transferred when one coulomb of charge passes through a potential difference of 385 V.

(1)

energy transferred = ... J

(ii) Show that, when a charge of 180 000 C passes through the battery, the total amount of energy transferred to the battery is about 70 MJ.

(2)

(iii) During the charging process, energy is also transferred to the charging station from the mains supply.

Explain why the amount of energy transferred from the mains supply is more than 70 MJ.

(2)

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(b) Charging takes 110 minutes and causes a total charge of 180 000 C to pass through the battery.

(i) State the equation linking charge, current and time.

(1)

(ii) Calculate the average charging current in the battery.

(3)

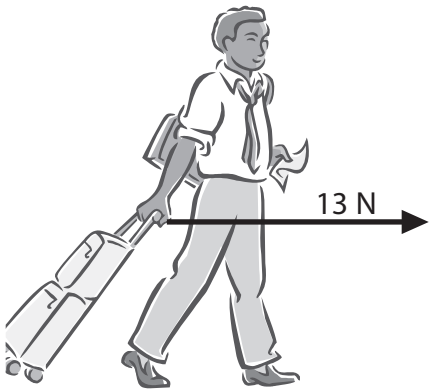
current = ... A

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13 A person has a suitcase with wheels.



(a) The person pulls the suitcase with a horizontal force of 13 N for 110 m.

(i) State the equation linking work done, force and distance moved.

(1)

(ii) Calculate the work done on the suitcase by the person.

(2)

work done = ... J

(iii) How much energy is transferred to the suitcase?

(1)

energy transferred = ... J

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(b) The suitcase falls over.



Explain why it loses gravitational potential energy when it falls.

(2)

.....

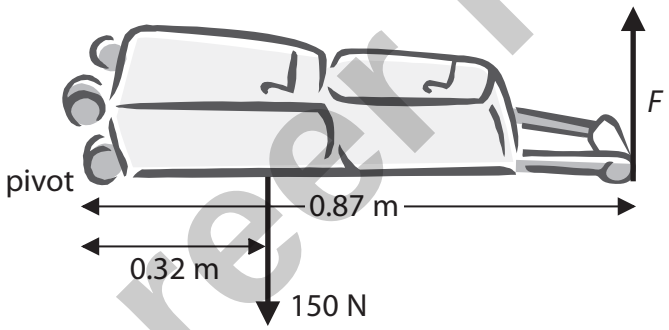
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.....

.....

(c) The person starts to raise the suitcase again by pulling on the handle with force *F*.

The weight of the suitcase is 150 N.



(i) State the equation linking moment, force and perpendicular distance from the pivot.

(1)

.....

(ii) Calculate the force *F* that the person must apply on the handle to start raising the suitcase.

(3)

force *F* = ... N

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14 A man uses a wheelbarrow to carry some logs along a flat path, as shown.



©http://commons.wikimedia.org/wiki/file:wheelbarrow_%28PSF%29.png

(a) He pushes with a horizontal force of 140 N and the wheelbarrow moves 39 m.

(i) State the relationship between work done, force and distance moved.

(1)

(ii) Calculate the work done moving the wheelbarrow.

(2)

work done = ... J

(iii) State how much energy is transferred to the wheelbarrow.

(1)

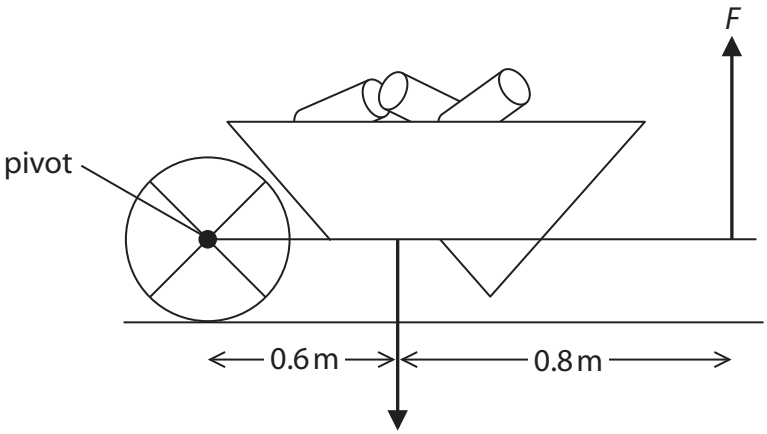
energy transferred = ... J

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(b) The man stops and holds the wheelbarrow horizontally, as shown.



The man exerts a total upward force of *F* N.

The weight of the loaded wheelbarrow is 470 N.

(i) Mark X on the diagram to indicate the centre of gravity of the loaded wheelbarrow.

(1)

(ii) State the equation linking moment, force and perpendicular distance from the pivot.

(1)

(iii) Calculate the force *F*.

(4)

force *F* = ... N

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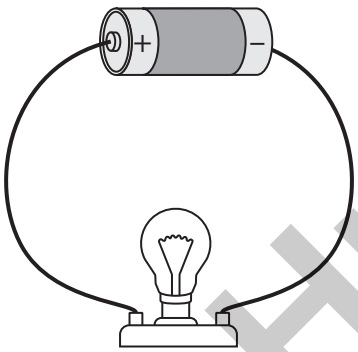
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15 (a) Which of these is a unit for energy?

(1)

- ☒ **A** joule
- ☒ **B** kilogram
- ☒ **C** newton
- ☒ **D** watt

(b) The diagram shows a cell connected to a lamp.



Use words from the box to complete the sentences.

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

(3)

chemical	trical	l	ork

The cell converts ..... energy into ..... energy.

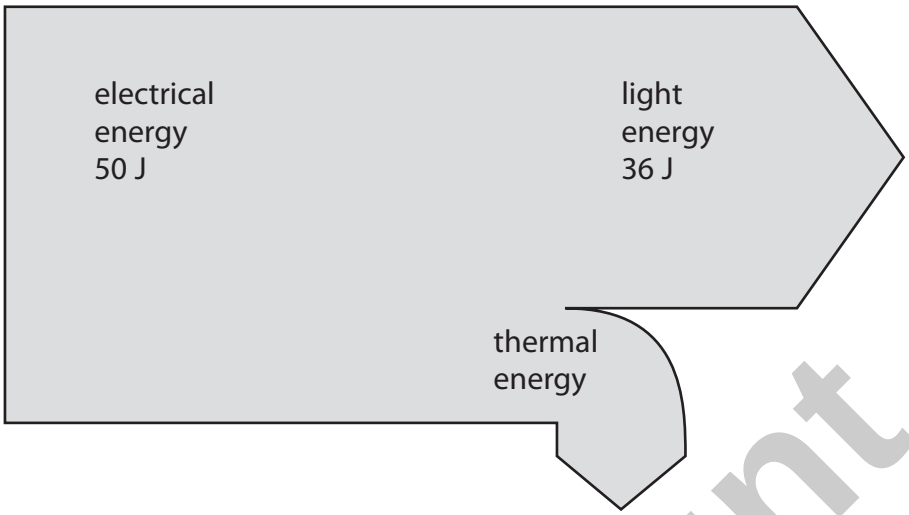
The lamp converts this energy into ..... energy and ..... energy.

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(c) This is the Sankey energy diagram for a low energy lamp.



(i) Calculate the amount of thermal energy wasted in the lamp.

(1)

thermal energy = ... J

(ii) State the equation linking efficiency, useful energy output and total energy input.

(1)

(iii) Calculate the efficiency of the lamp.

(2)

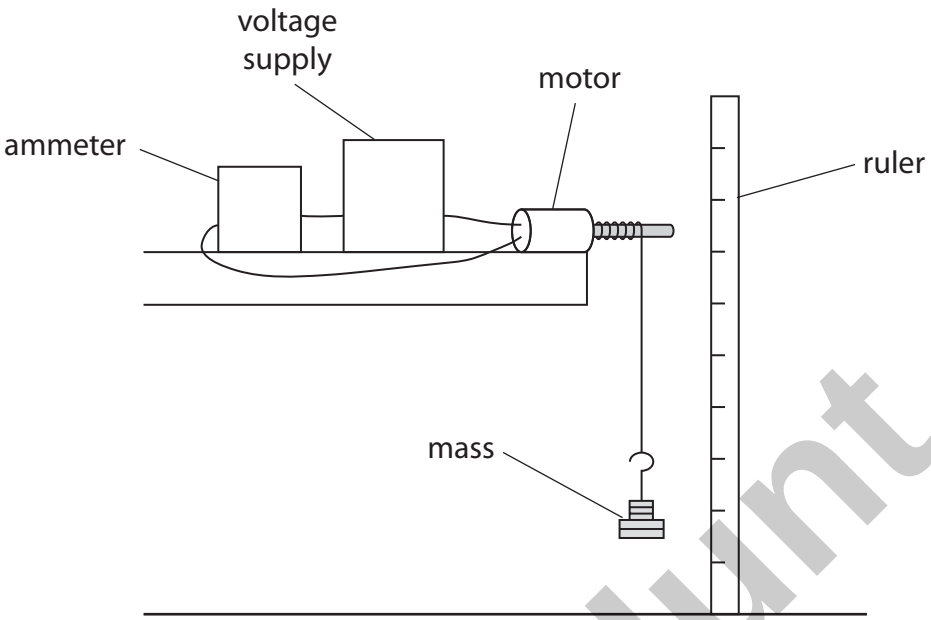
efficiency = ...

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16 (a) The diagram shows a motor lifting a 130 g mass.



The current in the motor is 2.1 A and the voltage across it is 12 V.

The motor takes 1.5 s to lift the mass.

(i) Calculate the electrical energy transferred to the motor as it lifts the mass.

Give your answer to two significant figures.

(3)

energy = ... J

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(ii) State the equation linking gravitational potential energy, mass, *g* and height.

(1)

(iii) The motor lifts a 130 g mass to a height of 63 cm.

Calculate the gravitational potential energy (GPE) gained by the 130 g mass.

(2)

GPE = ... J

(iv) Why is the amount of GPE gained by the mass less than the amount of electrical energy transferred to the motor?

(2)

.....

.....

.....

.....

.....

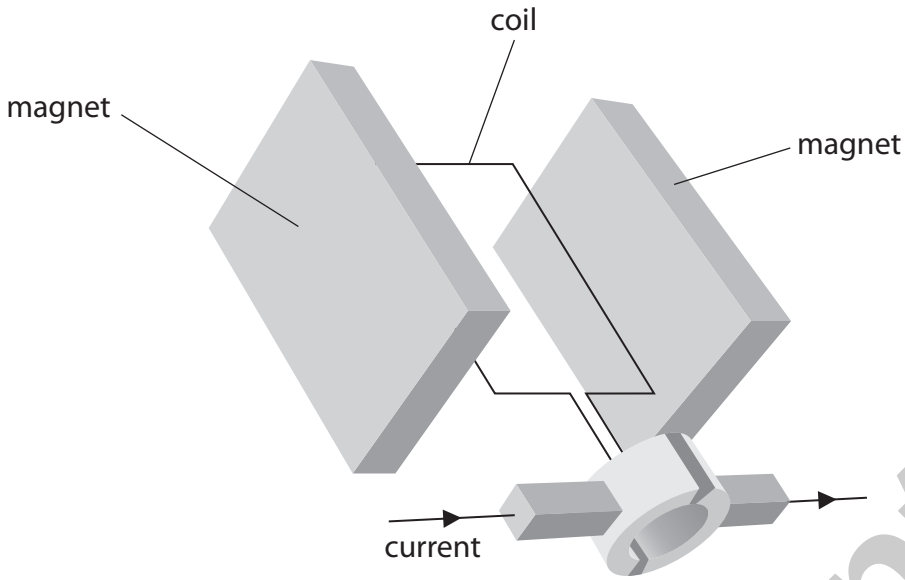
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(b) The diagram shows an electric motor and the direction of current.



Explain how the current produces movement of the coil.

(4)

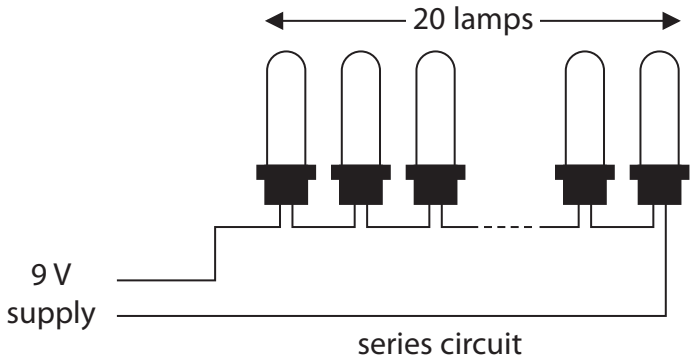
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17 The diagram shows some lamps connected together.

There are 20 small lamps connected in series with a 9 V supply.



(a) (i) What is the voltage across each lamp in the series circuit?

(1)

.....

(ii) Each lamp has a power of 1.5 W.

State the equation linking power, current and voltage.

(1)

(iii) Show that the current in the circuit is about 3 A.

(2)

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(b) (i) The lamps are on for 7 hours a day for 5 days.

Calculate the total energy transferred during this time.

(3)

energy transferred = ... J

(ii) Describe the energy changes that take place in the lamps when they are connected to the power supply.

(2)

.....

.....

.....

.....

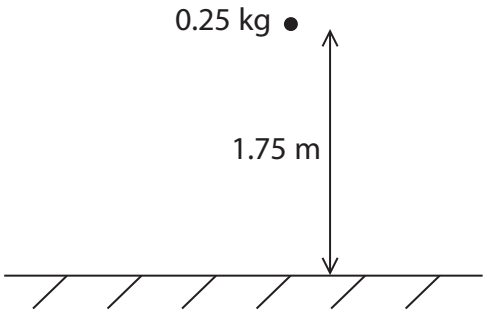
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18 A ball has a mass of 0.25 kg.

A student holds the ball 1.75 m above the ground.



(a) (i) State the equation linking gravitational potential energy (GPE), mass, *g* and height.

(1)

(ii) Calculate the gravitational potential energy of the ball.

(2)

GPE = ... J

(b) The student lets the ball fall.

State the value of the kinetic energy (KE) of the ball just before it hits the ground.

Assume that there is no air resistance.

(1)

KE = ... J

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(c) Another ball with the same mass has a kinetic energy of 3.1 J.

(i) State the equation linking kinetic energy, mass and speed.

(1)

(ii) Calculate the speed of the ball.

(3)

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speed = ... m/s

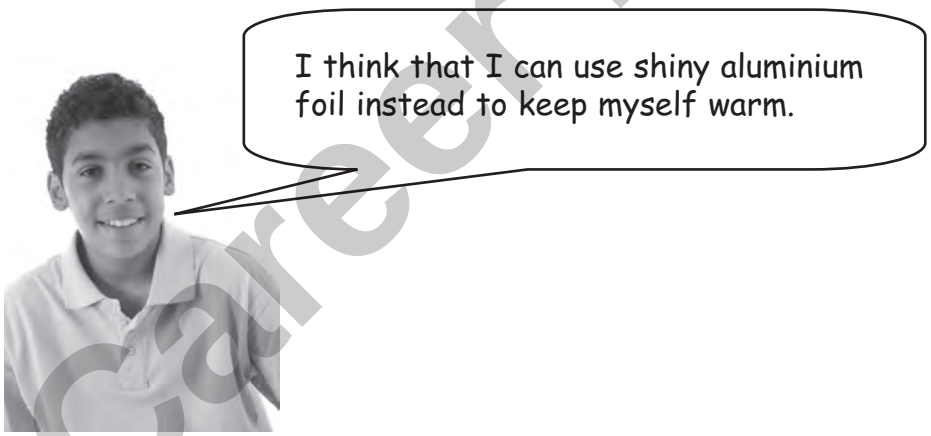
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19 A student feels cold at night and decides to sleep under a thick woollen blanket.

(a) Explain how the woollen blanket helps to keep the student warm.

(4)

(b) The student says



Do you agree with the student?

Explain why.

(1)

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20 The photograph shows a small aeroplane, of mass 600 kg.



This aeroplane has an electric motor powered by fuel cells.

Fuel cells use hydrogen gas and provide an electric current.

(a) When the aeroplane is working, the energy changes are

(1)

☒ **A** chemical → electrical → kinetic

☒ **B** electrical → chemical → kinetic

☒ **C** electrical → kinetic → chemical

☒ **D** kinetic → chemical → electrical

(b) The velocity of the aeroplane is 28 m/s.

(i) State the equation linking kinetic energy, mass and velocity.

(1)

(ii) Calculate the kinetic energy of the aeroplane.

(2)

Kinetic energy = ... J

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(c) The aeroplane takes off and climbs to a height of 1000 m.

(i) State the equation linking gravitational potential energy (GPE), mass, *g* and height.

(1)

(ii) Calculate the gravitational potential energy gained by the aeroplane.

(2)

GPE of the aeroplane = ... J

(iii) The fuel cells provide a maximum total power of 24 kW. The aeroplane also carries a large rechargeable battery.

Show, by calculation, that the aeroplane needs this extra source of power to climb to 1000 m in 3 minutes.

(2)

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(iv) The aeroplane uses fuel cells connected together in series in a 'stack'.

The voltage of each fuel cell is 0.6 V. The maximum current in each fuel cell is 30 A.

Show that there must be more than 1300 fuel cells in the stack.

(2)

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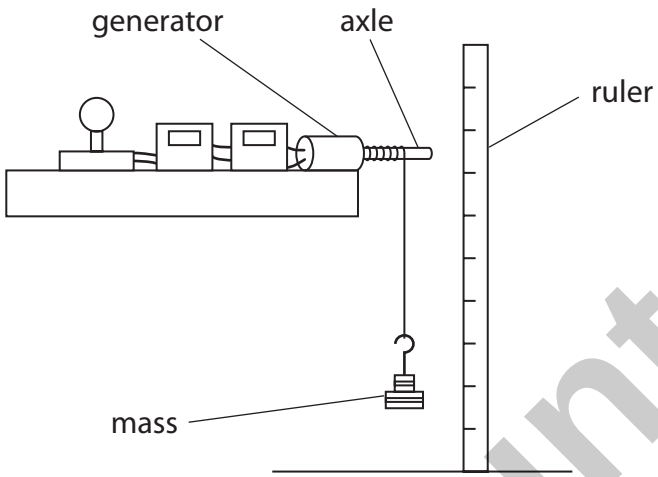
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21 (a) A student investigates the energy transfers in a small generator.

She connects the generator to a circuit that includes a lamp.

She hangs a mass from a string wound around the axle.

The lamp lights as the mass falls to the ground.



The table shows the student's results.

height that mass falls	0.61 m
mass	2.75 kg
time taken for mass to fall	1.3 s
average current in the lamp	0.46 A
average voltage across the lamp	12.7 V

(i) State the equation linking gravitational potential energy, mass, *g* and height.

(1)

(ii) Calculate the gravitational potential energy, GPE, lost by the mass.

(2)

GPE = ... J

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(iii) Explain why only some of the gravitational potential energy of the mass is transferred to the lamp.

(2)

(iv) Calculate the energy transferred to the lamp.

(2)

energy transferred = ... J

(b) Water from a reservoir can be used to generate electricity on a large scale.

Describe the energy transfers involved in this process.

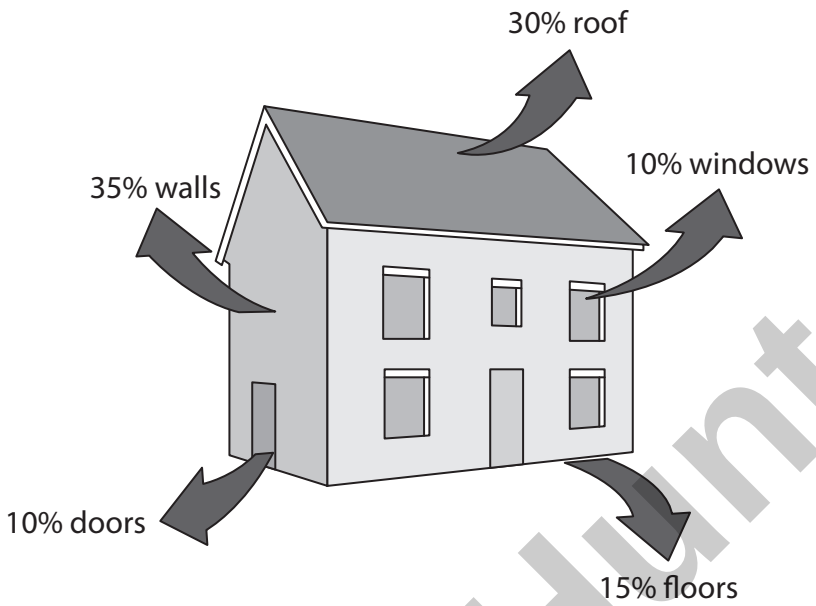
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22 The diagram shows typical values for the percentage energy losses from a house.



(a) Most energy is lost through

(1)

- ☒ **A** the floors
- ☒ **B** the roof
- ☒ **C** the walls
- ☒ **D** the windows

(b) The total percentage energy loss from the roof and the windows is

(1)

- ☒ **A** 10%
- ☒ **B** 20%
- ☒ **C** 30%
- ☒ **D** 40%

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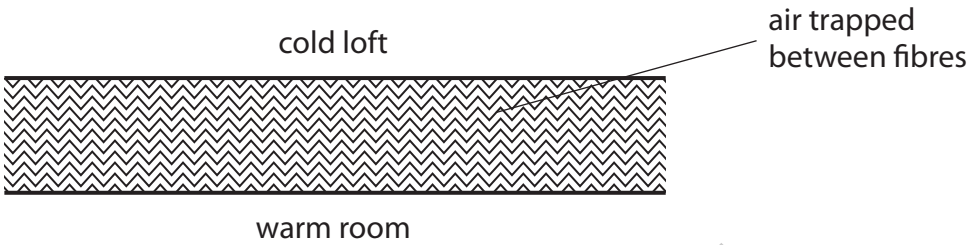
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(c) Insulation is used to reduce energy losses from houses.

Insulating material often consists of fibres with air between them.

The diagram shows a section through some insulating material.



(i) Explain how this type of insulation reduces energy loss by **conduction**.

(2)

.....

.....

.....

.....

.....

(ii) Explain how this type of insulation reduces energy loss by **convection**.

(2)

.....

.....

.....

.....

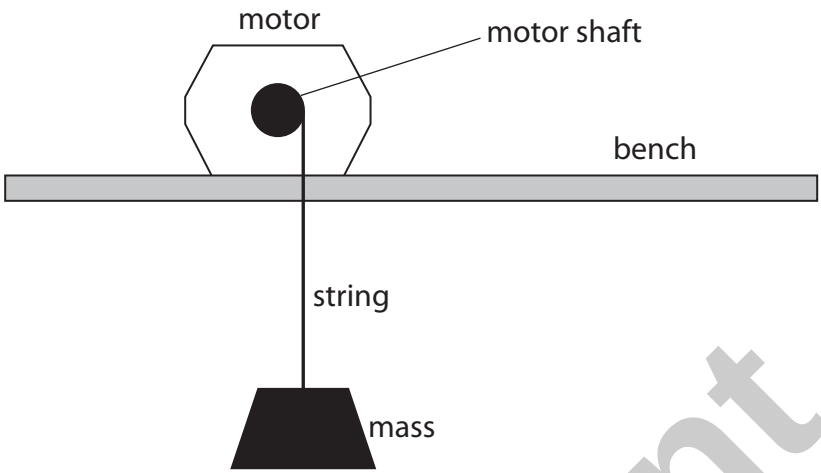
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23 A student investigates the efficiency of an electric motor.



She uses the motor to lift a mass.

The table shows her measurements.

Current in motor	1.3 A
Voltage across motor	10.3 V
Time taken to lift mass	4.7 s
Force needed to lift mass	20 N
Distance the mass was lifted	0.85 m

(a) Calculate the electrical energy supplied to the motor during this time.

(2)

energy supplied = ... J

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(b) (i) State the equation linking work done, force and distance moved.

(1)

(ii) Calculate the work done on the mass.

(2)

work done = ... J

(iii) State the useful energy transferred to the mass.

(1)

.....

(c) (i) State the equation linking efficiency, useful energy output and total energy input.

(1)

(ii) Calculate the efficiency of the motor.

(2)

efficiency = ...

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24 A shopping centre has escalators to move people between floors.



(a) A man of mass 78 kg steps on to an escalator.

The escalator lifts him a height of 5.0 m.

(i) State the equation linking gravitational potential energy, mass, *g* and height.

(1)

(ii) Show that the gravitational potential energy gained by the man is about 4000 J.

(2)

(iii) State the work done on the man and give the unit.

(2)

Work done = ... Unit .....

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(b) The escalator is powered by a 7.5 kW electric motor.

(i) State the equation linking efficiency, useful energy output and total energy input.

(1)

(ii) The escalator lifts 30 people each minute.

Each person has a mass of 78 kg.

Calculate the efficiency of the escalator.

(3)

Efficiency = ...

(c) Another escalator has an efficiency of 20%.

Its input power is 15 kW.

Draw a Sankey diagram for this escalator.

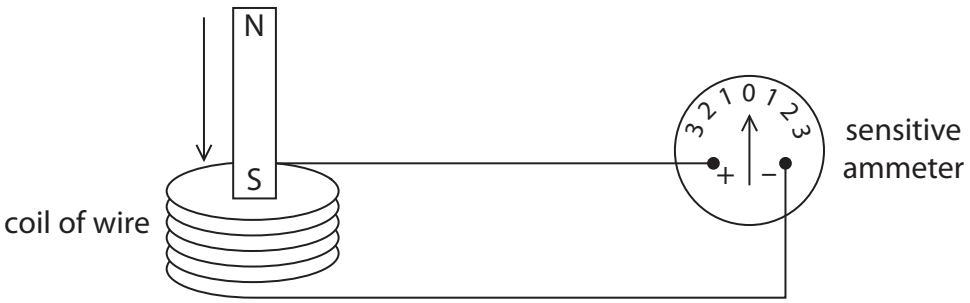
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25 (a) A student uses this apparatus to investigate electromagnetic induction.



When the S pole of the magnet is moved into the coil, the pointer on the sensitive ammeter moves to the left.

Describe two ways that the student can make the pointer move to the right.

(2)

1 .....

.....

2 .....

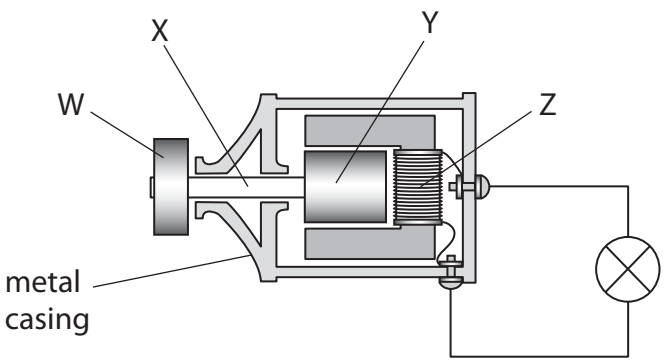
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(b) The student has a bicycle with a dynamo (generator) that supplies electricity for its lights. The diagram shows the dynamo.

The friction wheel, W, presses against the bicycle tyre. When the student pedals, the friction wheel turns and causes part Y to rotate.

Key

W	friction wheel
X	axle
Y	
Z	



(i) Complete the key for the diagram by giving the names of parts Y and Z.

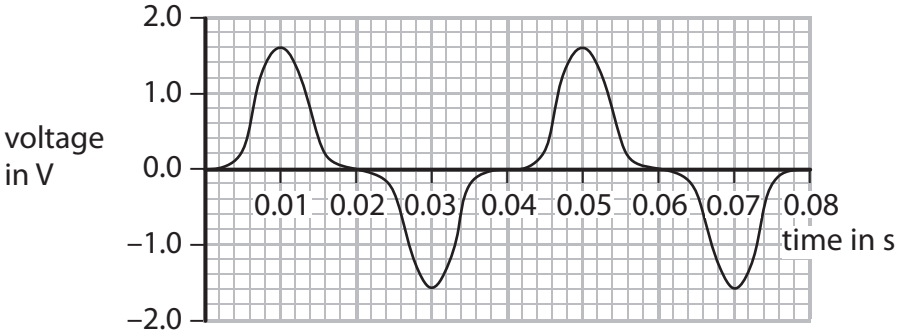
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(ii) The graph shows how the output voltage of the dynamo varies with time as the student pedals steadily.



State the maximum output voltage of the dynamo.

(1)

maximum output voltage = ... V

(iii) Calculate the frequency of the output voltage.

(2)

frequency = ... Hz

(iv) Which row of the table is correct when the friction wheel turns faster?

(1)

	Output voltage is	Frequency of output voltage is
☒ **A**	lower	lower
☒ **B**	higher	lower
☒ **C**	higher	higher
☒ **D**	lower	higher

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(v) Apart from changing the speed of the friction wheel, suggest how the output voltage of the dynamo can be increased.

(1)

.....

.....

(c) The student cycles for 290 s.

Her dynamo produces a constant useful power output of 3.1 W and is 72% efficient.

(i) Calculate the total useful energy output.

(3)

useful energy output = ... J

(ii) State the relationship between efficiency, useful energy output and total energy input.

(1)

(iii) Calculate the total energy input.

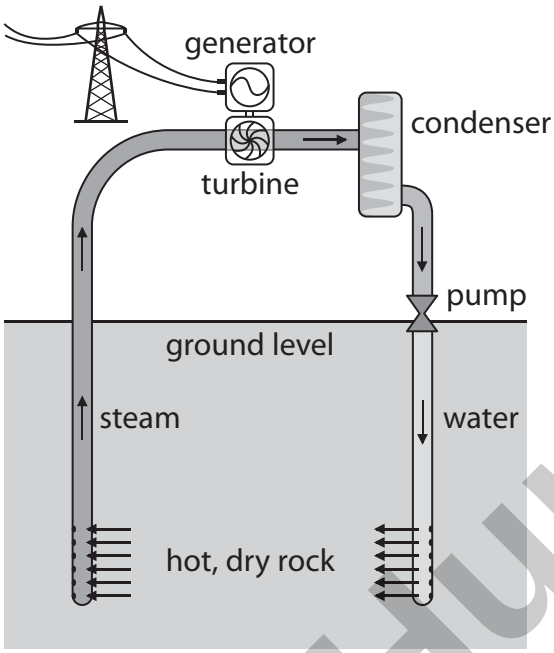
(3)

total energy input = ... J

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26 The diagram shows a type of power station used to generate electricity.



(a) (i) What type of renewable resource does this power station use?

(1)

.....

(ii) Name another renewable resource.

(1)

.....

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(b) Cold water is pumped down into the hot, dry rock.

Describe the energy transfers at each stage of electricity generation from this resource.

(4)

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27 The photograph shows equipment used for generating electricity from renewable sources.



(a) Complete the sentences using words from the box.

chemical	**t**	**kinetic**	**light**	**sound**

(i) The panel of solar cells transforms ..... energy into electrical energy.

(1)

(ii) The wind turbine transforms ..... energy into electrical energy.

(1)

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(b) On a windy day, the wind turbine transfers 78 W of power.

(i) State the equation linking power, energy transferred and time.

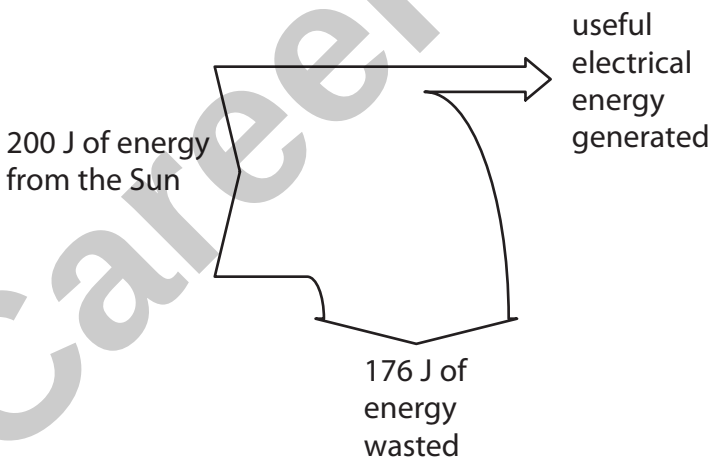
(1)

(ii) Calculate the amount of energy the turbine transfers in 10 s.

(3)

Energy transferred = ... J

(c) The Sankey diagram shows the energy transferred by the panel of solar cells.



Show that the efficiency of the panel of solar cells is 12%.

(2)

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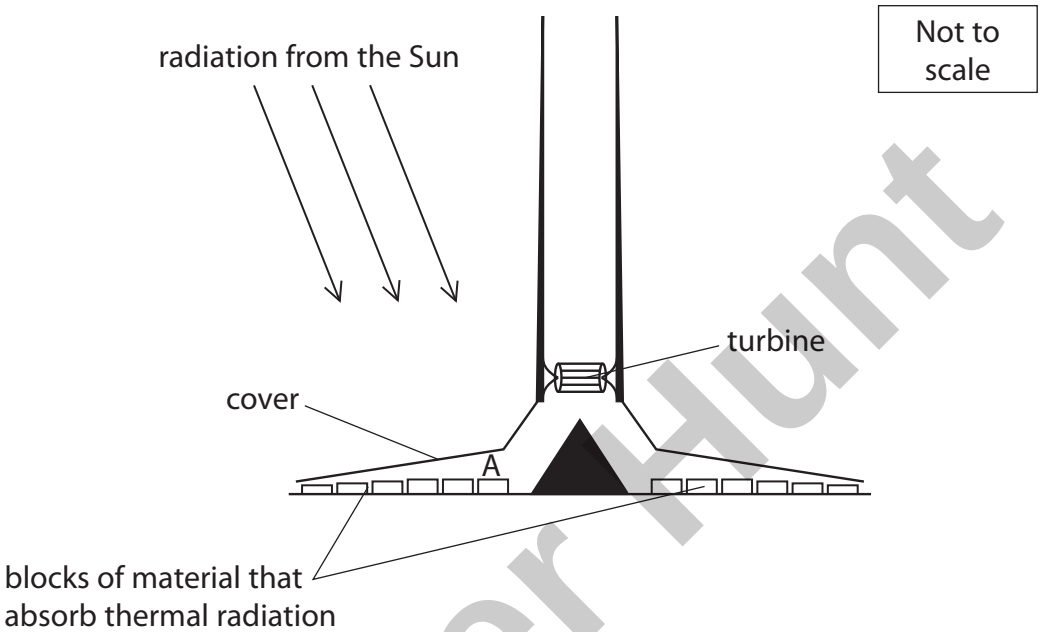
28 An experimental solar updraft tower (SUT) was built in the south of Spain.

This part of Spain has little rainfall and is hot in summer months.

The SUT was used as a 50 kW electricity generator.

The diagram shows the component parts of the tower.

The cover allows visible light to pass through but traps infrared. Rows of blocks under the cover absorb thermal radiation.



(a) (i) Explain what happens to the air at A just under the cover.

(3)

.....

.....

.....

.....

.....

.....

(ii) On the diagram, mark the directions of the air movements over the blocks of material and through the turbine.

(2)

(iii) State the name of this effect.

(1)

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(b) (i) Complete the energy transfer diagram for a SUT.

(2)

..... → ..... → electrical

(ii) Describe how a SUT can be used to generate electricity.

(2)

.....

.....

.....

.....

(c) (i) Suggest why the SUT generates most electricity during daylight hours.

(1)

.....

.....

(ii) Suggest why there are blocks of material that absorb thermal radiation in the SUT.

(1)

.....

.....

(iii) Suggest an alternative to these blocks that would improve the total energy output of the SUT.

(1)

.....

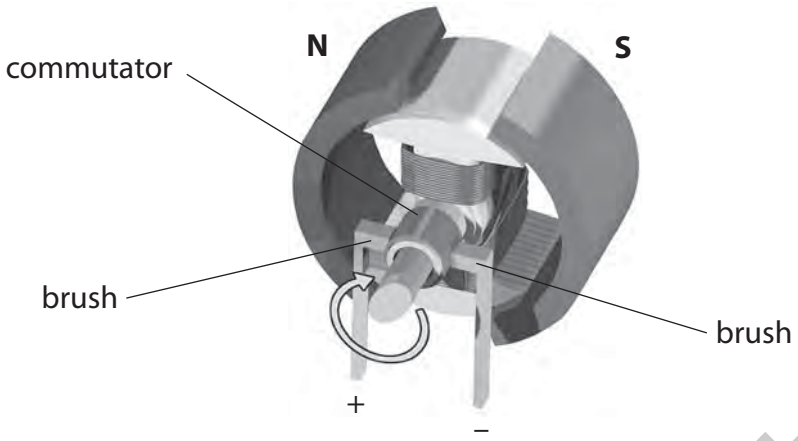
.....

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29 The diagram shows an electric motor.



(a) This electric motor needs a direct current (d.c).

(i) Explain what is meant by the term direct current.

(1)

.....

.....

(ii) Explain the purpose of the brushes and the commutator in a d.c. motor.

(3)

.....

.....

.....

.....

.....

.....

(iii) The motor turns clockwise when the direction of the current goes from + to – .

State what happens to the motor when both the magnetic field and the current are reversed.

(1)

.....

.....

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(b) The photograph shows a machine at a coal mine.



© Andrew Curtis

The machine lifts up containers of coal from the mine and lowers empty containers down.

The machine uses an electric motor connected to a 600 V d.c. supply.

The maximum current in the motor is 4000 A.

(i) State the equation linking power, current and voltage.

(1)

(ii) Calculate the maximum power available from the motor.

(2)

maximum power = ... MW

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(c) The machine lifts a load weighing 400 000 N through 190 m.

(i) State the relationship between work done, force and distance moved.

(1)

(ii) Calculate the work done on the load.

(2)

work done on load = ... J

(d) The machine uses an average (mean) power of 1.9 MW to do 67 MJ of work.

(i) Calculate the time needed to do this work.

(3)

time = ... s

(ii) State the effect of using a lower average power to do this work.

(1)

.....

.....

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Chapter 4: Energy Resources and Transfers Answer

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Question number	Answer	Notes	Marks
1	five suitable comments: O/P = output power **Wind** • wind O/P is (far) too low (to meet demand)/the lowest; • (can't rely on) wind O/P is weather dependent; **Gas** • gas O/P (too) low /need many gas power stations (to meet demand); • gas (turbine) is the fastest to start up; **Tidal** • tidal gives the highest O/P; • tidal only occurs at fixed times (so is not useful); **Nuclear** • nuclear O/P is (relatively) high; • nuclear takes too long to start up; **Coal** • coal O/P is second highest; • coal second fastest to start up; **Evaluation statement(s)** • none of them is enough to meet the power demand; • nuclear/wind/tidal would be unsuitable; OR coal or gas could be suitable; OR a mixture of stations would be suitable; **Costs** **allow 1 mark for relevant statement**	ignore comments about • renewable • non-renewable • green-house effect • climate change • pollution can't be used for sudden need/RA e.g. coal is most expensive fuel gas is second most expensive fuel total marks =5	5

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Question number	Answer	Notes	Marks
2 (a) (i)	B - 960 joules per second;		1
(ii)	power = current x voltage;	allow equation as correct symbols and/or rearrangement e.g. I = P ÷ V	1
(iii)	appropriate calculation (including substitution OR rearrangement); answer to at least 2 sf seen anywhere; e. 960 = I × 230 (I =) 4.2 (A)	using 4 (A) to calculate power (920 W) or voltage (240 V) scores 1 mark max. (4.17391) allow 4.1 (A)	2
(b) (i)	any 3 of: MP1. large **current** to earth / in earth wire; MP2. fuse blows / melts / breaks; MP3. idea that circuit is broken; MP4. idea that the risk of shock is reduced / prevented;	ignore references to electricity or charge allow 'current surge' for large current 'ground' for earth ignore references to fire	3
(ii)	D - 13 A;		1
(c)	MP1. a way of measuring current e.g. ammeter; MP2. a **method** to vary current in fuse; MP3. a **method** of identifying that the fuse has broken e.g. lamp goes out, idea that current falls to zero etc.;	accept any points seen in diagram allow data logger allow **variable** power supply, **variable** resistor	3

Total 11 marks

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Question number			Answer	Notes	Marks
3	a		B;		1
			E;		1
	b	i	p = m.v	in words or accepted symbols do not accept 'M' for momentum	1
		ii	substitution; evaluation; e.g. 900 x 15 14 000 unit = kg m/s OR N s;	 13 500 Independent Allow kg ms^{-1}	3
		iii	KE = ½ m.v^2;	in words or accepted symbols allow speed for velocity	1
		iv	substitution; evaluation; e.g. 0.5 x 900 x 15^2 100 000(J)	 101 250 Allow 101 000	2
				total = 9 marks	

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Question number	Answer	Notes	Marks
4	Any FOUR suitable points where ever seen Location, e.g. MP1. Latitude / Sun angle; MP2. suitability of site – e.g. enough area for solar array; MP3. geological factor – e.g. accessible source of heat / hot water; MP4. proximity of population/cities; Climate, e.g. MP5. Effect of seasons; MP6. hours of sunlight; MP7. intensity of sunlight; MP8. geothermal power station unaffected by climate;	Allow arguments for or against e.g. build solar on the equator e.g. no shadow from hills/trees e.g. volcanic activity e.g. rainy season e.g. short winter days, sunny all year round e.g. strong sun, cloudy	4

(Total for Question 4 = 4 marks)

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Question number			Answer	Accept	Reject	Marks
5	(a)		Any one of Reduced (running) costs; No atmospheric pollution / CO_2; Renewable (resource);	 No polluting emissions No greenhouse gases Cleaner (only if qualified)	The wind is free No costs	1

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Question number			Answer	A	Reject	Marks
5	(b)		Up to two points about each of unreliability, environmental issues, site choice, maintenance difficulties, data use, or cost. 1 mark per point to a maximum 4 marks Unreliability - the wind does not always blow (at the right speed); the turbine does not always provide output OR a back-up generator is needed; Environmental effects - spoils the view OR is noisy; (construction) destroys habitats OR a hazard to flying birds; Site choice – a large site is needed; a windy site is needed; Maintenance difficulties – need to work in remote location (usually); need to work in a hazardous location e.g at height / sea; Data use – one turbine produces less power than a power station; need many/800 turbines to give same output as coal-fired; Cost – building a wind farm needs much money / time; other costs for research / land / maintenance;	Accept – appropriate reverse arguments in terms of the suitability of coal-fired power stations Ignore comments about efficiency or cost effectiveness		4
					Total	**5**

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Question number	Answer	Notes	Marks
6 (a) (i)	turbine		1
(ii)	C generator		1
(b) (i)	power = voltage x current	Allow: equivalent arrangements Allow: P=IV etc Reject use of units for quantities	1
(ii)	Correct equation (any arrangement); e.g.: power in = power out / $V_{IN}I_{IN} = V_{OUT}I_{OUT}$ / $I_{IN}/I_{OUT} = V_{OUT}/V_{IN}$ Correct substitution; e.g.: V_{OUT}/V_{IN} = 115/25 (or 4.6) OR I_{OUT}/I_{IN} = 25/115 (or 0.22) Correct deduction based on working: e.g. output current is smaller	Accept: 5/23 and correct conversion to volts Bald 'output current smaller' = 0 mark Bald 'output current 4.6 times smaller' = 3 marks	3
(iii)	(lower current leads to) less (resistive) energy /heat/ power losses		1

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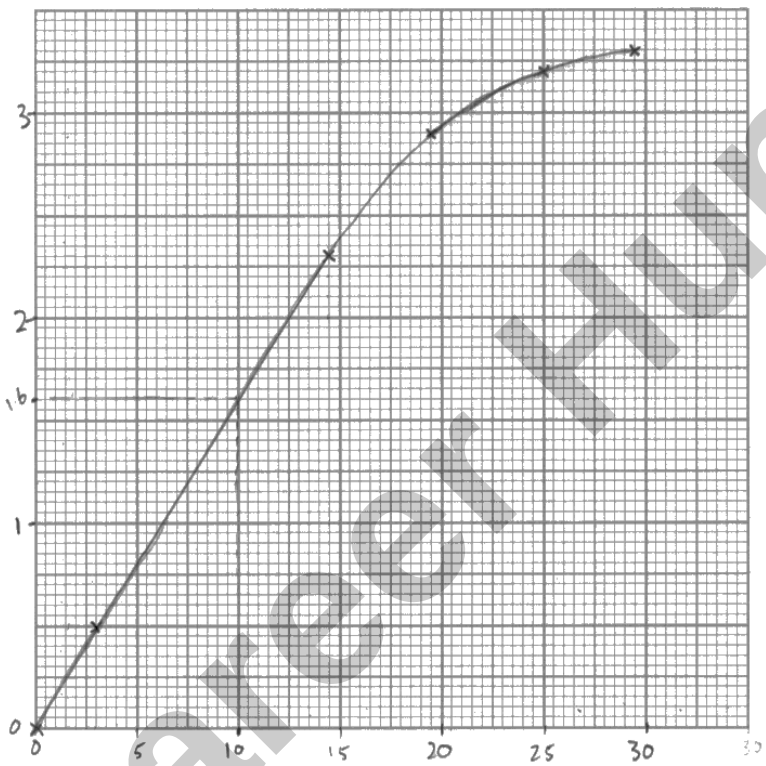
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Question number	Answer	Notes	Marks
6 (c)	ANY FOUR FROM Radioactive / emits radiation; High activity; Long half live / need for long term storage; Danger / harm to people /environment; Expensive to contain / dispose of; Need for security /shielding / burial; Social aspect eg. location of storage;		4

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Question number	Answer	Notes	Marks
7 (a)	A		1
(b) (i)	suitable scales; 6 points plotted;; curve of best fit;	• Must use > half width and half height of grid • to nearest ½ square, up to two marks available for this, -1 each error • reject dot to dot • allow a reasonably smooth curve, points should be evenly distributed about the line	4



Voltage across X in V	Current in X in A
0	0
3.0	0.5
14.5	2.3
19.5	2.9
25.0	3.2
29.5	3.3

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(ii)	V= I x R	in words, or accepted symbols or rearranged	1
(iii)	value of I from graph; rearranged equation/sub into equation; evaluation; unit; e.g. I= 1.6 (±1/2 a small square) 10 = 1.6 x R OR R = 10/1.6 R= 6.3 Ω / ohms	allow ECF from graph answers without working can gain full marks R= 6.25 allow answers which round to a number in the range 5.8 to 6.3	4
(iv)	any three **descriptions** from:- MP1. as V increases I increases (at first); MP2. constant gradient/constant R (at first); MP3. I is proportional to V; MP4. gradient changes at high voltage/eq; MP5. ΔI smaller (than previously) for V > 15V;	allow as I increases V increases graph line linear (at first) nonlinear above ~ 15 V graph is less steep at high voltage R increases for V > 15V (to ~8Ω) ignore slows down positive correlation	3

(v)	any two **conclusions** from:- MP1. resistance is constant at first; MP2. **resistance** is not constant / **resistance** increases as V (or I) increases; MP3. because X gets hot(ter); MP4. X is a filament lamp; total marks = 15	allow V and I are proportional at first, it obeys Ohms law at first non-ohmic /does not obey Ohms law / V and I are not proportional increasing temperature	2

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Question number	Answer	Notes	Marks
8 (a)	any 3 of: MP1. idea of {rubbing / tearing} of {materials / surfaces}; MP2. idea of movement / transfer of electrons; MP3. electrons have negative charge; MP4. (object becomes) negatively charged by gaining electrons OR positively charged by losing electrons; MP5. need for insulating material(s);	movement of positive {charge / electrons} can only score MP1 and MP5 ignore 'friction'	3
(b)	any 2 of: MP1. idea of **opposite** charges OR positive and negative charges; MP2. idea of attraction; MP3. idea of an (attractive) force larger than the weight of the loose end of tape;	reject if mentions positive electrons ignore 'different' condone 'unlike'	2

Total 5 marks

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Question number		Answer	Notes	Mar
9(a)		C (kinetic energy to electrical energy)		1
(b) (i)			No mark for stating the formula, since E = I x V x t is given on page 2	3
		Conversion to seconds; Substitution into correctly rearranged equation; Calculation; e.g. (time =) 60 (s) $\frac{39\ 000\ 000}{(490 \times 60)}$ 1300 (V)	60 seen in working 1330, 1327, 1326.5 (V) Correct answer without working scores full marks Allow 1.3 kV for THREE marks Allow Power of Ten error , for a maximum of TWO marks e.g. 1.326 x10^{-3}, 1.33, 130	
(ii)		Any four of MP1 (High voltage leads to) low current; MP2 mention of a relevant equation e.g. P=IV, $P=I^2R$; MP3 Less energy is lost (from the wires); MP4 More efficient; MP5 can use thinner wires;	 Allow less heat loss Ignore cost argument Allow: Can transmit the energy further	4
(c) (i)		Current that changes direction (continuously); 100 times per second;	Allow switches from +ve to –ve Allow 50 times/cycles per second. Allow time period e.g. 0.01 s, 0.02 s, 1/50s	2
(ii)		Transformers change the voltage / current; Transformers use alternating current / a.c.;	Allow step-up, step-down Allow reverse argument	2

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Question number	Answer	Notes	Marks
10(a) (i)	idea that Energy source which cannot be **replaced**;	allow: • can't be used again • supply is limited in time • can't be replenished (for a long time) • can't be regenerated ignore: • can' be recycled • can't be stored • unqualifie 'finite/limited/will run out' • not sustainable • can be used up	1
(ii)	Any from for 1 mark; Coal Oil or named fuel Gas	allow: crude oil fossil (fuel(s)) petrol diesel gasoline kerosene paraffin methane butane propane ignore: burning fuel(s)	1

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Question number	Answer	Notes	Marks
(b) (i)	AT WIND FARM: any one from • Step-up transformer used at the wind farm; • volt ge increased (for transmission); DURING TRANSMISSION: any one from • transmitted at (high voltage and) low current; • no/little energy is wasted during transmission; AT CITY END: any one from • Step down transformer at 'other end'/OWTTE; • voltage reduced to 230V/for safety/for homes;	allow: description of a transformer Allow small voltage loss in transmission	3

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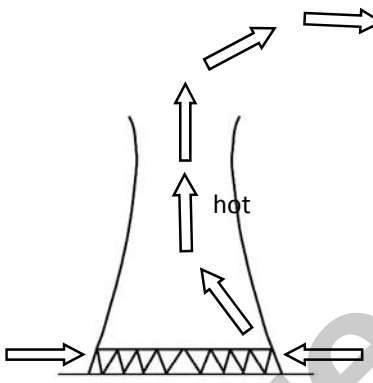
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Question number	Answer	Notes	Marks
(b) (ii)	Answer to a maximum of SIX marks to include: up to 4 **ideas** from advantages and up to 4 **ideas** from disadvantages **Annotate with ticks / underlining** advantages 1. Renewable energy resource; 2. No /little carbon emission or air pollution *OR* will not add to global warming OR little pollution; 3. Source of energy is free *OR* low running costs; 4. Brings employment/construction to some remote areas *OR* good for the local economy; 5. Lots of energy available OR abundant source *OR* wind farm can generate large amounts of electricity; 6. wind turbines can be more **efficient** than conventional power stations; disadvantages 1. Unsightly/ugly *OR* can damage views/ blight landscapes / local people may find them an intrusion; 2. Can be noisy/ causes noise pollution; 3. Only work when the wind blows/ above certain wind speed *OR* no constant output of electricity OR not reliable; 4. Each generator can only generate a small amount of electricity *OR* many are needed to supply the amount of electricity required for a city; 5. Costly to construct /maintain; 6. can only be placed in certain areas OR require large areas;	If a single word list, penalise by ONE mark accept suitable/sensible alternatives ignore: • environmentally friendly • cheaper than fossil fuels • kills birds /harming animals • unqualified 'expensive' /'high costs' • safer • carbon-neutral • unqualified 'more efficient'/ 'high efficiency'	6
		Total	**11**

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Question number	Answer	Notes	Marks
11(a)	any four of: MP1. (due to) convection; MP2. (heated) air expands OR molecules move apart; MP3. (heated) air becomes less dense; MP4. **hot** / **less dense** air rises; MP5. idea that air entering from outside is **cool(er)**; MP6. (above the cooling tower) air cools and {contracts / becomes more dense}; MP7. **cool** / **denser** air falls (outside the cooling tower); MP8. process (of convection) is repeated / continuous; e.g. (diagram for MP4, MP5, MP7 and MP8)  	allow particles for molecules reject 'molecules expand' reject 'molecules become less dense'	4
(b)	any three of: MP1. temperature proportional to (average kinetic) energy; MP2. idea that particles leave the surface / escape the liquid / turn into a gas; MP3. highest energy **particles** leave the liquid; MP4. idea that (average kinetic) energy of (remaining particles in) liquid is reduced;	 allow idea that gas **particles** have higher (average kinetic) energy / speed than particles in liquid; allow (average) speed of particles in liquid reduced	3

Total 7 marks

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Question number	Answer	Notes	Marks
12(a) (i)	385 (J);		1
(ii)		reverse calculation e.g. calculating a voltage or charge gains 1 mark max.	
	substitution into E=QV; evaluation to at least 2 s.f.;	if no other mark given allow 1 mark for 10^6 or 1000000 seen in working	2
	e. (E =) 385 × 180 000 (E =) 69 000 000 (J) / 69 (MJ)	allow ecf from 8(a)(i) value	
(iii)	MP1. idea of <u>energy</u> wasted; MP2. appropriate mechanism;	allow not 100% efficient, <u>energy</u> lost e.g. heat in wires	2
(b) (i)	charge = current × time;	allow abbreviations e.g. Q = I × t or rearrangements	1
(ii)	substitution; rearrangement; evaluation; e. 180 000 = current x (110 x 60) (current =) 180 000 / (110 × 60) (current =) 27 (A)	ignore not converting time to seconds until evaluation allow 27.3, 27.27… 1600, 1640, 1636 etc. gain 2 marks if no other mark given allow 1 mark for 60 seen anywhere in working (attempt to convert to seconds)	3

Total 9 marks

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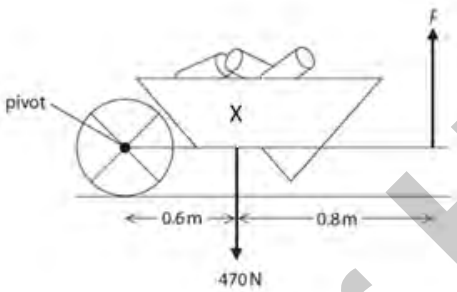
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Question number	Answer	Notes	Marks
13 (a) (i)	Work done = force x distance moved;	Allow W = F x d and rearrangements	1
(ii)	Substitution into correct equation; Calculation; e.g. 13 x 110 1430 (J)	Correct answer without working scores 2 marks	2
(iii)	Same response as for 3(a)(ii)	1430 (J) or ecf	1
(b)	Any two of - MP1 Idea that GPE depends on height OR Statement that GPE = mgh; MP2 Idea that h is reduced; MP3 Idea that centre of gravity (is now) lower;	 Allow centre of mass for centre of gravity	2
(c) (i)	Moment = force x (perpendicular) distance (from the pivot);	Allow moment = F x d and rearrangements	1
(ii)	Calculate given moment; Equate moments; Calculation; e.g. (150 x 0.32) = 48 for one mark 150 x 0.32 = F x 0.87 for two marks F (= 150 x 0.32 / 0.87) = 55 (N) for three marks	If no other mark gained, allow a statement that "clockwise moment = anticlockwise moment" for one mark 55.172 (N)	3

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Question number	Answer	Notes	Marks
14 (a) (i)	work done = force × distance (moved);	Accept correct symbols e.g. W = F x d W = F x s	1
(ii)	substitution; evaluation; e.g. (work =) 140 × 39 5500 (J)	 5460	2
(iii)	same answer as 5(a)(ii)	allow 'the same'	1
(b) (i)	X in line with the weight arrow and vertically between the tail of the arrow and the top of the wheelbarrow (not including the logs);  	judge alignment with weight arrow by eye	1
(ii)	moment = force × (perpendicular) distance (from pivot);	condone M = F x d M = F x s	1
(iii)	principle of moments (stated or implied); total distance hand to pivot calculated; substitution showing either correct moment (or both); final rearrangement and evaluation; e.g. (total) clockwise (moment) = (total) anticlockwise (moment) (distance) = 0.6 + 0.8 = 1.4 m 470 × 0.6 = F × 1.4 F = 470 × 0.6 / 1.4 = 200 (N)	 accept 1.4 or 0.6 + 0.8 seen in working accept 282 seen in working allow 201, 201.43 350, 352, 353, 352.5 gets 2 marks	4

Total 10 marks

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Question number			Answer	Notes	Marks
15	a		B;		1
			E;		1
15	b	i	p = m.v	in words or accepted symbols do not accept 'M' for momentum	1
		ii	substitution; evaluation; e.g. 900 x 15 14 000 unit = kg m/s OR N s;	 13 500 Independent Allow kg ms^{-1}	3
		iii	KE = ½ m.v^2;	in words or accepted symbols allow speed for velocity	1
		iv	substitution; evaluation; e.g. 0.5 x 900 x 15^2 100 000(J)	 101 250 Allow 101 000	2
				total = 9 marks	

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Question number	Answer	Notes	Marks
16 (a) (i)	sub into E = I x V x t; evaluation; rounding to 2SF; e.g. (E=) 2.1 x 1.5 x 12 37.8 (J) 38 (J)	Correct answer without working gains 3 marks	3
(ii)	GPE = m x g x h ;	accept: • word equations and rearrangements do not accept: • gravity for g • 10 for g • a 'units' only eqn	1
(iii)	sub into eqn; evaluation; e.g. (GPE=) 0.13 x10 x 0.63 0.82 (J)	no POT error as eqn has 'g' 0.819 (J) allow 0.802 (J) (g as 9.81)	2
(iv)	any TWO from: MP1 energy 'lost' as heat and/or sound; MP2 mass has gained KE; MP3 mass of string has been ignored / eq; MP4 motor not 100% efficient;	allow eqn	2

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Question number	Answer	Notes	Marks
16 (b)	Any FOUR from: MP1. Current in <u>coil</u> ; MP2. (Creates) magnetic field (around the wires of the coil); MP3. Interaction of (this) field with that of (permanent) magnets; MP4. There is a force on the wire(of coil); MP5. Reference to left hand rule; MP6. force up on one side and down on other side; MP7. Idea that commutator reverses current (every half turn);	allow credit for points shown labelled diagram current in circuit is not enough coil becomes an electromagnet can be shown on diagram idea of catapult field reference to moment/turning effect on the coil	4

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Question number		Answer	Notes	Marks
17 (a)	I	0.45;	no unit penalty	1
	ii	Power = current × voltage;	Allow P = I × V and rearrangements	1
	iii	Substitution; Evaluation; e.g. 1.5= I x 0.45 I = 3.3 (A) (answer to at least 2 s.f.)	Allow reverse argument yielding 1.35 (W) for 1mark	2
(b)	i	conversion of time to seconds; substitution into correct equation (E = I × V × t); evaluation; e.g. time = 7 × 5 × 60 × 60 (= 126 000) E = 3.3 x 9 x 7 x 5 x 60 x 60 3 742 000 (J)	Allow solution in stages i.e. from P=IV and P =E/t Allow for full marks 3 402 000 (J) (from use of 3 A given above) 3 780 000 (J) (from 1.5 x 20 x 7 x 5 x 60 x 60) Allow max of 1 if time not in seconds, e.g. 1040 (J) (from 3.3 x 9 x 7 x 5, time in hours) 62400 (J) (from 3.3 x 9 x 7 x 5 x 60, time in minutes)	3
	ii	A description to include electrical; to **light** (and heat);	Reject "electricity" for the first mark Allow chemical to electrical to light for 1 mark only	2
			Total	9

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Question number	Answer	Notes	Marks
18 (a) i	GPE = mass × *g* × height ;	Allow GPE = m × *g* × h and rearrangements	1
ii	Substitution into correct equation; Evaluation; e.g. 0.25 x 10 x 1.75 4.375 (J)	Reject "gravity" for *g* in 11(a)(i) 4.4, 4.38 Allow use of 9.81 (or 9.8) → 4.29 for full marks	2
(b)	Value given in 11(a)(ii);		1
(c) i	KE = ½ × mass × speed^2 ;	Allow KE = ½ × m × v^2 and rearrangements	1
ii	Substitution into correct equation; Transformation; Evaluation; e.g. 3.1 = ½ × 0.25 × v^2 v^2 = 3.1 ÷ ½ × 0.25 v = 4.98 (m/s)	Substitution and transposition either order Accept 5.0, 5 and allow truncation e.g. 4.97 m/s	3
		Total	8

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Question number	Answer	Notes	Marks
19 (a)	Any 4 of: heat loss is reduced / traps heat; <u>relating to the air being an insulator –</u> air is a (good) insulator / air insulates / air is insulation / air is a bad conductor /air reduces conduction; <u>relating to the blanket / fibres being an insulator –</u> blanket is a (good) insulator / blanket insulates / blanket is insulation / blanket is a bad conductor / blanket reduces conduction; <u>relating to convection –</u> air is trapped / blanket traps air / air movement reduced; convection (currents) reduced / convection (currents) stopped; <u>relating to sweating –</u> sweat cannot evaporate; (so) less cooling effect from sweating;	seen anywhere in the answer ACCEPT 'air stops conduction / air does not conduct' ACCEPT 'blanket', 'fibres', 'cloth', 'fabric', etc as the same thing – 'it' refers to the blanket ACCEPT 'blanket stops conduction / blanket does not conduct' ACCEPT 'air cannot move' IGNORE 'keeps out cold air' NOT ACCEPT 'stops sweating'	4
(b)	Mark is for the reason and must match yes / no statement Any ONE of - <u>Yes / right</u> (Al / foil / heat) reflects; Al is a poor absorber/emitter (of radiation); <u>No / wrong</u> (Al / foil) is a (good) conductor / bad insulator;	IGNORE shiny ACCEPT answers that refer to the blanket if they imply a relevant point, e.g. 'no, because the blanket would conduct away less heat'	1

Total 5 Marks

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Question number	Answer	Notes	Marks
20 (a)	A (chemical → electrical → kinetic)		1
(b) (i)	KE = ½ x m x v^2 ;		1
(ii)	substitution into correct equation; Calculation; e.g. ½ x 600 x 28^2 ; 240000 (J);	correct answer = 2 marks ACCEPT 235200 (J);	2
(c) (i)	gpe = mass x *g* x height;	ACCEPT GPE = mgh ACCEPT gravitational field strength/acceleration due to gravity for g	1
(ii)	substitution into correct equation; Calculation; e.g. 600 x 10 x 1000 6 000 000 (J) or 6000 k(J) or 6 M(J)	correct answer = 2 marks ALLOW 5 880 000 (from *g* = 9.8)	2
(iii)	EITHER <u>Calculation of energy supplied (by fuel cells)</u> 24 kW x 180 s OR 4 320 000 (J); <u>Comparison with energy required</u> 4 320 000 < 6 000 000; OR <u>Calculation of power required</u> 6 000 000 J ÷ 180 s OR 33.3 kW; <u>Comparision with fuel cells</u> 33.3 kW > 24 kW;	 ALLOW ECF if 6 000 000 not seen ALLOW ECF if 6 000 000 not seen	2

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Question number	Answer	Notes	Marks
(c) (iv)	use of P= I x V for one cell ; e.g. 30 x 0.6 OR 18(W) calculation; e.g 24 000 ÷ 18 = 1333 (> 1300) OR 1300 x 18 = 23400 (< 24000) ALTERNATIVE Using E= IVt for one cell; e.g. 30 x 0.6 x180 OR 3240(J) calculation; e.g. 4 320 000 ÷ 3240 = 1333 (> 1300) OR 1300 x 3240 = 4 212 000 (< 4 320 000)	First Marking Point can be credited if ‘18’ or ’30 x 0.6’ seen in calculation	2

Total 11 Marks

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Question number	Answer	Notes	Marks
21(a) (i)	gravitational potential energy = mass x g x height	Allow symbols and rearrangements, e.g. GPE = m x g x h	1
(ii)	Substitution into correct equation; Calculation; e.g. GPE = 2.75 x 10 x 0.61 = 17 (J)	16.8, 16.775, 16.78 (J) allow calculation with g = 9.81 =16.46 (J)	2
(iii)	Any two of- MP1. idea that system is inefficient OR not 100% efficient; MP2. idea that energy is lost / wasted / dissipated ; MP3. explanation /detail of fate of energy; e.g. used when working against {friction / drag / air resistance} as thermal energy to parts of the apparatus or surroundings transferred to surroundings by sound converted into KE as mass fell	condone used / transferred elsewhere Need mention of 'object' Ignore light allow to overcome friction allow heat for thermal energy	2
(iv)	Substitution into correct equation; Calculation; e.g. Energy transferred = 0.46 x 12.7 x 1.3 7.6 (J)	allow answer without working or equation seen (7.5946)	2
(b)	three of the following ideas- MP1. water has (initial) GPE; MP2. KE of (moving) water; MP3. Work done on turbine / generator; MP4. Work done against magnetic force; MP5. Electrical energy/power/current/voltage (produced);	allow KE in turbine / generator	3

Total 10 marks

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Question number			Answer	Notes	Marks
22	(a)		C (the walls)		1
22	(b)		D (40%)		1
22	(c)	(i)	Any **two** of – • Fibres are good insulators / bad conductors; • Air is a bad conductor / good insulator; • Because air particles are widely spaced; • conduction requires solids/does not occur in gases;	no marks for • 'air is trapped' as is given in stem • conduction/convection mechanism described e.**g. air can't convect up through layers**	2
		(ii)	stopping /reducing (formation of) convection <u>currents</u>; air in the insulation can't move/eq;	allow air is trapped fibres prevent movement of air	2

Total 6 marks

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Question number			Answer	Notes	Marks
23	(a)		Substitution into **correct** equation; Calculation; e.g. 1.3 x 10.3 x 4.7; 63 (J);	No credit for merely quoting the equation as $E = IVt$ is given on p2. 62.9 (J)	2
	(b)	(i)	Work done = force x distance moved (in the direction of the force);	Accept rearrangements and symbols e.g. force = $\frac{\text{work}}{\text{distance}}$ W = F x d F=W/d	1
		(ii)	Substitution into **correct** equation; Calculation; e.g. Work done = 20 x 0.85; 17 (J);		2
		(iii)	Value given in 8(b)(ii);	Allow GP(E)	1
	(c)	(i)	Efficiency = useful energy output divided by total energy input;	Accept efficiency in terms of work or power and percentage e.g. Efficiency = (work out / work in) x 100 %	1
		(ii)	17 divided by 63; 0.27;	Allow ecf answer from b(ii) [or (b)(iii)] divided by answer from (a) Allow 27%	2

Total 9 marks

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Question number	Answer	Notes	Marks
24 (a) (i)	GPE = mass x g x height	ACCEPT equivalent rearrangement ACCEPT suitable abbreviations e.g. GPE = mgh ACCEPT 'gravity' or 'gravitional field strength' or 'acceleration due to gravity' for g	1
(ii)	78 x 10 x 5; 3900 (J);		2
(iii)	3900; J / joule;	Accept 4000 J REJECT 'Nm' for 'J' ALLOW kJ only if it matches the value (i.e. 3.9)	2
(b) (i)	efficiency = useful energy output / total energy input	ALLOW 'power' for 'energy'	1

(ii)	in one second –
	useful energy out = (30 x 3900) / 60;
	efficiency = 1950 / 7500;
	0.26 / 26%
		Allow
		useful energy out = (30 x 4000) / 60;
		efficiency = 2000 / 7500;
		0.27 / 27%
		
		CQ on a(ii)
			3

(c)	right general shape reasonably correct proportions / 3kW and 12 kW seen correctly labelled	 ACCEPT "input / waste / useful" or "electrical / kinetic or GPE / waste heat or sound"	3

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Question number	Answer	Notes	Marks
25 (a)	any two from: MP1. reverse the magnet (N into coil); MP2. reverse the connections at the ammeter; MP3. move the magnet out of coil;	ignore all references to • speed of movement • numbers of turns on the coil CARE that candidate does not conflate MP2 and 3 to negate their answer allow for MP2 invert the coil	(2)
(b) (i)	Y= magnet; Z = coil (of wire);		(2)
(ii)	(±)1.6 (V);		(1)
(iii)	reading of time for 1 cycle ; evaluation; e.g. 0.04s 25 (Hz)	no mark for eqn as it is given time can be assumed if f= 1/0.04 seen allow for 1 mark 50, 12.5 (Hz)	(2)
(iv)	C higher higher ;		(1)
(v)	any one from stronger magnet; more turns on the coil;	ignore bigger magnet condone more coils	(1)
(c) (i)	rearrangement of eqn; substitution; evaluation; e.g. work done (energy output) = power x time (=) 3.1 x 290 900 (W)	Accept 899 (W)	(3)
(ii)	$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$	accept standard abbreviations rearrangements with factor of X 100	(1)
(iii)	substitution; rearrangement of eqn; evaluation; e.g. input energy = $\frac{\text{output energy}}{\text{efficiency}}$ = $\frac{899\ (W)}{0.72}$ = 1200 (J)	ECF from ci allow 900 for 899 1245, 1250, 1300 (J)	(3)

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Question number	Answer	Notes	Marks
26 (a) (i)	geothermal / geothermic;	allow nuclear	1
(ii)	any suitable resource or method; e.g. • wind (turbine) • hydro-electric • waves • tidal • solar (panels) • biofuels/biomass	ignore nuclear ignore unqualified 'water' allow photovoltaic cells, (sun)light allow wood	1
(b)	any four from: MP1. thermal energy is transferred from hot rock to cold water OR water heats up; MP2. water molecules gain KE (as they are heated); MP3. steam gains KE as it is heated by the rock; MP4. GPE of steam increases as it gains height; MP5. turbine gains KE from hot water/steam; MP6. generator (coils) transfer KE (from turbine) into electrical energy; MP7. electrical energy is transferred from pump into GPE/KE of water;	allow 'mechanical energy' for KE throughout allow 'heat' for thermal energy allow water turned into steam allow turbine transfers KE to electrical energy total marks = 6	4

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Question number	Answer	Notes	Marks
27 (a) (i)	light;		2
(ii)	kinetic;		
(b) (i)	Power = energy ÷ time	power = energy ÷ time energy = power x time time = energy ÷ power ONLY ACCEPT standard letters (P, E, t)	1
(ii)	Substitution into correct equation; Rearrangement; Calculation; e. 78 = energy ÷ 10 78 x 10 780 (J)	Correct final value gets all three marks irrespective of working. Substitution and rearrangement in either order. Rearrangement may be shown in (b)(i)	3
(c)	Useful energy calculated; Correct substitution in formula; e. 200 – 176 OR 24 (J) 24 ÷ 200 (x 100 = 12%) ALTERNATIVE METHOD energy wasted = 176 ÷ 200 OR 88(%); useful energy transfer = 100 – 88 = (12%);	Second line of working scores 2 (since the use of 24 implies first line has been correctly carried out) Second line of working scores 2 (since the use of 88 implies first line has been correctly carried out)	2

Total 8 Marks

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Question number	Answer	Notes	Marks
28 (a) (i)	any three from: MP1. air becomes hot; MP2. air expands; MP3. air becomes less dense; MP4. air rises;	NOTE cannot award MP4 unless MP2 or MP3 has been given reject for 1 mark(ie MAX mark = 2) air particles expand OR air particles become less dense	(3)
(ii)	clear inward arrow above the heat absorbing materials; clear up arrow inside the tower;		(2)
(iii)	convection (current);		(1)
(b) (i)	thermal (energy); kinetic (energy);	allow heat or solar or light	(2)
(ii)	(hot) air turns turbines; turbines turn the generator/magnets inside a coil;		(2)
(c) (i)	during the day there is direct heating from the sun/eq;	allow RA	(1)
(ii)	any sensible suggestion e.g. so that convection continues beyond daylight hours; to act as heat source for night time;		(1)
(iii)	any sensible suggestion e.g. water tanks (to provide hot water at night); crops;	Allow photovoltaic cells solar panel (dull) black objects / blocks painted black	(1)

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Question number	Answer	Notes	Marks
29 (a) (i)	Current that passes in one direction **only**;	ignore current varies	1
(ii)	Any three of - MP1 provides a connection / current to the coil/commutator; MP2 idea of reverses the current in the coil; MP3 Every half turn; MP4 Reverses (coil) field /polarity (every half turn); MP5 So that the force is always in the same direction; MP6 So that the motor keeps turning (the same way);	 allow swops the contacts/ ensures that current always flows clockwise through the coil/eq so the moment is always in the same direction	3
(iii)	Any one of - Still spins clockwise; No (overall) effect/direction remains the same; The two changes cancel out/nothing changes;	 Ignore "nothing happens" unless clear that rotation continues	1
(b) (i)	power = voltage × current;	Accept symbols P=I×V Condone a mix of correct symbols and words	1
(ii)	Substitution and calculation; Conversion to megawatts; e.g. P=I×V P= 4000 × 600 = 2 400 000 (W) = 2 400 000 ÷ 1 000 000 = 2.4 (MW)	 division by 10^6 or 1 000 000 seen correct answer without working scores two marks	2

Continued

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Question number		Answer	Notes	Marks
(c)	(i)	work done = force × distance (moved)	Accept symbols W=F×d W =Fd	1
	(ii)	Substitution; Calculation; e.g. Work = 400 000 × 190 76 000 000 (J)	Accept 76 MJ with correct unit 7.6×10^7 (J) 76×10^6 (J)	2
(d)	(i)	Substitution into given equation; P = W/t Rearrangement; Calculation; e.g. 1.9 = 67 ÷ t……worth 1 t = 67 ÷ 1.9 ……worth 2 = 35 (s)…….worth 3	No mark for the equation as it is given in QP Substitution and rearrangement in either order Or (in joules and watts) 67 000 000 ÷ 1 900 000 (35.26) correct answer without working =3	3
	(ii)	Any one of :- Takes longer /eq; More time needed to raise coal; Load moves more slowly;	Ignore: unqualified comments about the amount of work done	1

Total 15 marks

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Chapter 5: Solids, Liquids and Gasses

Question

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1 (a) Temperature can be measured using different scales.

Complete the table by inserting the missing temperatures.

(2)

Temperature	Boiling point of liquid nitrogen	Boiling point of water
in °C		100
in Kelvin	77	

(b) Some students measure the volume of a sample of gas at different temperatures.

The table below shows their results.

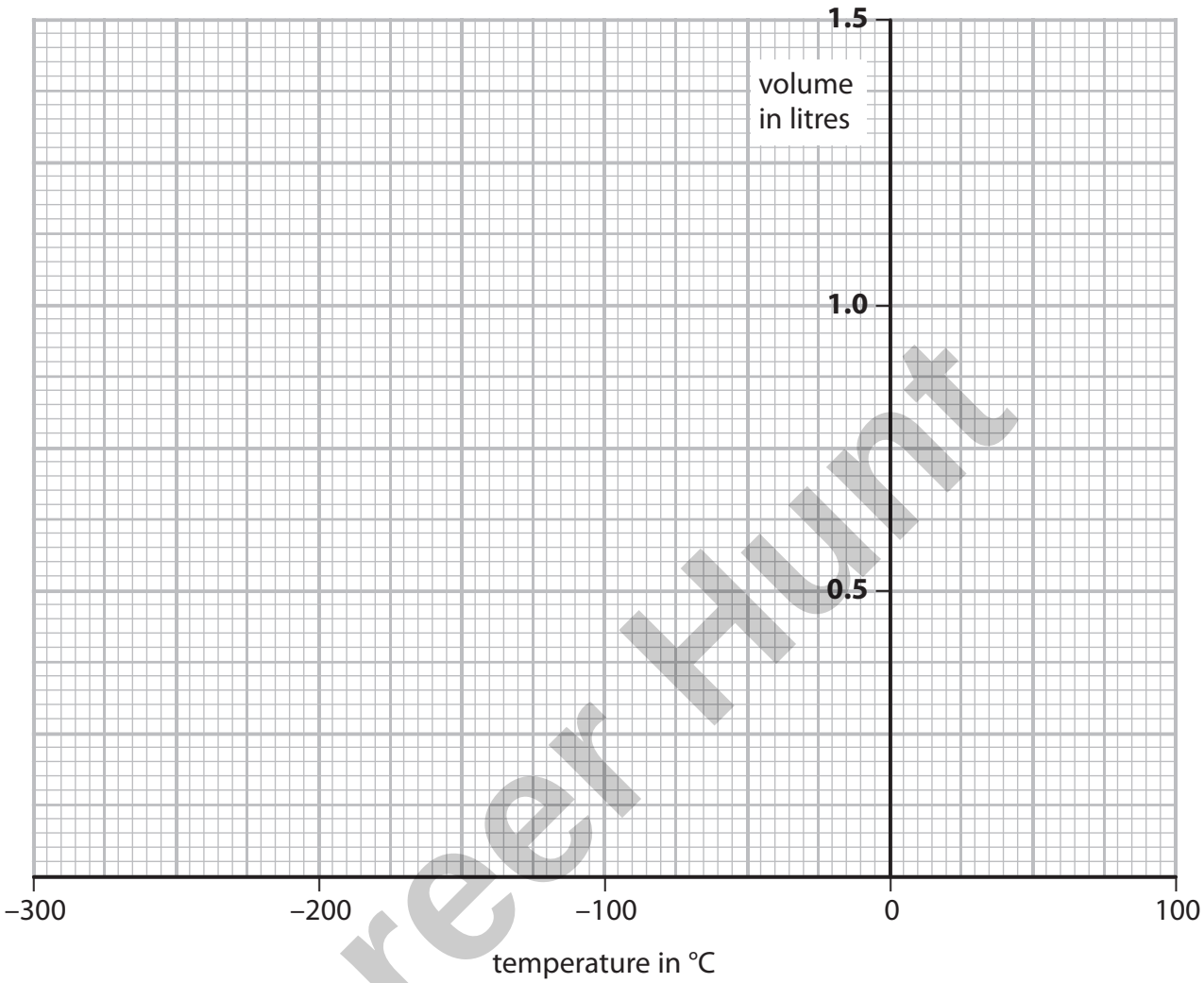
Temperature in °C	Volume in litres
– 20	0.95
0	0.85
50	1.20
80	1.30
100	1.40

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(i) Draw a graph to show how the volume of gas varies with temperature.

(3)



(ii) Circle the anomalous point on your graph.

(1)

(iii) Use your graph to find the temperature of the gas when its volume is zero.

(1)

temperature = ... °C

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2 A student investigates ice, water and steam.

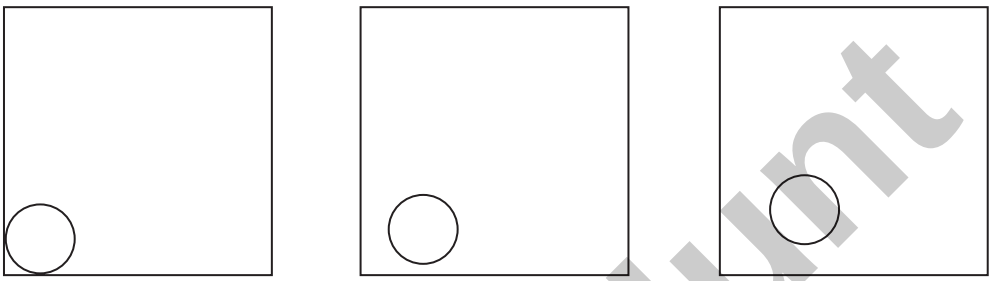
She heats up a sample of ice.

When it has all melted, she carries on heating until the water has all boiled to steam.

(a) Complete the diagram to show how the particles are arranged in ice, water and steam.

One particle in each box has been drawn for you.

(4)



ice water steam

(b) Complete the table by describing how the particles move in ice, water and steam.

(3)

Substance	How the particles move
ice	
water	
steam	

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3 James Dewar was a scientist who investigated liquid oxygen.

(a) He discovered that the boiling point of liquid oxygen is –183 °C.

(i) Convert –183 °C to a temperature on the Kelvin scale.

(1)

Temperature = ... K

(ii) Use ideas about particles to describe the changes that happen when a liquid boils to form a gas.

(3)

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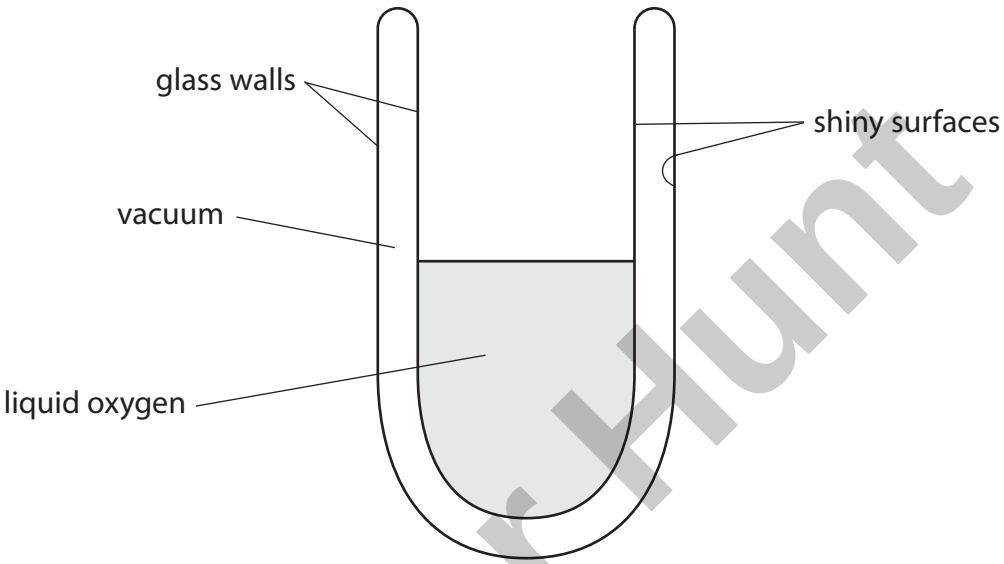
(b) Dewar invented a special flask for storing liquid oxygen in the laboratory.

It was designed to reduce heat flow from the air outside to the liquid oxygen inside.

The flask had two glass walls with a vacuum between them.

The inside glass surfaces were each covered with a thin layer of shiny metal.

The diagram shows a cross section of the flask.



(i) Explain how the **shiny surfaces** reduce the thermal energy transferred to the liquid oxygen from the laboratory.

(2)

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(ii) Explain how the **vacuum** reduces the thermal energy transferred to the liquid oxygen from the laboratory.

(2)

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(c) Dewar's flask did not have a lid when it was holding liquid oxygen.

Suggest why a lid was not needed.

(2)

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4 The particles in the different states of matter behave differently.

(a) Draw a straight line linking each state of matter with the description of its particles.

(2)

state of matter	description of particles
solid	close together, moving about and can slide past one another
liquid	far apart, moving quickly and at random
gas	close together, vibrating about fixed positions

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(b) Ethyne is a substance that is a gas at room temperature.

At a temperature of –81 °C, ethyne can exist as a solid, a liquid or a gas.

This temperature is called the triple point of ethyne.

(i) Complete the table by giving the missing temperatures.

(2)

	Temperature in °C	**Temperature in kelvin**
room temperature		291
triple point of ethyne	–81	

(ii) State what happens to the average kinetic energy of the gas molecules as the temperature is lowered from room temperature to the triple point of ethyne.

(1)

.....

.....

(iii) State what happens to the volume of an ethyne molecule when the gas changes to a solid at the triple point.

(1)

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5 The properties of materials can be explained using particle theory.

Brownian motion provides evidence to support particle theory.

(a) (i) Give an example of Brownian motion.

(1)

.....

.....

(ii) Explain how Brownian motion supports the idea that matter is made from tiny particles in continuous motion.

(2)

.....

.....

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(b) These are some observations about samples of ice, water and steam.

	Shape	Size
ice	keeps a fixed shape	keeps a fixed size
water	takes the shape of the container	keeps a fixed size
steam	takes the shape of the container	fills the container

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Explain each of the observations in terms of the arrangement and motion of the particles.

You may use diagrams to help your answer.

(6)

particles in ice .....

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particles in water .....

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particles in steam .....

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6 The picture shows a runner.



(a) As he runs, the runner gets hot.

To avoid overheating, his body sweats.

As the sweat evaporates, it cools his body.

Use ideas about particles to explain why evaporation leads to cooling.

(3)

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(b) At the end of a long race, runners are given a shiny foil sheet to wear.

This stops them cooling down too quickly.



(i) Suggest why a runner might cool down too quickly if he does not wear a foil sheet.

(2)

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(ii) Explain how the foil sheet reduces heat loss.

(2)

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7 A student blows up two balloons to the same size.

She puts one balloon into a freezer.

After a while, the student compares the two balloons.

The balloon that has been cooled is smaller.



(a) Use ideas about particles to explain why the cooled balloon is smaller.

(4)

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(b) The student decides to investigate the link between temperature and the size of the balloon.

She writes a plan.

> I will change the temperature of the balloon by putting it into a freezer.
>
> To get a range of different temperatures I will put the balloon into the freezer for different times.
>
> I will measure the temperature of the balloon using a thermometer.
>
> To measure the size of the balloon I will take it out of the freezer and line it up next to a ruler.
>
> To make sure it is a fair test I will repeat the experiment three times.
>
> I will plot a graph of size against temperature.

There are several faults in the student's plan.

Identify **three** of these faults and suggest an improvement to correct each one.

(6)

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2 .....

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3 .....

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8 The photograph shows a water barrel with a tap.

The barrel is used to store rainwater.



A student investigates the water depth in the barrel.

She measures the depth and then opens the tap.

As water flows out of the barrel, she measures the depth every minute.

The table shows her results.

Time in minutes	Depth in cm
0	86
1	52
2	31
3	18
4	11
5	7
6	4

(a) Which two measuring instruments should the student use in her investigation?

(2)

1 .....

2 .....

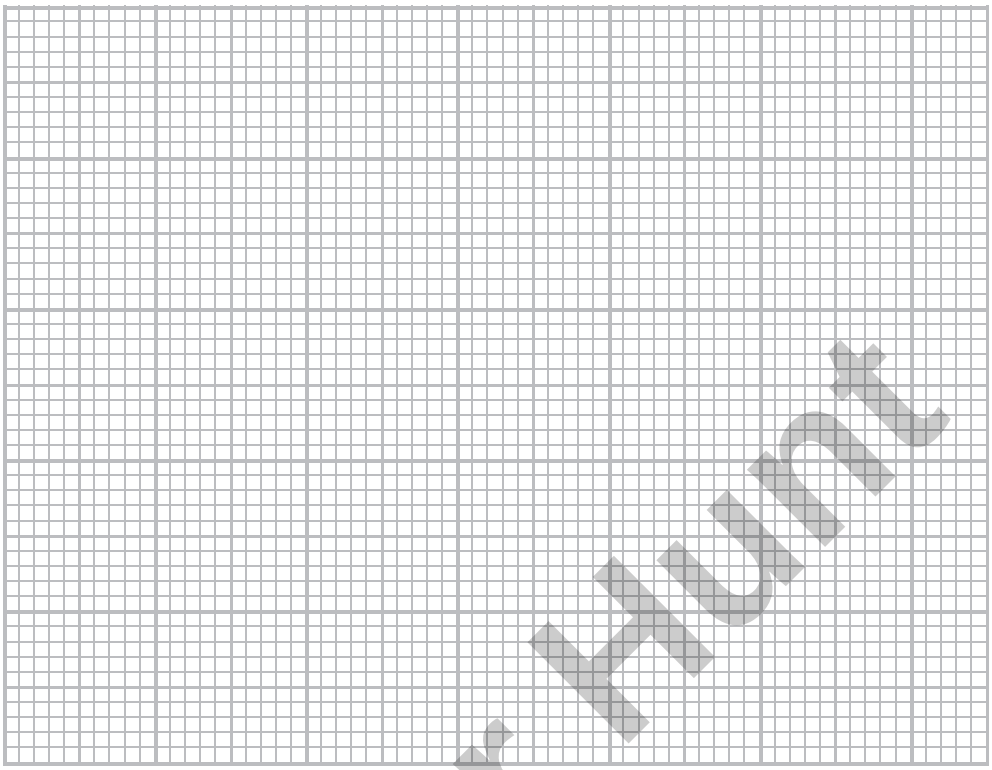
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(b) (i) Plot a graph to show how the depth changes with time, and draw the curve of best fit.

(5)



(ii) Describe the relationship between depth and time.

(2)

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(c) The student notices that the water flows out less quickly as time passes.

Suggest a reason for the decrease in flow.

(1)

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9 This question is about temperature and pressure in gases.

(a) A gas is heated in a container which has a constant volume.

The particles in the gas

(1)

- ☒ **A** expand
- ☒ **B** hit the walls of the container harder
- ☒ **C** move closer together
- ☒ **D** have a lower average speed

(b) Describe what happens to the average kinetic energy of particles as the temperature decreases from 10 K towards 0 K.

(2)

.....

.....

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.....

(c) (i) Convert a temperature of 27 °C into kelvin (K).

(1)

temperature = ... K

(ii) The gas in a cylinder has a pressure of 210 kPa at a temperature of 27 °C.

Calculate the new pressure when the temperature of the gas rises to 81 °C.

(3)

pressure = ... kPa

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10 A student measures the diameter of a coin.

She uses the digital caliper shown in the photograph.



The digital caliper gives readings to the nearest 0.01 mm.

(a) The student measures the diameter of the coin eight times.

Her readings are shown below.

mm 20.31	mm 20.33
mm 20.35	mm 20.34
mm 20.44	mm 20.30
mm 20.33	mm 20.30

(i) Circle the anomalous reading.

(1)

(ii) Calculate the average diameter of the coin.

(3)

Average = ... mm

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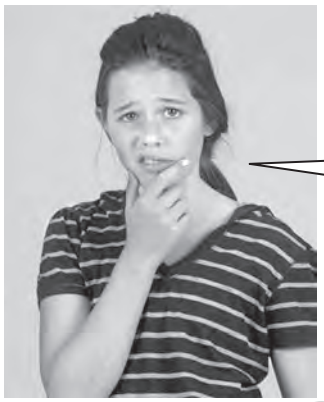
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(b) The student wants to find the thickness of a coin.

She takes several similar coins and measures them together as shown.



She says:



If I measure all the coins at once and divide this value by the number of coins it will be more accurate.

Do you agree with the student?

Explain why.

(2)

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(c) The student wants to find the density of the coin.

She uses her values for the diameter and thickness of the coin to calculate its volume.

What else must she do to find the density of the coin?

(3)

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11 The photograph shows some large concrete cubes.



The mass of one of the concrete cubes is 1000 kg.

(a) State the weight of this concrete cube.

Give the unit.

(2)

weight of concrete cube = ... unit .....

(b) The density of this concrete cube is 2300 kg/m^3.

(i) State the equation linking density, mass and volume.

(1)

(ii) Calculate the volume of this concrete cube.

(2)

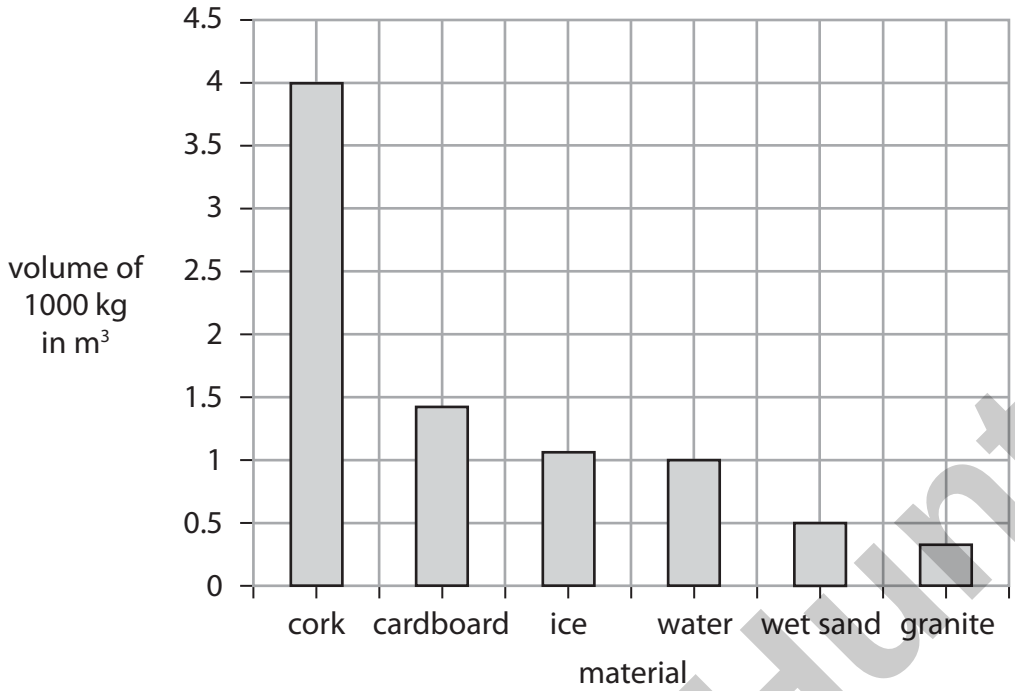
volume of concrete cube = ... m^3

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(c) The graph shows the volumes of 1000 kg of some other materials.



(i) State the type of graph shown.

(1)

.....

(ii) Give a reason why a line graph is not an appropriate way to display this data.

(1)

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(iii) Use information from the graph to compare the densities of cork and water.

(2)

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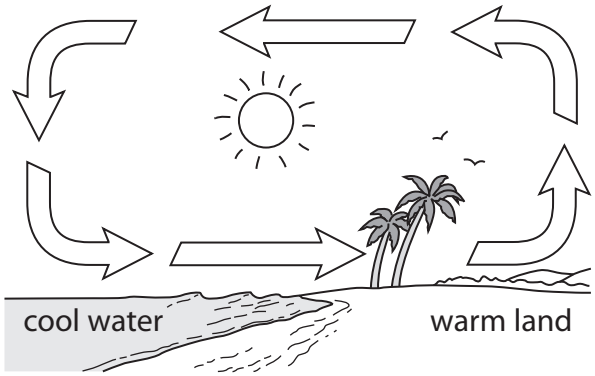
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12 The diagram shows how air moves near the coast on a warm day.



(a) Explain why air moves as shown on the diagram.

(5)

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(b) Explain how Brownian motion provides evidence that air is made of small particles.

(3)

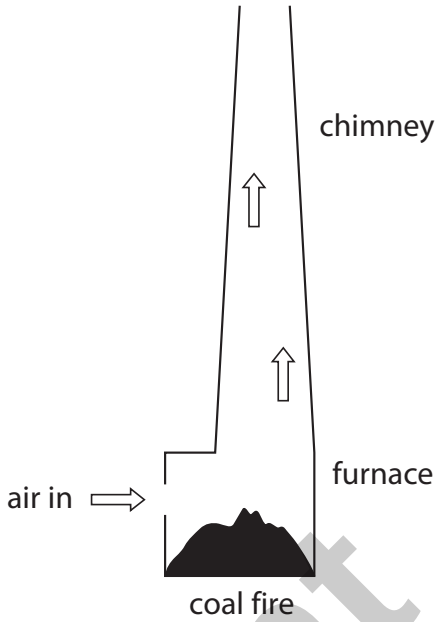
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13 The diagram shows a chimney over a furnace.

A coal fire is burning in the furnace.

Air moves into the furnace and up the chimney.



Describe how the process of convection causes this air movement.

(5)

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14 (a) Temperature can be measured using different scales.

Complete the table by inserting the missing temperatures.

(2)

Temperature	Boiling point of liquid nitrogen	Boiling point of water
in °C		100
in Kelvin	77	

(b) Some students measure the volume of a sample of gas at different temperatures.

The table below shows their results.

Temperature in °C	Volume in litres
– 20	0.95
0	0.85
50	1.20
80	1.30
100	1.40

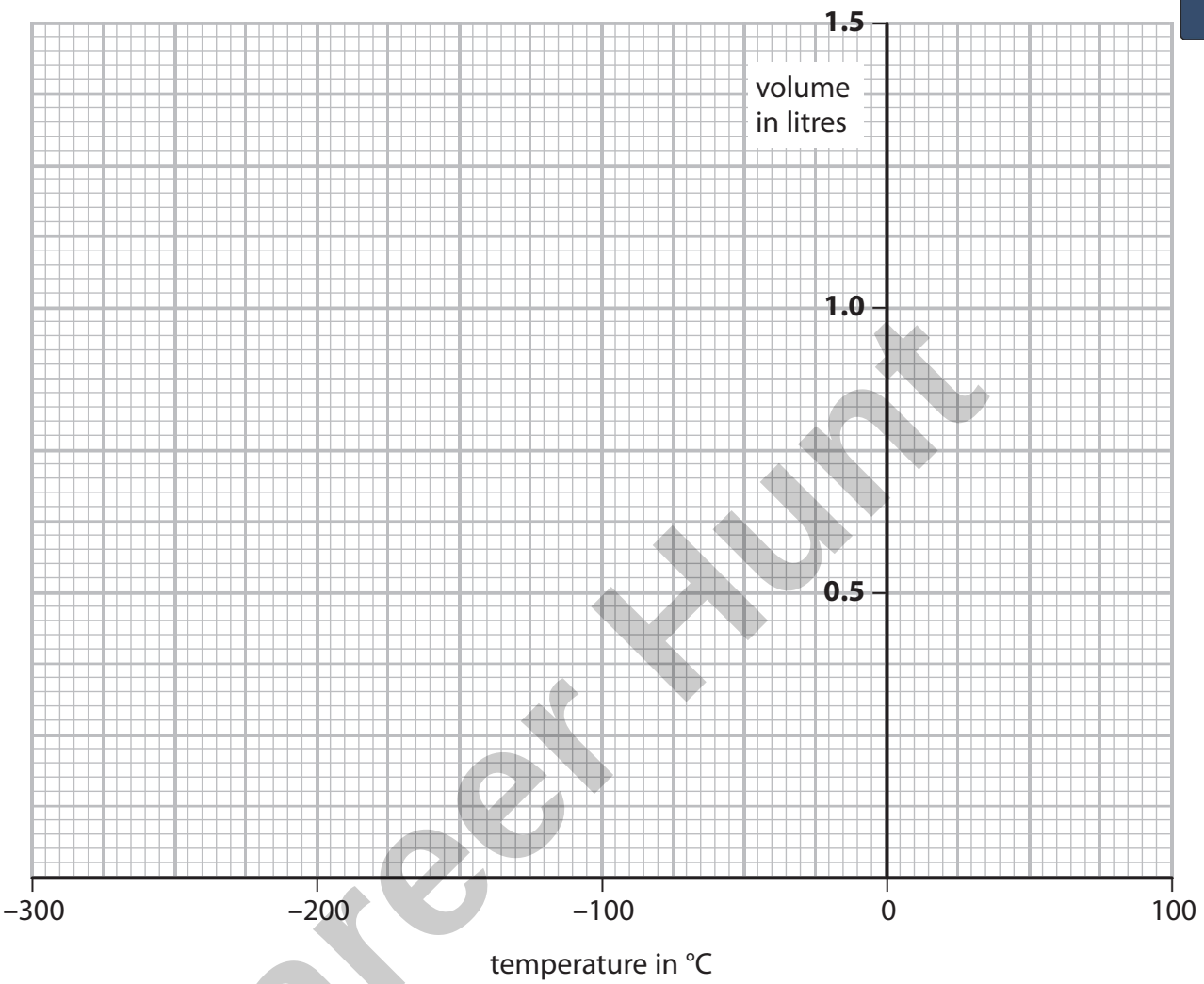
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(i) Draw a graph to show how the volume of gas varies with temperature.

(3)



(ii) Circle the anomalous point on your graph.

(1)

(iii) Use your graph to find the temperature of the gas when its volume is zero.

(1)

temperature = ... °C

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15 A student measures the circumference of a circular pipe.

He wraps a length of string around the pipe five times and marks it with ink, as shown in the photograph.



(a) The student unwraps the string and holds it against a ruler with a centimetre scale. The next photograph shows the first two ink marks on the string.



(i) Estimate the circumference of the pipe, using the photograph of the string and the centimetre scale.

Give your answer to two significant figures.

(2)

estimated circumference = ... cm

(ii) The student finds that the total length of string for 5 turns is 25.6 cm.

Calculate the average (mean) circumference of the pipe using this value.

(1)

average circumference = ... cm

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(iii) The student measures the **diameter** of the pipe using a digital calliper.



The calliper shows that the diameter is 15.10 mm.

Calculate the circumference of the pipe using the formula

$$\text{circumference} = \text{diameter} \times \pi$$

(2)

calculated circumference = ... cm

(b) The student uses two methods to find the circumference

- averaging, using a measured length of string
- calculating, using the digital calliper reading

Explain why the two methods are likely to give different results.

(4)

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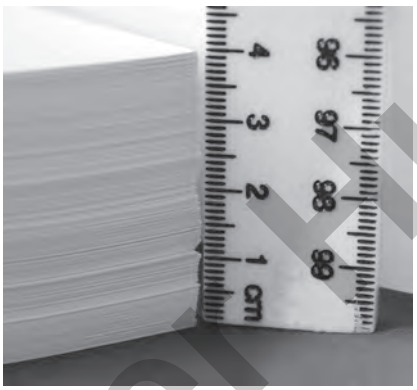
16 A student plans to measure the thickness of a sheet of paper with a ruler.

(a) Explain why it is difficult to measure the thickness of a single piece of paper with a ruler.

(2)

(b) The student puts a pile of 400 sheets of paper on a table.

He uses a ruler to measure the height of the pile.



The student records the thickness of the pile as 4.1 cm.

(i) This means that the thickness of **one** piece of paper is about

(1)

☒ **A** 1 cm

☒ **B** 1 mm

☒ **C** 0.1 mm

☒ **D** 0.01 mm

(ii) Suggest two reasons why the student's value for the thickness of the pile may be inaccurate.

(2)

1 .....

.....

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2 .....

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(c) The student folds the sheet of paper to make a paper aeroplane.

He throws the paper aeroplane into the air and it flies at a constant velocity.

(i) Explain why the forces on the paper aeroplane must be balanced.

(2)

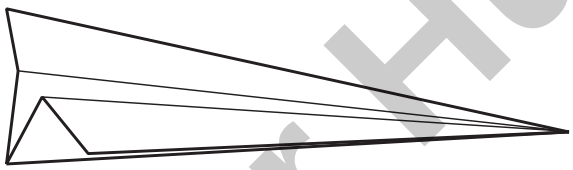
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(ii) The diagram shows the paper aeroplane as it moves at a constant velocity towards the right and slightly downwards.



Add labelled arrows to the diagram to show the directions of the forces of

- weight
- lift
- drag

(3)

(iii) As it flies, the paper aeroplane loses gravitational potential energy.

What happens to this energy?

(1)

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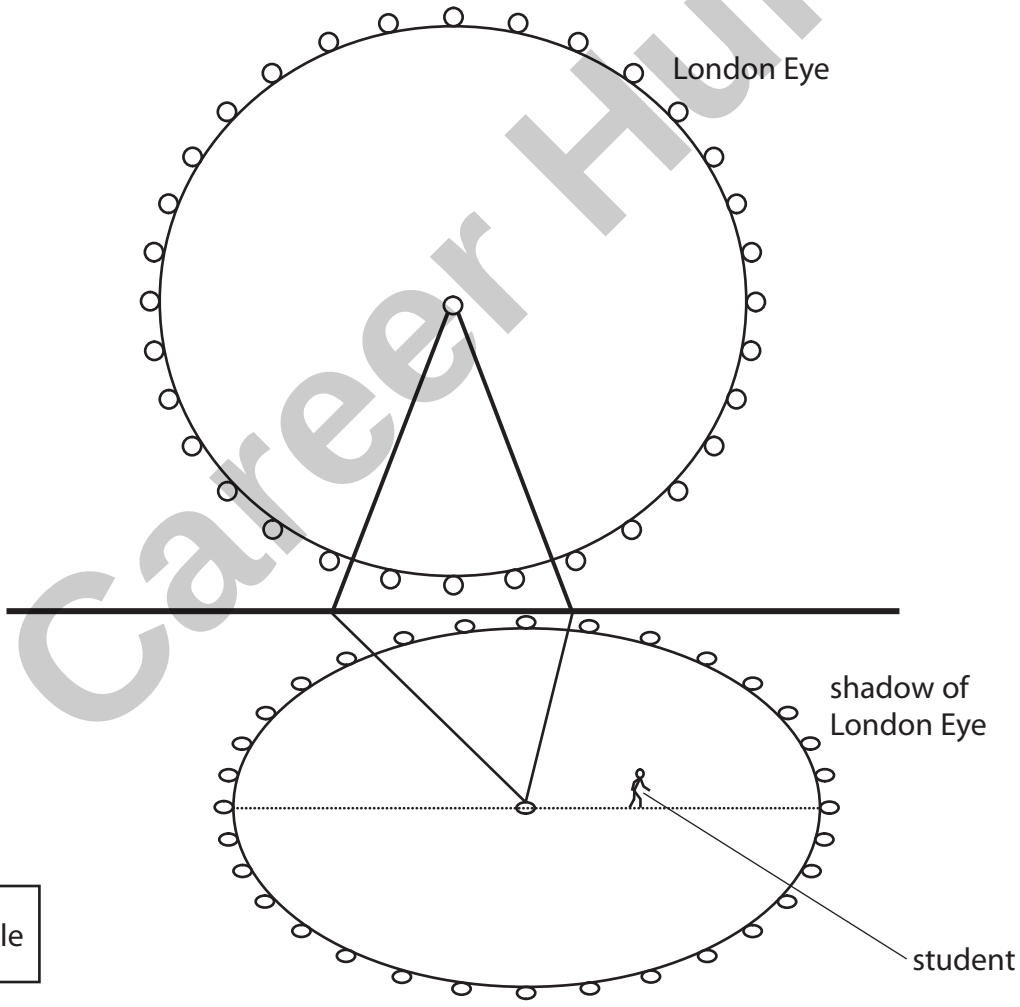
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17 The London Eye is a large Ferris wheel.



A student measures the diameter of the London Eye using two methods.

(a) Her first method is to walk across the shadow of the wheel and count her steps.



Not to scale

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She counts 170 steps across the diameter of the wheel.

She estimates that each of her steps is 0.74 m long.

(i) Calculate the diameter of the wheel using the student's data.

Give your answer to the nearest metre.

(2)

Diameter = ... m

(ii) Suggest **two** reasons why this value may not be accurate.

(2)

1 .....

.....

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2 .....

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(iii) Suggest **one** way that the student could improve this method to give a more accurate value.

(1)

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(b) Her second method is to use an altimeter. The altimeter can measure height to the nearest 5 m.

The student goes for a ride on the London Eye. She notes her height above the ground every five minutes.

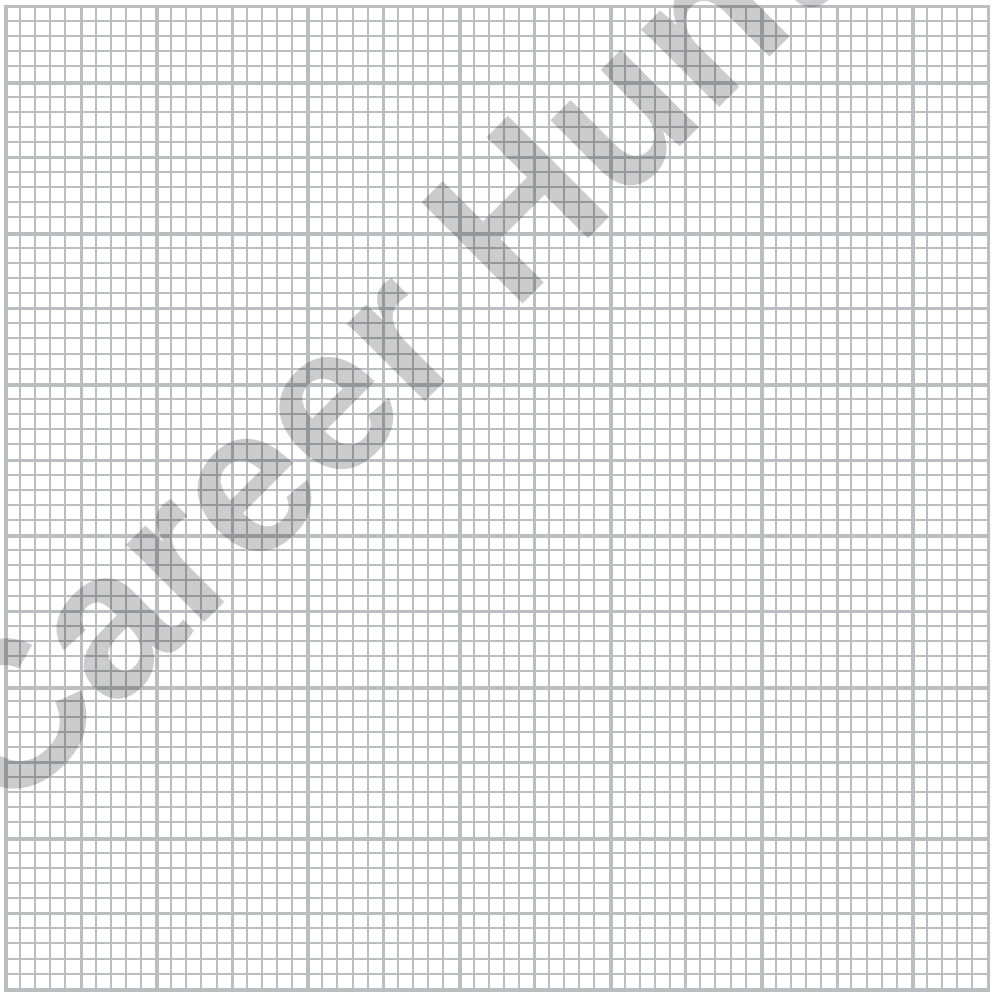
Her results are shown in the table.

Time in minutes	0	5	10	15	20	25	30
Height in m	0	30	90	120	90	30	0

(i) Use the grid to plot a graph of these results.

Draw a curved line of best fit.

(5)



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(ii) Use your graph to find the diameter of the wheel according to the altimeter readings.

(1)

Diameter of the wheel according to the altimeter = ... m

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(iii) The London Eye website gives the diameter of the wheel as 122 m.

Does the value for the diameter of the wheel from the student's altimeter readings agree with the website value?

Give a reason for your answer.

(1)

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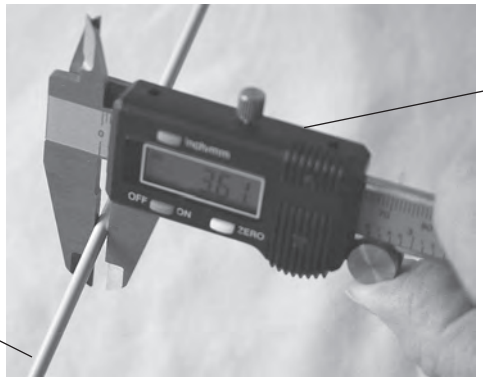
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18 A student uses a digital calliper to measure the diameter of a knitting needle.



The digital calliper gives readings to the nearest 0.01 mm.

(a) The student measures the diameter of the knitting needle eight times.

These are her readings.



(i) Circle the anomalous reading.

(1)

(ii) Calculate the average value for the diameter of the knitting needle.

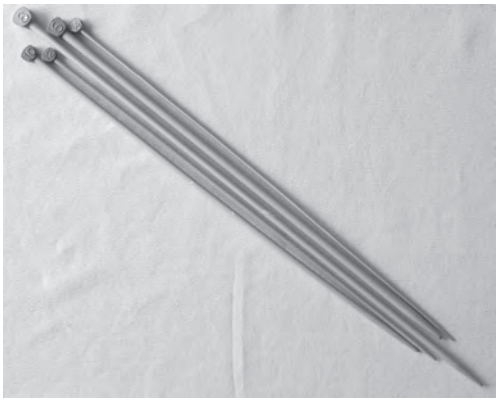
(3)

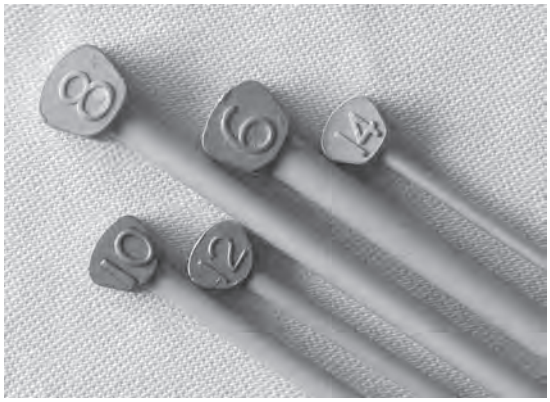
average diameter = ... mm

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(b) The student finds more knitting needles, some of which are shown in the photographs.





Each knitting needle is marked with a number that indicates its size.

Each number corresponds to a set diameter, as shown in the table.

Number on knitting needle	Diameter in mm
14	2.00
12	2.75
10	3.25
8	4.00
6	5.00
4	6.00

The student displays this data as a chart.



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(i) Name the type of chart used by the student.

(1)

(ii) Explain why the data is best displayed using this chart rather than another type of graph.

(2)

(iii) Describe the relationship between the number on a knitting needle and its diameter.

(2)

(c) The knitting needles are not uniform in shape.

Describe how the student could measure the volume of a non-uniform shape.

(4)

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19 (a) Some units can be written in different ways.

(i) A power of 1 watt is the same as

(1)

☒ **A** 1 joule per coulomb (1 J/C)

☒ **B** 1 joule per second (1 J/s)

☒ **C** 1 newton per square metre (1 N/m^2)

☒ **D** 1 newton per kilogram (1 N/kg)

(ii) A pressure of 1 pascal is the same as

(1)

☒ **A** 1 joule per coulomb (1 J/C)

☒ **B** 1 joule per second (1 J/s)

☒ **C** 1 newton per square metre (1 N/m^2)

☒ **D** 1 newton per kilogram (1 N/kg)

(b) Magnetic fields can be indicated using lines.

(i) The arrow on a magnetic field line shows

(1)

☒ **A** the direction of a magnetic field

☒ **B** the electrostatic attraction

☒ **C** the presence of an electric current

☒ **D** the strength of a magnetic field

(ii) Equal spaces between magnetic field lines show that the magnetic field

(1)

☒ **A** has uniform strength

☒ **B** goes from a S-pole to a N-pole

☒ **C** must be caused by a current

☒ **D** must be caused by a bar magnet

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20 A diver works in the sea on a day when the atmospheric pressure is 101 kPa and the density of the seawater is 1028 kg/m^3.



(a) The diver uses compressed air to breathe under water.

1700 litres of air from the atmosphere is compressed into a 12-litre gas cylinder.

The compressed air quickly cools to its original temperature.

Calculate the pressure of the air in the cylinder.

(3)

pressure = ... kPa

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(b) (i) State the equation linking pressure difference, depth, density and *g*.

(1)

(ii) Calculate the increase in pressure when the diver descends from the surface to a depth of 11 m.

(2)

increase in pressure = ... kPa

(iii) Calculate the total pressure on the diver at a depth of 11 m.

Assume that the atmospheric pressure remains at 101 kPa.

(1)

total pressure = ... kPa

(c) As the diver breathes out, bubbles of gas are released and rise to the surface.

The bubbles increase in volume as they rise.

Explain this increase in volume.

(2)

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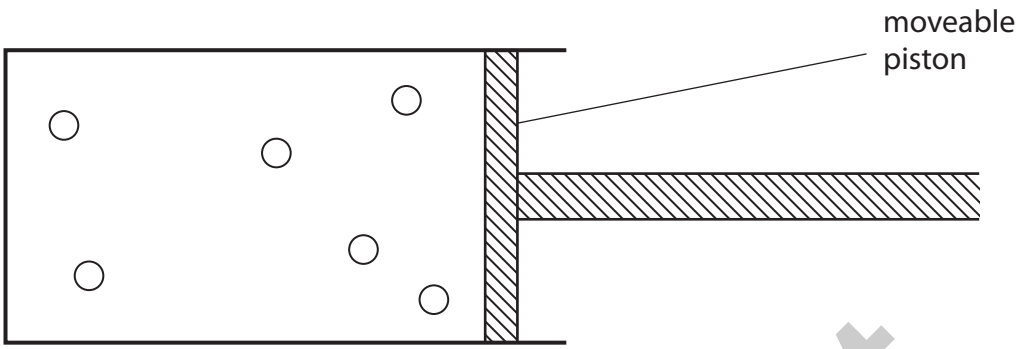
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21 The diagram shows some gas particles in a container.

The piston can be moved in or out to change the volume of the gas.



(a) Add arrows to the diagram to show the random motion of the gas particles.

(2)

(b) Explain how the motion of the gas particles produces a pressure inside the container.

(3)

(c) State what would happen to the pressure if you pushed the piston into the container without changing the temperature.

(1)

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(d) When the gas in the container is heated, the piston moves outwards.

Place ticks (✓) against the **three** correct statements.

(3)

Statement	Tick (✓)
the gas particles get bigger	
the mass of the gas particles stays the same	
the gas particles move faster	
the average distance between the gas particles increases	
the temperature of the gas decreases	

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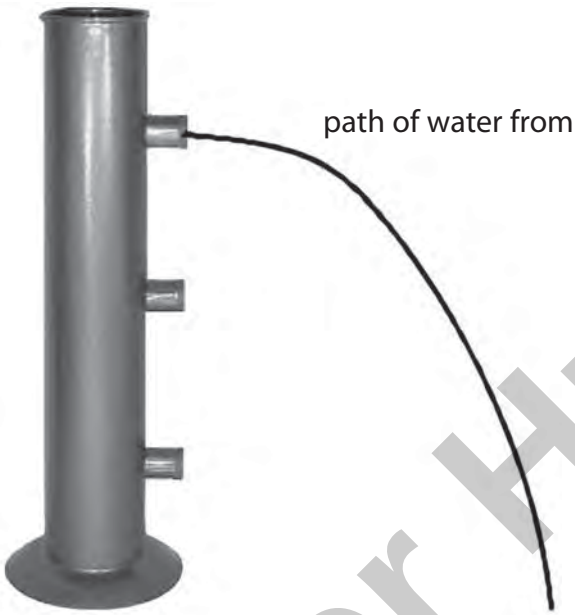
22 This question is about pressure in a liquid.

(a) A teacher uses this apparatus to demonstrate pressure difference in water.

The apparatus is hollow and has three short tubes at different depths.

The teacher completely fills the apparatus with water.

Water comes out of all the tubes.



(i) State the relationship between pressure difference, height, density and *g*.

(1)

(ii) The diagram shows the path of water coming from the top tube.

Complete the diagram by drawing the paths of water you would expect to see from the other two tubes.

(2)

(iii) Explain the pattern of the paths of water from the tubes.

(2)

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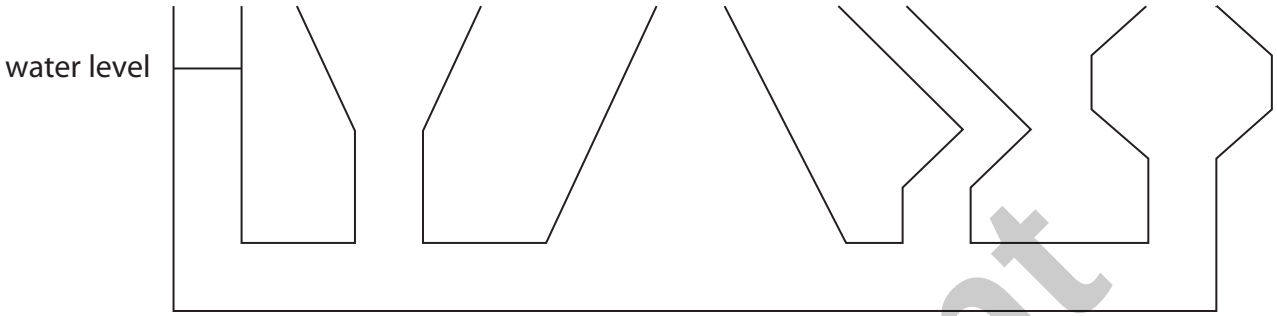
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(b) In another demonstration, the teacher uses this container.

The container is made of glass and each section has a different shape.

The teacher pours water into the container until it reaches the level shown in the left-hand section.



(i) Complete the diagram by drawing the water levels in the other four sections.

(1)

(ii) Explain why the water fills the container in the way you have shown.

(2)

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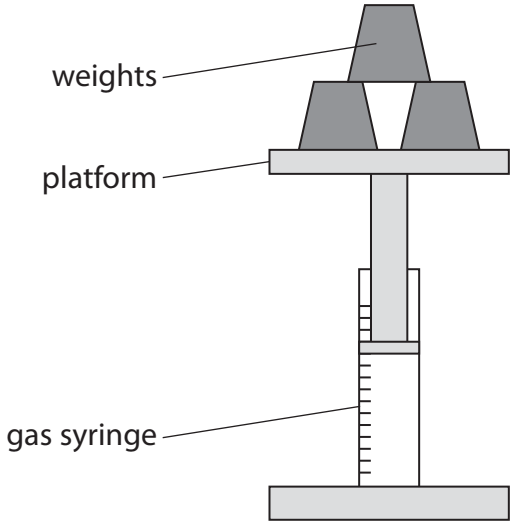
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23 A student uses this apparatus to investigate the pressure and volume inside a sealed gas syringe.



She takes readings of the volume as she increases the pressure (loading) and as she decreases the pressure (unloading).

These are her results.

Pressure in kPa	Volume of gas in cm^3		
	loading	unloading	average (mean)
100	50	50	50
90	56	55	55.5
84	60	60	60
55	90		92
60	85	83	84
50	101	101	101

(a) (i) Complete the table by filling in the missing value.

(1)

(ii) Suggest why the student takes readings for increasing the pressure and for decreasing the pressure.

(2)

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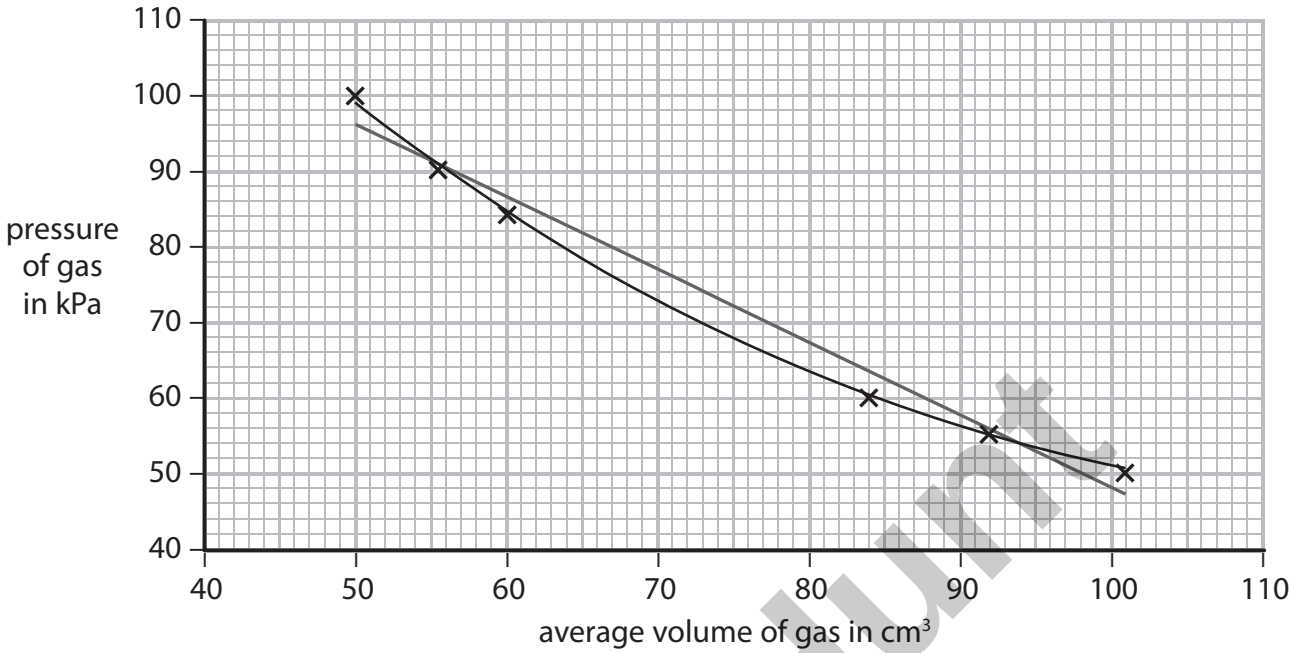
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(b) The student plots this graph.



(i) Suggest a reason why the axes do not start from the origin (0,0).

(1)

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(ii) The student has drawn both a straight line of best fit and a curve of best fit.

Discuss which line is correct for this investigation.

(2)

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(iii) Suggest a way that the student could make this experiment valid (a fair test).

(1)

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(iv) Suggest two ways in which the student could improve the quality of her data.

(2)

1 .....

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2 .....

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(c) The student concludes that her data validates the relationship between pressure and volume of a fixed mass of gas.

Use data from this table to evaluate her conclusion.

(3)

Pressure in kPa	Average volume in cm^3	Space for calculations
100	50	
90	55.5	
84	60	
55	92	
60	84	
50	101	

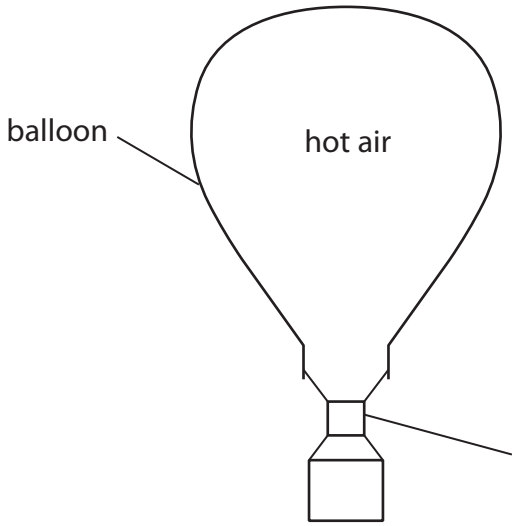
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24 A hot air balloon is filled with air through an opening.

The air is heated using a burner.



(a) Describe the effect of an increase in temperature on the average speed of the air molecules.

(1)

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(b) The hot air causes a pressure on the inside of the balloon.

Use ideas about molecules to explain how the hot air causes this pressure.

(3)

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(c) Give a reason why the hottest air rises to the top of the balloon.

(1)

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(d) The average density of the hot air in the balloon is 0.95 kg/m^3.

The volume of this air is 2800 m^3.

(i) State the equation linking density, mass and volume.

(1)

(ii) Calculate the mass of hot air in the balloon.

(3)

mass of hot air = ... kg

(e) As the balloon climbs higher, the air pressure outside it decreases.

(i) Suggest a reason for this change in the outside air pressure.

(1)

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(ii) Suggest how the decrease in air pressure outside the balloon affects the hot air inside.

(1)

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25 All gases above absolute zero exert a pressure on the walls of their container.

(a) (i) State the value of absolute zero in °C.

(1)

absolute zero = ... °C

(ii) Explain, in terms of its molecules, how a gas exerts a pressure on the walls of its container.

(3)

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(b) A pressure switch is used in a washing machine to control the flow of water. The water pushes on a flexible container and compresses some trapped air. When the pressure of this trapped air reaches 104 kPa, the pressure switch turns the water off.

The pressure of the trapped air is given by this relationship

$$\text{pressure of the trapped air} = \text{atmospheric pressure} + \text{pressure difference caused by water}$$

(i) State the equation linking pressure difference, height, density and g.

(1)

(ii) Calculate the height of water in the machine when the pressure of the trapped air reaches 104 kPa and the switch operates.

[atmospheric pressure = 100 kPa, density of water = 1000 kg/m^3]

(4)

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height of water = ... m

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26 The photograph shows a car tyre that needs to be inflated.



Author: Ildar Sagdejev

The tyre exerts a pressure on the road of 270 kPa.

The area of the tyre touching the road is 0.016 m^2.

(a) (i) State the equation linking pressure, force and area.

(1)

(ii) Calculate the force exerted on the road by the tyre.

Give the unit.

(4)

force = ... unit .....

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(b) Use ideas about molecules to explain why the air inside the tyre exerts pressure.

(3)

(c) Air is pumped into the tyre to inflate it.

This increases the temperature and the pressure of the air in the tyre.

Use ideas about molecules to explain why the air pressure in the tyre increases.

(3)

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27 The volume of a piece of brass is 16.3 cm^3.

A student measures its mass using an electronic balance.

The mass of the brass is 138 g.

(a) (i) State the equation linking density, mass and volume.

(1)

(ii) Calculate the density of brass.

Give the unit.

(3)

density = ... unit .....

(b) The student notices that the electronic balance has a zero error, so it shows mass readings that are all slightly too small.

This means that the density value is

(1)

☒ **A** incorrect and slightly too large

☒ **B** incorrect and slightly too small

☒ **C** correct because the student used three significant figures

☒ **D** correct because the mass of the block is more than zero

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28 (a) A diver breathes air from a cylinder when he is under water.



(i) The cylinder contains 8 litres of air at 200 times atmospheric pressure.

The air is released from the cylinder at normal atmospheric pressure.

The diver needs 16 litres of air per minute.

Calculate the maximum amount of time that the diver can breathe under water using this cylinder.

(3)

time = ... minutes

(ii) When the diver breathes out, bubbles are released.

Suggest why the bubbles expand as they rise to the surface.

(2)

.....

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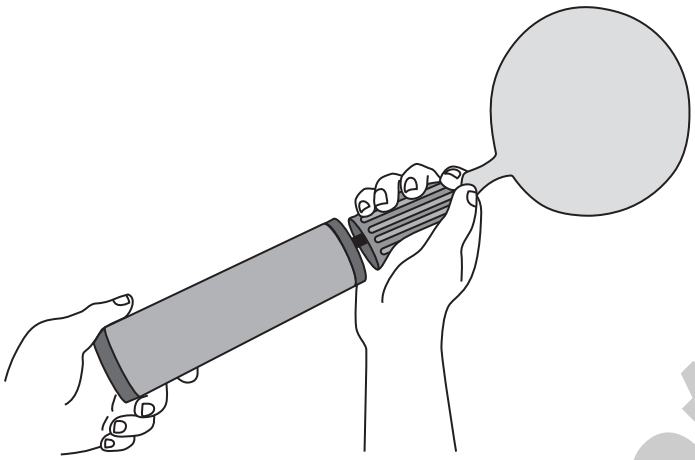
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(b) A student wants to investigate how the volume of a balloon changes with pressure.



(i) Suggest how the student could measure the volume of an inflated balloon.

(2)

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(ii) The student plans to measure the pressure of the air in the balloon.

> To measure the pressure in the balloon I will count how many times I push the pump. The same amount of air goes into the balloon with each push.
>
> When there is twice as much air in the balloon the pressure will be twice as high, so the pressure will be proportional to the number of times I push the pump.

Explain why the student's plan will not work.

(2)

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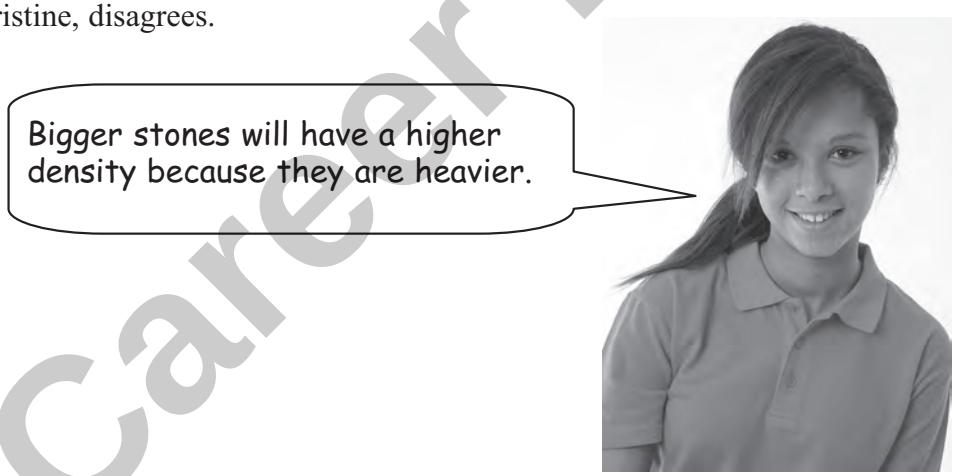
29 Kalpana finds a small stone.

To help her identify the type of stone, Kalpana decides to find its density.

Kalpana explains why she thinks this will help.



Her friend, Christine, disagrees.



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(a) Who is correct Kalpana or Christine?

(2)

.....

Explain your answer.

.....

.....

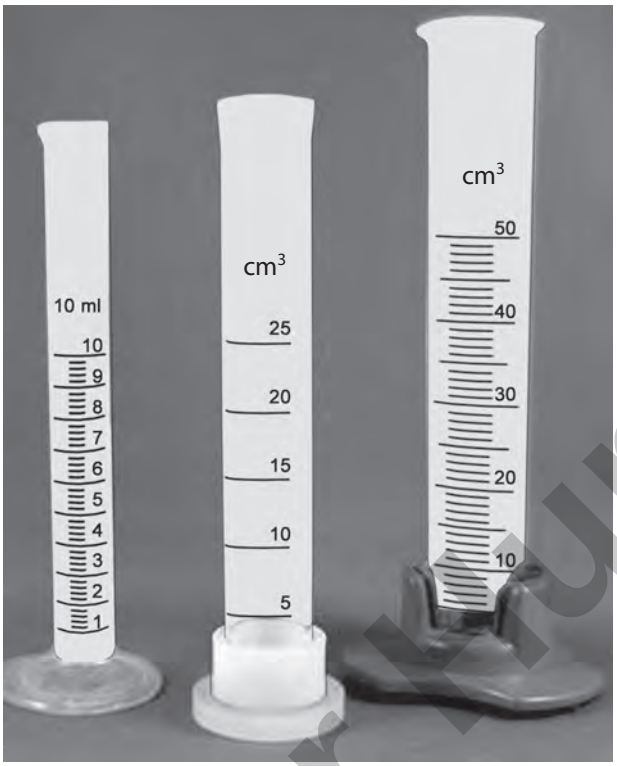
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(b) Kalpana uses a measuring cylinder to find the volume of water displaced by the stone.

She has three measuring cylinders to choose from.



A **B** **C**

(i) Which measuring cylinder would give the most **precise** measurement? Explain your answer.

(2)

.....

.....

.....

.....

(ii) The most precise measuring cylinder may not give an **accurate** reading.

Suggest why.

(1)

.....

.....

.....

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(c) The table shows the measurements that Kalpana makes.

Mass of stone in g	Volume of stone in cm^3
54	23

(i) State the equation linking density, mass and volume.

(1)

(ii) Calculate the density of the stone.

State your answer to an appropriate number of significant figures.

Give the unit.

(3)

Density ..... Unit .....

(d) (i) How can Kalpana use her value of density to identify the type of stone?

(2)

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(ii) Kalpana may still be unsure about the type of stone.

Suggest why.

(1)

.....

.....

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30 Compressed air from a can is used to clean computer keyboards.



(a) Use ideas about particles to explain how a gas causes a pressure on the inside of a container.

(3)

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(b) The can has a warning sign on it.

WARNING
Pressurised container
Do not expose to temperatures above 50 °C

(i) How would increasing the temperature of the compressed air affect the pressure in the can?

(1)

.....

.....

(ii) Explain your answer.

(2)

.....

.....

.....

.....

(c) The can has a volume of 400 cm^3 and the pressure of the compressed air inside is 5 times atmospheric pressure.

Calculate the volume that the air would occupy if it were all released to atmospheric pressure.

(2)

Volume ..... cm^3

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31 A student measures the density of water.

She uses a measuring cylinder and an electronic balance.





(a) State the equation linking density, mass and volume.

(1)

(b) A correct unit for density is

(1)

- ☒ **A** g/cm
- ☒ **B** kg/cm
- ☒ **C** g/cm^2
- ☒ **D** g/cm^3

(c) Complete the table to show what is measured by an electronic balance.

(1)

Measuring instrument	What it measures
measuring cylinder	volume
electronic balance	

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(d) Describe how the student should use each instrument to make her measurements as accurate as possible.

(4)

Measuring cylinder

.....

.....

.....

.....

.....

Electronic balance

.....

.....

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.....

.....

(e) The student wants to make sure her experiment is a fair test.

(i) State **one** factor that she should keep the same throughout her experiment.

(1)

.....

(ii) Why is it important that she keeps this factor constant?

(1)

.....

.....

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Chapter 5: Solids, Liquids and Gasses Answer

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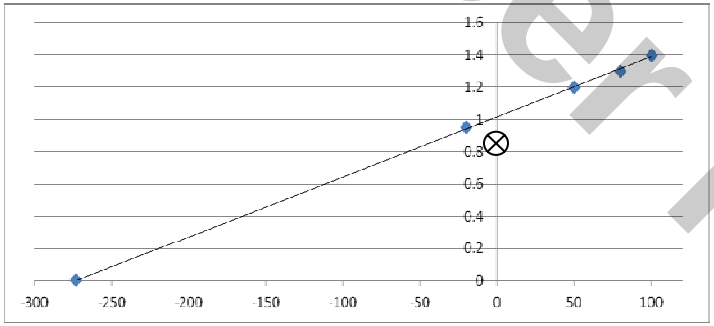
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Question number		Answer	Notes	Marks
1 (a)		<table><tr><td>temperature</td><td>point of nitrogen</td><td>boiling point of water</td></tr><tr><td>in °C</td><td>-196</td><td></td></tr><tr><td>in Kelvin</td><td></td><td>373</td></tr></table> one mark for each correct;;	ignore -273	2

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1 (b (i) (ii)		Plotting to nearest half-square (minus one for each plotting error, up to max 2 marks) ;; line of best fit that intersects x-axis between -250 and -300; point (0, 0.85) circled or otherwise indicated; 	

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Question number	Answer	Notes	Marks
2 (a)	Ice – Regular arrangement; Water – Irregular arrangement; No gaps big enough to add another particle; Steam – Random and spaced (compared to water);	Ignore • variation in particle size Allow ice sample that does not fill the box Gaps to be smaller than printed particle (bottom left) Allow water with “surface” shown and space above Ignore arrows / lines indicating movement	4

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(b)	Ice – Vibrate (about fixed positions); Water – Change position/ move over each other; Steam – EITHER Random movement; OR Range of speeds;	Ignore ideas of • collisions • filling container • bonds • freedom • flowing Accept • oscillate • shake • jiggle Accept for change of position • move slowly • move around Allow slide past each other Accept quickly for range of speeds	3

(Total for Question 1 = 7 marks)

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Question number		Answer	Notes	Marks
3 (a) (i)		90 (K)		1
(ii)		Any three of MP1 Idea that particles/molecules move apart; MP2 Idea that particles/molecules gain (kinetic) energy; MP3 Idea that particles/molecules move more freely; MP4 Idea that particles/molecules leave the liquid;	Ignore: molecules vibrate Allow: molecules spread out, take up more space May be shown on labelled diagram Allow: idea of moving **faster** Ignore : 'move **more'** Allow bonds break Ignore unqualified 'move **more'** Allow escape Ignore evaporate	3
(b) (i)		Any two of MP1 radiation / infrared; MP2 Idea of reflection; MP3 Idea of little/no absorption; MP4 Idea of poor emission;	Allow IR Allow bad radiator	2
(ii)		Any two of (in a vacuum there are) no atoms/molecules/particles; so no/poor conduction; so no/little convection (currents);	Allow: no 'medium' no 'material' There are no molecules to conduct = 2 marks There are no molecules to convect = 2 marks	2

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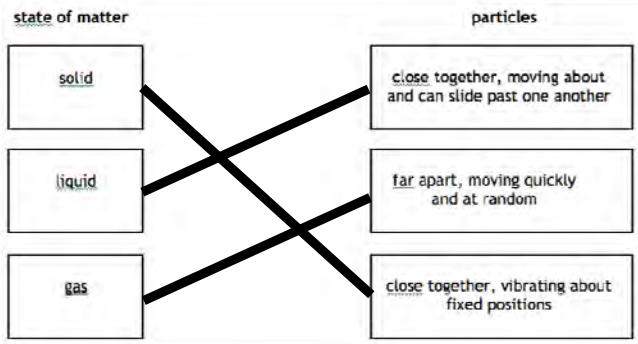
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(c)		Any two of MP1 Idea that there is cold gas/air/oxygen just above the liquid (surface); MP2 Idea that the gas/air/oxygen in the room is warmer; MP3 Idea that convection currents in air (above liquid surface) unlikely; MP4 Idea that (evaporated) oxygen /air / gas would insulate the surface; MP5 Idea that oxygen/gas would build up pressure in a sealed vessel;	Ignore “heat rises” Allow: warm air won’t fall, cool air won’t rise Ignore density arguments Allow: gas is a poor conductor Allow: flask would burst if it had a lid	2

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Question number	Answer	Notes	Marks
4 (a)	any one line correct for one mark; all three lines correct for two marks;;  	more than one line to a box does not score	2
(b) (i)	18; 192; Temperature in °C / Temperature in kelvin room temperature: **18** / 291 triple point of ethyne: -81 / **192**		2
(ii)	decreases / OWTTE;	ignore “molecules slow down”	1
(iii)	remains constant / no change / nothing;		1

Total 6 marks

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Question number	Answer	Notes	Marks
5(a) (i)	smoke particles in air (in smoke cell) OR pollen on water OR dust particles in air;	Accept correct description of Brownian motion applied to unspecified particles in a suitable medium	1
(ii)	Any two of - MP1 Idea that tiny/smaller particles are hitting; MP2 Larger (observed) particles are moved; MP3 Idea of random motion of larger particles;	Allow zig-zag movement	2
(b)	Any six ideas about arrangement and motion of particles Max 2 for each state	Accept same ideas shown in labelled diagrams	max 6
	Solid – Regular pattern OR close packed; Vibration in position; Little space between particles;	Condone fixed position	
	Liquid – Irregular pattern; Able to move over/past other particles; Little space between particles;	Condone no fixed position Ignore vibration relating to liquid	
	Gas – No pattern; Able to move freely/fast; Larger space between particles;	Condone no fixed position Ignore vibration relating to gas	

Total 9 marks

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Question number	Answer	Notes	Marks
6 (a)	Any three of evaporation as liquid→ gas/vapour; higher (kinetic) energy/faster particles/molecules leave/ evaporate; reducing (average) energy of particles left /heat remaining; reducing temperature;	 Accept: water/sweat → gas/vapour Accept: particles leaving take heat with them Accept: lower energy particles remain	3
(b) (i)	(still covered in) sweat /evaporation mentioned; not generating as much 'new' heat;	Ignore: conduction, convection and radiation losses Ignore: reference to shiny sheet	2
(ii)	Either barrier to reduce particle movement; reducing convection / evaporation; OR (shiny) surface reflects/poor absorber; reducing radiation /IR losses;	Ignore: conduction losses Accept: barrier to air currents / air is trapped	2

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Question number	Answer	Notes	Marks
7 (a)	any four from – (at lower temp) particles move at lower speed / lower kinetic energy; on average; so hit sides less often / with less energy; reducing force / pressure; tension in rubber; pulls balloon material into smaller size;	Accept: momentum arguments	4

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Question number	Answer	Notes	Marks
(b)	Any **three** explanations of faulty method, with a workable improvement. Note that the fault needs to be properly identified, not just “the method is faulty / inadequate”, or the method numbered with a comment that “Step 2 is wrong” <u>Fault #1</u> 'different time in freezer' does not give range of temps / always cools to same temp; <u>Improvement #1</u> Way to get range of temp ; e.g use water bath(s), use freezer(s) set to different temps <u>Fault #2</u> Difficult /hard to 'measure temp of balloon with thermometer' OR this doesn’t measure temp of gas inside; <u>Improvement #2</u> Measure temperature of surroundings ; e.g. inside of freezer, water bath or air <u>Fault #3</u> Measuring / plotting ‘size' is imprecise /too vague; <u>Improvement #3</u> measure / plot a more precise quantity; e.g. volume / length / diameter / circumference	CREDIT any explanation OR improvement, up to three of each, wherever seen i.e. the “Fault” and “Improvement” marks do not have to form a matching pair. Allow answers that mention high and/or low temperatures Needs to be more than: can’t + statement from stimulus Ignore reference to room temperature Not temperature	max 6

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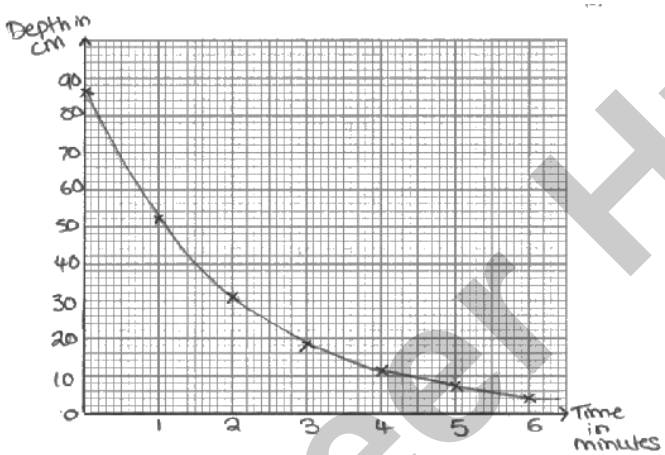
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	Fault #4 'measure size next to ruler' is an inaccurate method / difficult to measure (with a ruler) / comment on shape ; Improvement #4 Sensible method to measure (a relevant quantity); e.g. measure volume by displacing water, measure circumference using tape/string, use set squares with ruler Fault #5 repeating does not make it a fair test; Improvement #5 control a named variable that does; e.g. starting volume of balloon Fault #6 balloon may warm up between leaving the freezer and being measured; Improvement #5 method of minimising this; e.g. idea of measuring quickly, having whole experiment at the measured temperature	Allow mention of parallax NOT “time in freezer”	

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Question number	Answer	Notes	Marks
8 (a)	metre rule(r); stop watch / stop clock;	allow (metal) tape measure / measuring tape / metre stick ignore timer either order	2
(b) (i)	suitable scale chosen (>50% of grid used); axes labelled with quantities and unit; plotting correct to nearest half square (minus one for each plotting error);; line (curve) of best fit acceptable;  	reject 'm' for minutes orientation unimportant i.e. two plotting errors = no marks for plotting i.e. smooth curve within 1 small square of each point time in minutes / water depth in cm 0 / 6 1 / 2 2 / 1 3 / 8 4 / 1 5 / 6 /	5
(ii)	idea that **depth** decreases with time; idea that relationship is non linear;	allow RA ignore 'negative correlation' Ignore all references to 'proportional' and 'curved' allow idea of rate arguments e.g. 'depth decreases more slowly with time' gets 2 marks allow exponential decrease for 2 marks	2

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(c)	any 1 of: MP1. idea of pressure decreasing (with depth / time); MP2. idea of force changing with {pressure / depth / time}; MP3. idea of (available) GPE decreasing;	 allow RA allow 'weight' for force ignore 'mass'	1

Total 10 marks

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Question number	Answer	Notes	Marks
9 (a)	B (hit the walls of the container harder)		1
(b)	(average) **KE** (of particles) **decreases** (as the temperature falls); AND one of • (because) they move slower; • idea that at 0 K the particles have no kinetic energy; • idea that at 0 K the particles are not moving;	ignore • ' particles freeze' • KE is lost allow • 'it' for average KE • absolute zero for 0 K	2
(c) (i)	300 K;		1
(c) (ii)	both temperatures seen in Kelvin; Substitution; (Rearrangement and) Evaluation; e.g. $\frac{210\ 000}{300} = \frac{P_2}{354}$ this would get 2 marks if seen $\frac{210\ 000 \times 354}{300} = P_2$ this would get 2 marks if seen $(P_2) = 250(kPa)$ this is 3 marks	no mark for equation as it is given on page 2 **allow** • $\frac{210\ 000}{27} = \frac{P_2}{81}$ for 1 mark • 630 (kPa) for 2 marks • bald answer 248 (kPa) for 3 marks • answers which round to 250 Power of Ten error (POT) =-1	3

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Question number	Answer	Accept	Reject	Marks
10 (a) (i)	Anomaly clearly identified (20.44 mm);			1
(ii)	Averaging seen /162.7÷8 /142.26 ÷7; Anomaly excluded/ ÷7 seen ; Final answer rounded to 2 decimal places; e.g.: 20.32 (m	Ignore sig figs in working Allow full marks for correct answer, no working, i.e.: 20.32 (mm) = 3 marks If no working accept these other bald answers: 20.3228.. etc (mm)= 2 marks 20.34 (mm) = 2 marks 20.3375.. (mm) = 1 mark 20.33 (mm) = 1 mark		3

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Question number	Answer	Accept	Reject	Marks
(b)	Any two of: Yes / No (no mark) MP1 Good way of measuring small values / Measures a larger value; MP2 Taking a larger measurement might reduce (%) errors; MP3 Not actually measuring what is required (a particular coin); MP4 Possible to make a maths error e.g. when dividing / counting /rounding; MP5 Not all coins are necessarily the same / idea of anomalous coin / bent / worn;	Accept reverse arguments Ignore comments about human error Ignore reference to caliper precision Ignore comments about gaps		2

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Question number	Answer	Accept	Reject	Marks
(c)	Any three of: MP1Measure/find <u>mass</u>; MP2 Using a named instrument - e.g. (top pan) balance, scale(s); MP3 A sensible experimental precaution: e.g. Repeat readings / measure mass of several of coins and divide/ check balance zero; MP4 Formula to use (density = mass ÷ volume); MP5 A correct <u>density</u> unit mentioned (e.g. kg/m^3);	Ignore information about calculating or finding volume Accept “Weighing” to find <u>mass</u> Ignore measuring weight Ignore volume = $\pi r^2 h$		3

Total 9 marks

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Question number	Answer	Notes	Marks
11(a)	10 000; N;	allow 9800, 9810, 10^4 allow "newton(s)" marks are independent	2
(b) (i)	density = mass / volume;	allow abbreviation, e.g. ρ = m/V, d = m/V or rearrangements	1
(ii)	substitution OR rearrangement; evaluation; e.g. 2300 = 1000/volume = 0.43 (m^3)	award if either seen in working allow 0.4, 0.434, 0.435, 0.4347... condone 0.44	2
(c) (i)	bar chart / bar graph;	condone histogram	1
(ii)	any 1 from: MP1. idea that (density) data is discontinuous; MP2. materials have non-numerical values / are not quantifiable; MP3. material types identified as categories; MP4. idea that a line graph would indicate continuity;	 discrete, categoric, non/not continuous	1
(iii)	cork is less dense OR water is denser; cork 25%, ¼ as dense OR water four times denser;	 accept correct calculation of <u>both</u> densities for 2 marks	2

Total 9 marks

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Question number	Answer	Notes	Marks
12 (a)	Any FIVE from: MP1. Energy (transferred) from the sun; MP2. Air over the land is heated ; MP3. Warmer air over land expands; MP4. Air becomes less dense; MP5. Therefore rises (**must** have connection); MP6. Cooler air over sea becomes denser; MP7. Cooler air over sea sinks; MP8. Air (from over the sea) moves inland to replace rising air;	no mark for bald convection current land heats up air reject for 1 mark • particles expand and /or become less dense can **only** be awarded if MP3 or MP4 is given	5
		ignore • heat rises	1
b	MP1. Example of a larger particle given: e.g. ➢ smoke particles ➢ pollen MP2. Idea that larger particles move with random motion; MP3. Idea of collisions with smaller (invisible) particles;	Ignore • air/water particles move with random motion	1 1 1

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Question number	Answer	Notes	Marks
13	Any five of: MP1. the air (molecules are/is) warmed / heated (by the coal fire); MP2. air expands / molecules move apart; MP3. air becomes less dense; MP4. **hot** air or **less dense** air rises; MP5. cooler air (from outside the furnace) displaces warm air; MP6. (above the chimney) air cools / contracts / becomes more dense; MP7. **cooled** air falls; MP8. Process (of convection) is repeated / continuous;	NB 'convection' is in the stem allow another gas for air -1 for explanations which include the idea that the air particles become less dense/air particles expand/eq	5

Total 5 marks

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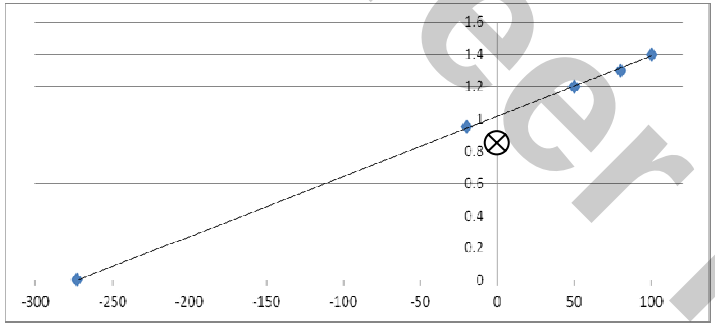
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Question number		Answer	Notes	Marks
14 (a)		<table><tr><td>temperature</td><td>point of nitrogen</td><td>boiling point of water</td></tr><tr><td>in °C</td><td>-196</td><td></td></tr><tr><td>in Kelvin</td><td></td><td>373</td></tr></table> one mark for each correct;;	ignore -273	2

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(b (i) (ii)		Plotting to nearest half-square (minus one for each plotting error, up to max 2 marks) ;; line of best fit that intersects x-axis between -250 and -300; point (0, 0.85) circled or otherwise indicated; 	 | Temperature in °C	Volume in litres | |---|---| | – 20 | 0.95 | | 0 | 0.85 | | 50 | 1.20 | | 80 | 1.30 | | 100 | 1.40 |	3 1
b(iii)		Reading from graph to nearest small square (±5 degrees);		1

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Question number		Answer	Notes	Marks
15 (a)	(i)	5.4 ± 0.1 (cm);; if out of range allow 1 mark for 5.4 ± 0.2 (cm) if answer quoted to 3 or more SF, then deduct 1 mark	In the range 5.3 to 5.5 = 2 marks 5.2 OR 5.6 = 1 mark	2
	(ii)	5.12 (cm)	Accept 5.1	1
	(iii)	Substitution; Calculation; e.g. circumference = 1.510 × 3.142 = 4.744 cm	 Accept 4.7, 4.74 condone 5 with working credit alternative values of π e.g. 1.510 x 3.14 = 4.741 2 marks for correct answer without working POT error max 1 mark	2
(b)		Any four of :- General - MP1. Different precision / use of significant figures; MP2. Calculation error / value for π / unit error; MP3. Unskilled use of equipment; MP4. width of pen mark; String - MP5. Stretches / bends / has inconsistent tension; MP6. Thickness of string makes the circumference larger; MP7. Parallax error (when using ruler); Calliper - MP8. Zero error / calibration error; MP9. Pipe damaged / pipe not quite circular / equation assumes pipe is circular;	Allow a reverse argument where appropriate ignore 'accurate' Can't do a true circle (only a helix) e.g. may not draw dots in a straight enough line, may not get the calliper at 90 degrees to the pipe, may crush the pipe with calliper Ignore unqualified 'human error' Total 9 Marks	4

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Question number	Answer	Notes	Marks
16 (a)	Any two of 1. ruler has a **mm** scale ; 2. idea of inappropriate precision; 3. paper is (very) thin;	**ignore** vague statements e.g. the ruler is too big **allow** scale is too big paper is thinner than 1 **mm**	2
(b) (i)	C 0.1 mm		1
(ii)	Any two of 1. parallax error; 2. gap left between ruler and paper; 3. ruler not perpendicular; 4. zero error;	**allow** • misreading or inaccurate reading of the ruler • damaged ruler • top sheet not flat **ignore** air gaps between sheets folded paper miscounting sheets different sizes of paper incorrect recording of measurements need for more precise instrument human error	2

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Question number	Answer	Notes	Marks
(c) (i)	An explanation including any 2 of	ignore idea that the forces are acting at different points on the plane	2
	1. cceleration needs an unbalanced force;	**allow** Newton I or Newton II unbalanced forces cause acceleration /deceleration / change of *velocity*	
	2. (constant velocity means) the aeroplane is not accelerating;	flying straight or not changing speed /direction	
	3. idea of absence of unbalanced/overall force;	'no resultant force' statement that there is a suitable pair of named balanced forces	
(ii)	weight arrow vertically down; lift arrow upwards; drag arrow to the left;	allow labelled arrows anywhere on the diagram vertical to 45deg to the right inside the angle of the plane wings	3
(iii)	lost as (/dissipated to) heat, sound etc	**allow** lost to the surroundings/air absorbed by surroundings/air i**gnore** kinetic energy 'other types of energy'	1
		Total	**11**

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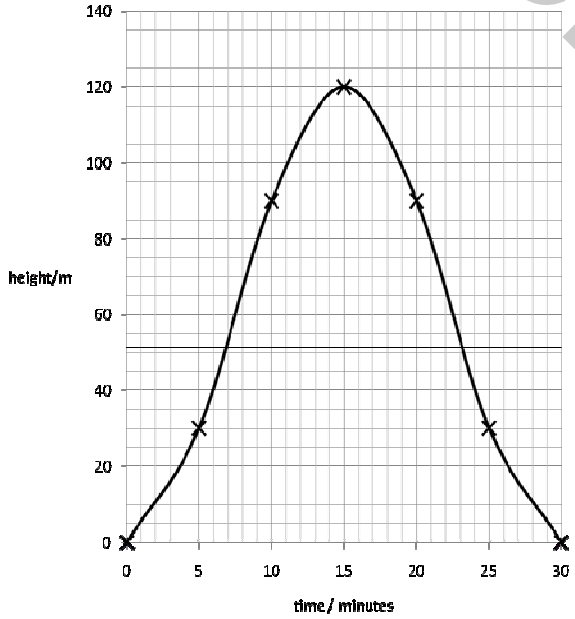
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Question number	Answer	Notes	Marks
17(a) (i)	170 x 0.74; 126 (m);	Correct final value = 2 irrespective of working If final value is incorrect, award one mark for correct working OR ACCEPT 125.8 (m) for one mark	2
(ii)	Any two of Miscounted number of paces; Guessed / estimated pace length; Uneven pace length; Measuring the shadow, not the wheel; Given to the nearest metre; ground may not be flat; shadow is different at different times of the day; shadow may have changed during measuring; may not have walked in a straight line; may not have walked across the centre of the shadow;	ACCEPT any other reasonable point IGNORE 'used no measuring equipment' IGNORE 'human error' alone	2
(iii)	Any one of Repeat and remove anomalies; check measurement of pace; use of tape measure / metre rule / trundle wheel / click wheel / step counter / GPS receiver;	ACCEPT other reasonable points 'Repeat' alone is insufficient IGNORE 'measure the actual London Eye' (doesn't improve the accuracy of *this* method)	1

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Question number	Answer	Notes	Marks
(b) (i) cont	Suitable scale chosen (>50% of grid used); Axes labelled with scales <u>and units</u>; Plotting to nearest half square (minus one for each plotting / scale error);; Line (curve) of best fit acceptable; Sample graph:  	Units required on each axis On the time axis, accept 'min(s)' but not 'm' Two marks for plotting – lose one mark for each mistake to a maximum of losing two marks Judged by eye Not 'dot-to-dot', line should pass within one small square of each plotted point ACCEPT graph plotted with axes either way round	5

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Question number	Answer	Notes	Marks
(b) (ii)	120 (m)	ACCEPT 120 ± 5 (m);	1
(b) (iii)	Yes (no mark) Because 122 m is within tolerance / error zone / uncertainty of altimeter reading / (altimeter is) correct to nearest 5m / reading may not have been at the very top;	Accept NO if back up by incorrect value for (b) (ii) REJECT inconsistent answers (e.g. 'no' followed by reasoning that supports 'yes') IGNORE 'only 2m away', 'very close to', 'nearly the same', 'rough estimate' – key marking point is uncertainty, not closeness	1

Total 12 Marks

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Question number	Answer	Notes	Marks
18 (a) (i)	only 2.65 (mm) circled;		1
(ii)	discards anomaly; performs averaging; quotes answer to 3sf / 2 d.p.; e.g. 3.60 + 3.62 + 3.63 + 3.61 ~~+ 2.65~~ + 3.62 + 3.60 + 3.61 (= 25.29) 25.29 ÷ 7 = 3.612857... = 3.61 (to 3 sf	÷ 7 or ÷ 8 sufficient even if sum is incorrect e.g. 3.61→3 marks 3.6128 →2 marks (wrong sf) 3.49→ 2 marks (includes anomaly) 3.4925→ 1 mark (includes anomaly and wrong sf)	3
(b) (i)	Bar chart/graph;	condone histogram	1
(ii)	Idea that (size) data is discontinuous; and either of - Idea that there are no values between sizes; Idea that a line graph would indicate continuity;	discrete, categoric, non continuous allow “no half sizes”	2
(iii)	Idea of inverse relationship; Idea of non-linearity;	allow a pattern sentence, condone negative correlation allow “almost” linear Ignore idea of proportionality	2

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Question number	Answer	Notes	Marks
(c)	Any four of - MP1. idea of a displacement method; MP2. instrument to measure volume (of liquid displaced); MP3. a relevant experimental detail; MP4. second relevant experimental detail; MP5. use of **known liquid density** to find volume from mass (if appropriate);	Allow overspill or rise in level Allow balance if mass method used (see MP5) Including • idea of repetition or averaging at any stage • **full** immersion of object • check liquid level in displacement can, • subtracting before and after volume measurements , • care with meniscus (e.g. in the measuring cylinder), • check zero or tare of balance • avoid parallax when reading scale as above	4

Total 13 marks

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Question number	Answer	Notes	Marks
19 (a) (i)	B - 1 joule per second (1 J/s)		1
(ii)	C - 1 newton per square metre (1 N/m^2)		1
(b) (i)	A - the direction of a magnetic field		1
(ii)	A - has uniform strength		1
		Total	**4**

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Question number	Answer	Notes	Marks
20 (a)	Substitution into given equation; Rearrangement; Calculation; e.g. $101 \times 1700 = p_2 \times 12$ $p_2 = 101 \times 1700 \div 12$ $= 14\,000$ (kPa)	NB Equation is given on page 2 of QP Substitution and rearrangement in either order Accept working in Pa or kPa, litres and/or m^3. POT error = -1 mark 14300 (kPa) 14 MPa correct answer without working scores 3 marks	3
(b) (i)	In words or $p = h \times \rho \times g$;	F r *g* Accept "acceleration due to gravity" Reject "gravity" For h Accept depth or height For p accept pressure or pressure difference or as Δp	1
(ii)	Substitution; Calculation; e.g. $p = 11 \times 1028 \times 10$ $= 110$ (kPa)	Allow $g = 9.8 m/s^2$ 113 (kPa) 113080 Pa Allow 111 kPa or 110818 Pa(from $g = 9.8 m/s^2$)	2
(iii)	Answer to (b)(ii) + 101 (kPa);	Allow 210 (kPa) 211 214 Reject answer if new PoT error	1

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Question number	Answer	Notes	Marks
(c)	EITHER MP1 pressure decreases (with decreasing depth)/ $p = h \times \rho \times g$; MP2 pV is constant (for fixed mass of gas)/ $p_1 \times V_1 = p_2 \times V_2$; OR MP3 Sea may be warmer near the surface; MP4 (causing the pressure inside the bubble to increase)which causes the volume to increase	 v is inversely proportional to p MP4 is DOP on MP3	2

Total 9 marks

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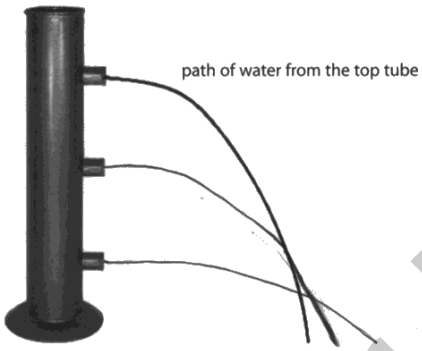
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Question number	Answer	Notes	Marks
21 (a)	minimum of three straight arrows for different particles (with different lengths); arrows in different directions;	judge by eye arrows need not be attached to particles but it should be clear which particle they refer to	2
(b)	any three from: MP1. particles collide/impact/eq; MP2. with sides/walls of container; MP3. idea that force is produced; MP4. idea of pressure as force on an area;	allow hit for collide allow particle changes momentum p = F/A	3
(c)	idea that pressure increases/eq;		1
(d)	<table><tr><th>Statement</th><th>Tick ( )</th></tr><tr><td>the gas particles get bigger</td><td></td></tr><tr><td>the mass of gas particles stays the same</td><td>✓</td></tr><tr><td>the gas particles move faster</td><td>✓</td></tr><tr><td>the average distance between gas particles increases</td><td>✓</td></tr><tr><td>the temperature of the gas decreases</td><td></td></tr></table> one mark for each correct;;; if 4 ticks then max mark is 2 if 5 ticks then zero marks		3
		total marks = 9	

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Question number	Answer	Notes	Marks
22 (a) (i)	pressure difference = ρ × g x h	accept in words or rearranged form allow 'd' for density do not accept 'gravity' must be 'g' or gravitational field strength	1
(ii)	both are curves; lowest curve travels further than top curve (if extrapolated);  		2
(iii)	MP1. water at bottom has greater pressure / pressure increases with depth; MP2. (therefore) force on water at the bottom is greatest;	allow idea that there is more weight above a point, the lower the point is allow water leaves lower holes with greater speed	2
(b) (i)	water level is constant in each vessel;	ignore lines drawn in gaps between vessels	1
(ii)	any two from: MP1. vessels are connected; MP2. same density / type of liquid in all; MP3. air pressure is the same for all; MP4. pressure only depends on the depth;	allow water flows to other vessels allow pressure does not depend on (surface) area total marks = 8	2

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Question number	Answer	Notes	Marks
23 (a) (i)	94;		1
(ii)	any two sensible suggestions: e.g. • to make results (more) reliable; • to produce an average reading; • to identify anomalous results; • because there may have been a temperature change; • because there may have been friction in the syringe;	ignore references to keeping it a fair test	2
(b) (i)	any sensible suggestion: e.g. • reduced scale gives fuller use of the grid; • because the lowest value of p or V is 50/eq; • because p or V cannot be zero;	allow RA ignore there are no values below 40	1
(ii)	idea of straight line having an even distribution of points about the line; all points seem to be on the curve;	no mark for a bald 'it's the curve' or 'it's the line' allow points are very close to the curve	2
(iii)	any sensible suggestion; e.g. • keep the temperature constant • ensure no air gets into/out of the syringe/eq • keep apparatus exactly the same • wait for same time after adding/removing loads to take the volume reading		1
(iv)	any two from: MP1. increase sensitivity/resolution of instruments; MP2. take reading(s) to fill in the middle of the graph/eq; MP3. take reading(s) to extend the range of the graph;	ignore references to parallax error / accuracy allow take readings with greater precision/eq	2

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Question number	Answer	Notes	Marks
24(a)	(Average speed) increases;		1
(b)	Any three of the following ideas-	allow	3
	MP1. Idea of (continuous) random motion; MP2. collide /impacts / eq; MP3. With walls (of balloon); MP4. idea that force is produced (by bombarding molecules); MP5. idea as pressure as force on an area;	 bombard, hit, impact upon momentum argument / N3 p = F/A	
(c)	Any one of the following ideas- MP1. convection (current moves hot air upwards); MP2. hot air/it is less dense;	allow RA ignore hot air rises condone lighter reject for MP2 less dense particles	1
(d) (i)	D = $\frac{\text{mass}}{\text{volume}}$;	Accept symbols or rearrangement e.g. $\rho = m/V$	1
(ii)	Substitution into correct equation; Rearrangement; Evaluation; e.g. $0.95 = \frac{m}{2800}$ m = 0.95 x 2800 = 2700 (kg)	allow sub and rearrangement in either order 2660	3
(e) (i)	Any one of the following ideas - MP1. atmospheric density decreases as height increases; MP2. depth (from top of atmosphere) decreases; MP3. temperature of air is colder / (cold)molecules move slower;	Allow • number of molecules decreases (from ρ.g.h idea)	1
(ii)	Any one of the following ideas - MP1. air inside/balloon expands; MP2. (hot) air escapes (from the balloon); MP3. hot air (now) cools down / need to use burner;	Allow idea that outside air is cooler at altitude	1

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Question number	Answer	Notes	Marks
(a) (i) 25	-273 (°C)		1
(ii)	any 3 of: MP1. idea of (continuous) **random** motion; MP2. collide/impacts/eq; MP3. with walls (of container); MP4. idea that force is produced (by bombarding molecules); MP5. idea of pressure as force on an area;	 bombard, hit, impact upon allow Newton's 2nd Law momentum argument p=F/A	3
(b) (i)	pressure = density x g x height;	in words or accepted symbols e.g. $p = \rho gh$ not 'gravity' for g	1
(ii)	use of correct pressure; substitution; rearrangement; evaluation; e. 104-100 = 4 kPa 4000 =1000 x 10 x h h = 4000/(1000x10) 0.4 (m)	sub and rearrange in either order deduct 1 mark for each of the following: • conversion error from kPa to Pa • use of wrong pressure e.g. use of 104 or 100 kPa and not changing to Pa gets 2 marks max	4

Total 9 marks

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Question number	Answer	Notes	Marks
26 (a) (i)	pressure = $\frac{\text{force}}{\text{area}}$	Allow symbols and rearrangements e.g. p=F/A	1
(ii)	substitute; rearrange; evaluate; **matching** unit; e.g. 270 000 = F ÷ 0.016 1 mark F = 270 000 x 0.016 2 marks 4320 3 marks N 4th mark	Substitution and rearrangement in either order allow in words Allow alternatives with matching unit, e.g. 4.32 3 marks kN 4th mark	4
(b)	Any three of MP1. idea of (continuous) random movement; MP2. collisions / impact/eq; MP3. with (inside) **walls** (of tyre); MP4. idea that force is produced (by bombarding molecules); MP5. idea of pressure as force on an area;	Allow momentum or NIII argument	3
(c)	any three of- MP1. (now) more particles/molecules in the tyre; MP2. molecules have more speed /more energy (because gas is warmer); MP3. more impacts/more frequent impacts / harder impacts (with walls of tyre); MP4. (hence) more force on the inside;	Allow change of momentum argument Allow collisions with walls do not award MP3 if the impacts are only with other molecules	3

Total 11 marks

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Question number	Answer	Notes	Marks
27 (a) (i)	density = $\frac{\text{mass}}{\text{volume}}$	Allow symbols and rearrangements, e.g. ρ = m / V	1
(ii)	substitution into correct equation; calculation; matching unit; e.g. Density = 138 ÷ 16.3 = 8.47 g/cm^3	8.466, 8.5	3
(b)	B (incorrect and slightly too small)		1

Total 5 marks

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Question number			Answer	Notes	Marks
28	(a)	(i)	substitution / rearrangement; final value for volume; final value for time; e. 8 x 200 = V x 1 V = 1600 (litres) time = 100 (minutes)	($p_1V_1 = p_2V_2$) – no mark as given on page 2. No credit for merely quoting the equation. Allow 99 minutes (i.e. assumption that the final 16 litres not available)	3
		(ii)	Any **two** suitable points, e.g. MP1. pressure decreases as depth decreases; MP2. reference to p = h˜g; MP3. reference to pV equation (if temperature constant); MP4. additional bubbles join together as they rise; MP5. temperature increases nearer surface;		2
	(b)	(i)	displacement method described; measure water displaced (with measuring cylinder); OR measure radius / diameter / circumference; calculate volume (with equation);		2
		(ii)	not a fair test; change of temperature / volume;	ignore 'each pump will have different pressure'	2

Total 9 marks

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Question number	Answer	Notes	Marks
29 (a)	Kalpana (no mark) ANY TWO – Density compares masses to volumes / reference to equation; So as mass increases, volume increases; In proportion;	If Christine is chosen, score = 0 for part (a)	2
(b) (i)	A / clearly identified; smallest scale divisions / measures to 0.2 (ml);	ALLOW 'the one measuring in ml' (identifies A in picture) MUST have chosen A DO NOT ALLOW 'it measures in ml'	1 1
(ii)	any ONE suitable, e.g. incorrect scale / calibration; misreading scale / parallax /not at eye level; meniscus makes it difficult to read; might not be level / flat; reading may be between divisions;	DO NOT ALLOW 'hard to measure'	1

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Question Number	Answer		Marks
(c) (i)	density = mass / volume;	ALLOW standard symbols (ALLOW d for density)	1
(ii)	substitution into correct equation:		1
	evaluation:		1
	unit:	VALUE MUST be 2 s.f. to be given evaluation mark	1
	e. 54/23 2.3 g/cm^3	2300 if unit is kg/m^3	
(d) (i)	compare with / look it up in;		1
	a book / data table / internet;		1
(ii)	any ONE suitable, e.g. (many) rock types with similar / same values;		1
	uncertainty in value / inaccurate measurements;		
	data tables incomplete;	IGNORE human error ALLOW 'rock may not be pure'	
		Total	**12**

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Question number	Answer	Notes	Marks
30 (a)	ANY THREE of particles in constant motion / particles have kinetic energy; in random directions; colliding with walls; causing a force on the walls; Pressure = force /area;	Answers need to refer to particles / molecules rather than 'the gas is...' ALLOW 'Hitting the walls' / 'bouncing off the walls' ALLOW 'push' / 'pushing'	3
(b) (i)	(pressure would) increase;		1
(ii)	(higher temp) increases (average) speed / kinetic energy of particles; So collide with walls more often / at higher speed;	IGNORE references to 'heating the particles' ALLOW 'hit harder'	1 1
(c)	Use of $p_1V_1 = p_2V_2$ (equation given) /substitution; 2000 (cm^3);	 2000 alone scores 2	2
		Total	**8**

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Question number	Answer	Notes	Marks
31(a)	density = mass/volume	ACCEPT equivalent rearrangement ACCEPT suitable abbreviations e.g. ˜ = m/v or d = m/v REJECT equation 'triangles' alone	1
(b)	D		1
(c)	<table><tr><th>Measuring instrument</th><th>Quantity measured</th></tr><tr><td>measuring cylinder</td><td>volume</td></tr><tr><td>electronic balance</td><td>**mass**</td></tr></table>	Reject weight	1

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Question number	Answer	Notes	Marks
(d)	MAX TWO FOR EACH measuring cylinder – eyes to water level / perpendicular view; to avoid parallax; measurement at bottom of meniscus; measuring cylinder on flat surface / clean cylinder; electronic balance – place on stable surface /avoid disturbing balance; set to zero / check zero; finding mass without an with water – (tare or subtraction);	Ignore repetition wherever seen Ignore clean balance	4
(e) (i)	temperature / type of water (e.g. salinity, not 'heavy')	DO NOT ACCEPT answers referring to keeping the apparatus the same	1
(ii)	can also affect the density / volume (DOP)	ACCEPT arguments that follow through e.g. increasing temperature will increase the volume, therefore decreasing the density REJECT idea that mass is affected by change in temperature	1

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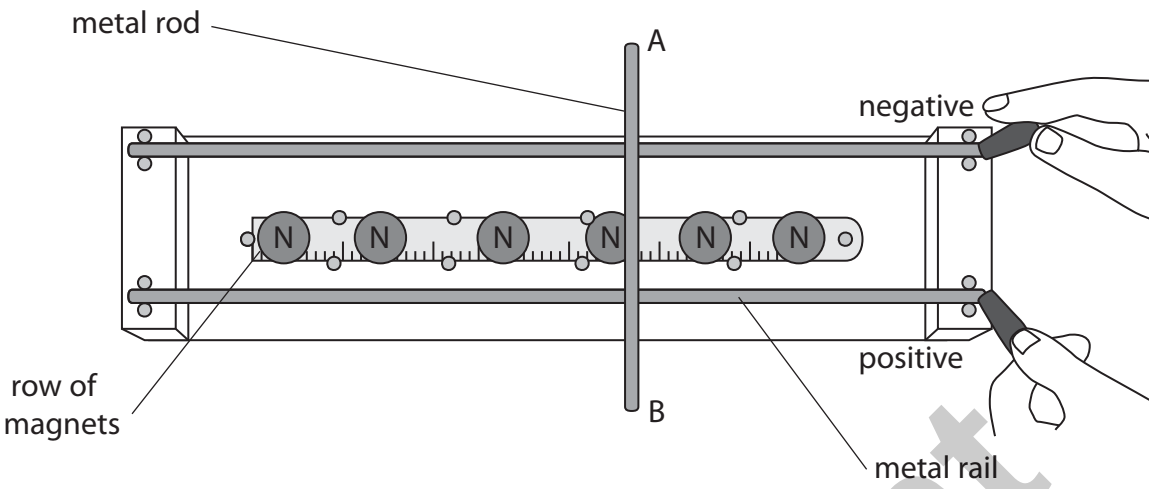
Chapter 6: Magnetism and Electromagnetism Question

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1 (a) A student uses this apparatus to investigate what happens to a current-carrying conductor in a magnetic field.



The student connects the two parallel horizontal metal rails to the positive and negative terminals of a power supply.

The metal rod AB rests across the rails and is free to move.

Explain what happens to the metal rod AB.

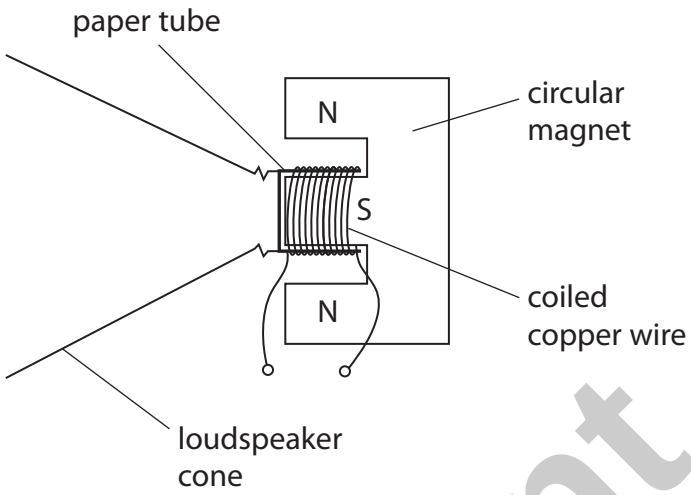
(4)

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(b) This diagram shows the construction of a simple loudspeaker.



A coil of wire is wrapped around a paper tube attached to the loudspeaker cone.

When there is an alternating current in the coil, the cone moves.

Describe how the alternating current generates a sound wave.

You may draw a diagram if it helps your answer.

(4)

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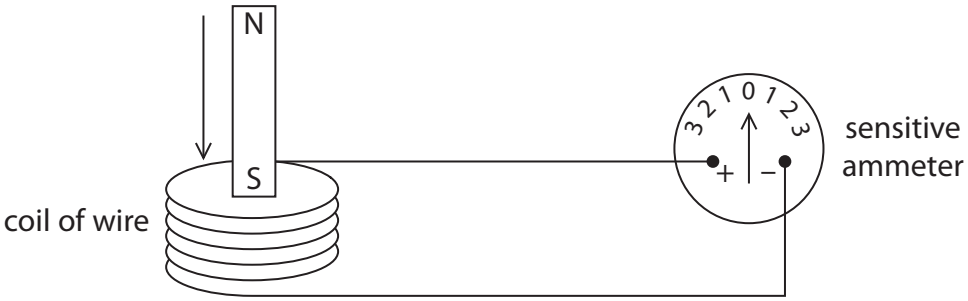
(Total for Question 1 = 8 marks)

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2 (a) A student uses this apparatus to investigate electromagnetic induction.



When the S pole of the magnet is moved into the coil, the pointer on the sensitive ammeter moves to the left.

Describe two ways that the student can make the pointer move to the right.

(2)

1 .....

.....

2 .....

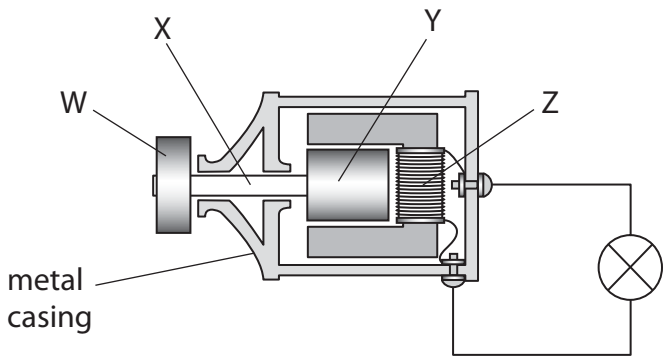
.....

(b) The student has a bicycle with a dynamo (generator) that supplies electricity for its lights. The diagram shows the dynamo.

The friction wheel, W, presses against the bicycle tyre. When the student pedals, the friction wheel turns and causes part Y to rotate.

Key

W	friction wheel
X	axle
Y	
Z	



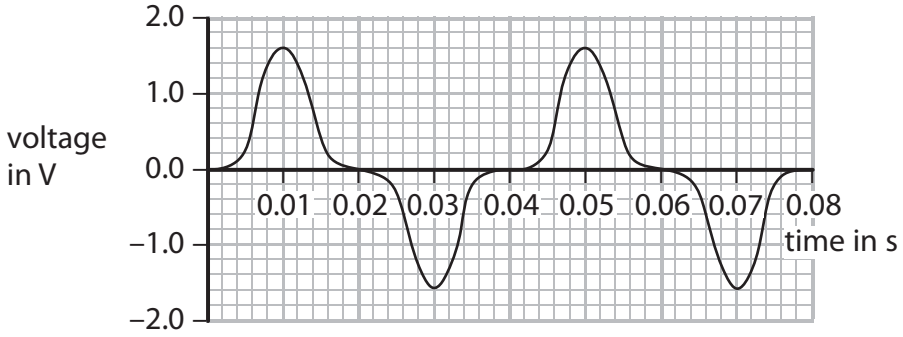
(i) Complete the key for the diagram by giving the names of parts Y and Z.

(2)

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(ii) The graph shows how the output voltage of the dynamo varies with time as the student pedals steadily.



State the maximum output voltage of the dynamo.

(1)

maximum output voltage = ... V

(iii) Calculate the frequency of the output voltage.

(2)

frequency = ... Hz

(iv) Which row of the table is correct when the friction wheel turns faster?

(1)

	Output voltage is	Frequency of output voltage is
☒ **A**	lower	lower
☒ **B**	higher	lower
☒ **C**	higher	higher
☒ **D**	lower	higher

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(v) Apart from changing the speed of the friction wheel, suggest how the output voltage of the dynamo can be increased.

(1)

.....

.....

(c) The student cycles for 290 s.

Her dynamo produces a constant useful power output of 3.1 W and is 72% efficient.

(i) Calculate the total useful energy output.

(3)

useful energy output = ... J

(ii) State the relationship between efficiency, useful energy output and total energy input.

(1)

(iii) Calculate the total energy input.

(3)

total energy input = ... J

(Total for Question 2 = 16 marks)

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3 Magnetic fields can have different shapes.

(a) (i) Describe an experiment to show the shape of the magnetic field around a bar magnet.

(2)

.....

.....

.....

.....

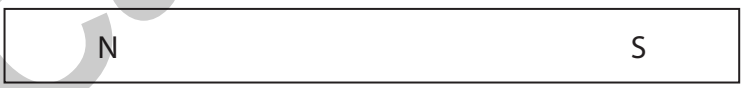
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(ii) The diagram shows a bar magnet.

Complete the diagram to show the shape of the field around the magnet.

(2)



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(b) The diagram shows two bar magnets.

They produce a uniform magnetic field.

On the diagram, sketch the part of the field that is uniform and label the poles.

(3)



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4 Diagram 1 shows some of the apparatus used to investigate the force on a current-carrying wire, XY, in a magnetic field.

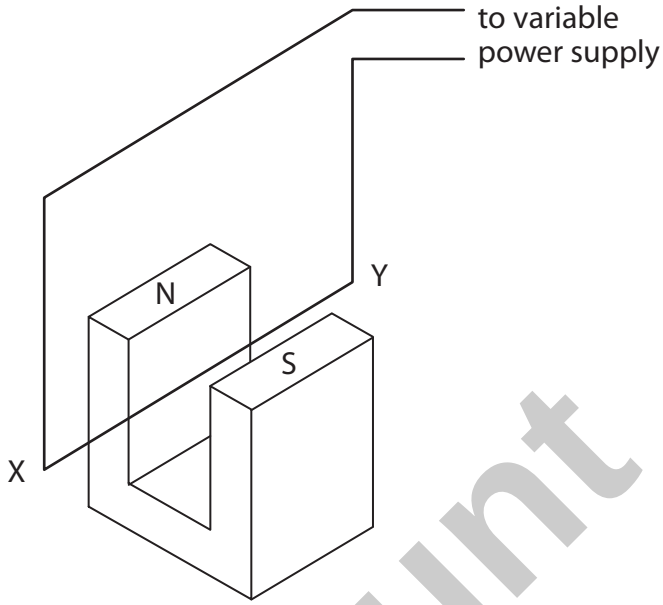


Diagram 1

(a) Diagram 2 shows the poles of the magnet viewed from above.

Draw the uniform magnetic field between the poles.

(2)



Diagram 2

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(b) The current-carrying wire XY is at right angles to the magnetic field.

The current in the wire is 10 A.

(i) Suggest why the wire used in this investigation must be thick.

(1)

.....

.....

(ii) Explain why the wire XY experiences a force when there is a current in the circuit.

(3)

.....

.....

.....

.....

.....

.....

(iii) State two ways in which this force can be reduced.

(2)

1 .....

.....

2 .....

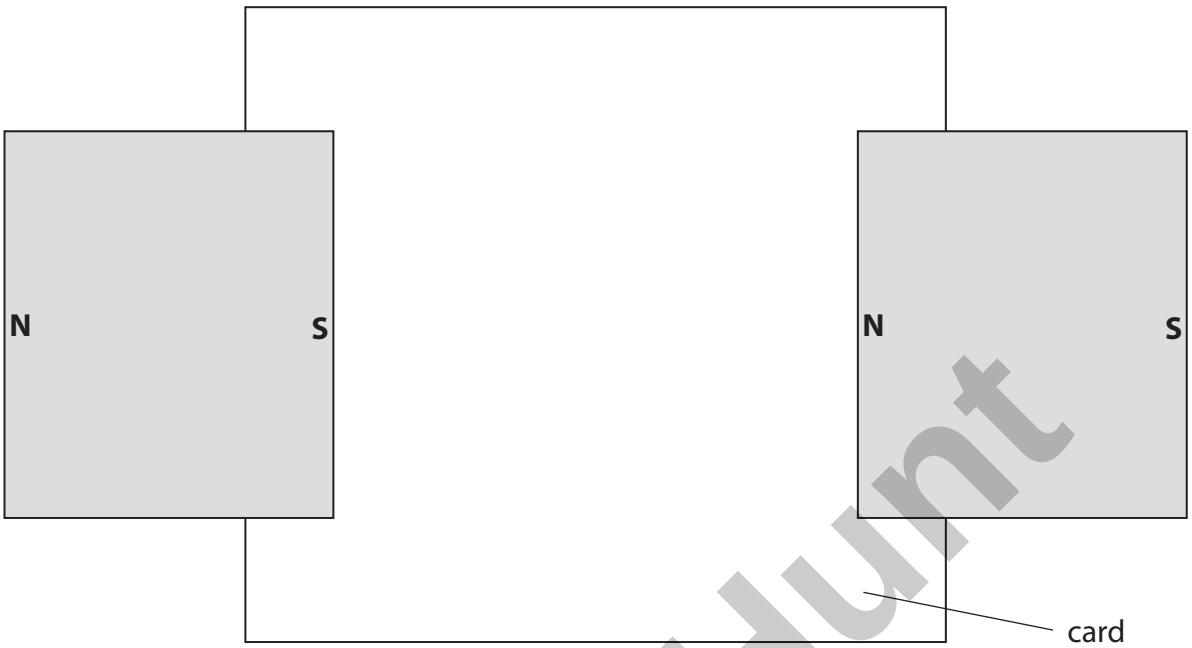
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5 The diagram shows a piece of card and two wide bar magnets.



(a) (i) Add to the diagram to show the shape and direction of the magnetic field pattern between the magnets.

(3)

(ii) Describe how to investigate the shape and direction of the magnetic field between the magnets.

(3)

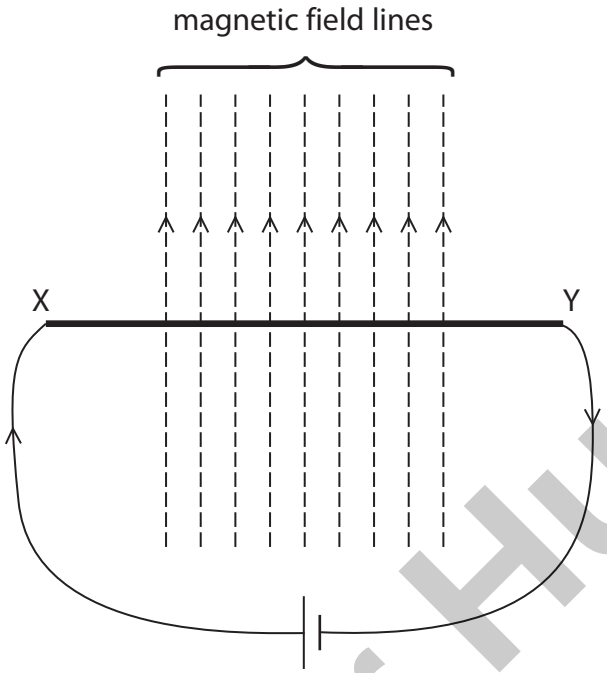
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(b) A metal rod, X Y, is placed in a magnetic field as shown.

Wires from a cell are connected to the ends of the rod so that there is a current from X to Y.



Describe the effect on the rod.

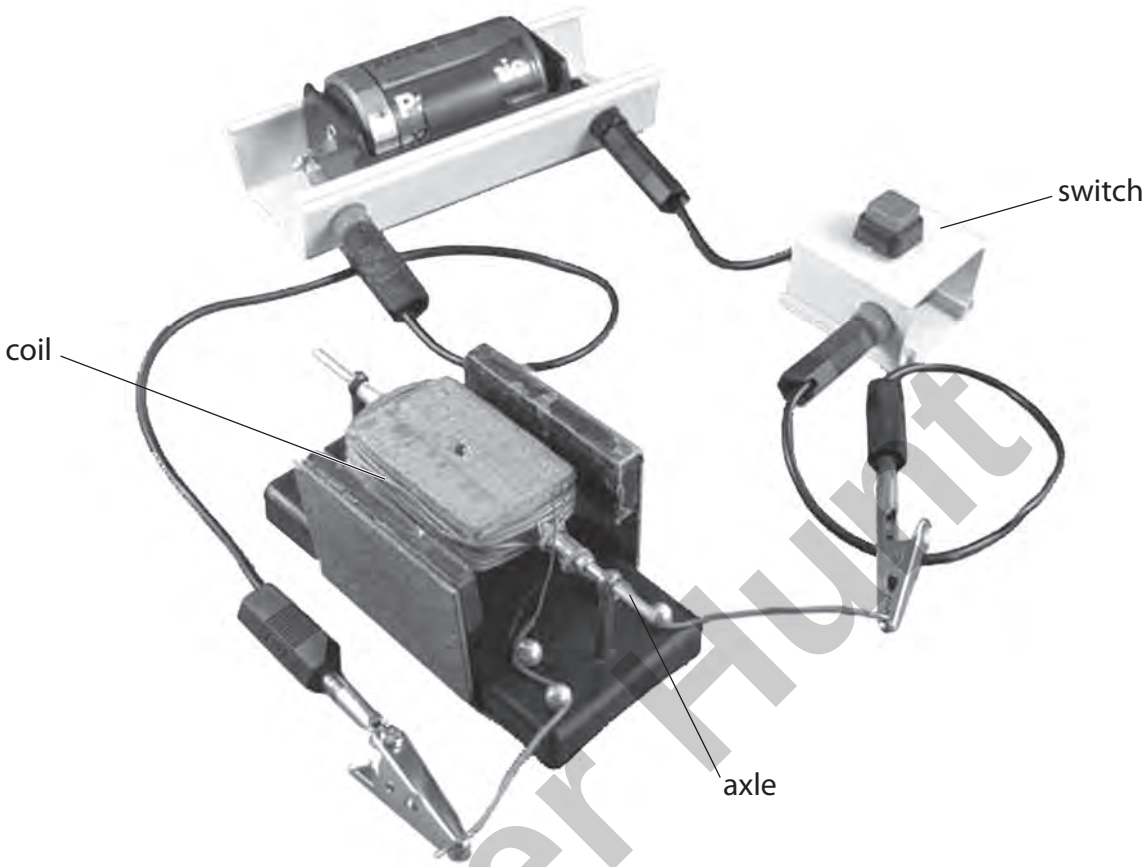
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6 The photograph shows a simple d.c. electric motor.



(a) When the switch is closed the coil spins.

Explain why this happens.

(3)

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(b) (i) Describe two ways to increase the speed of rotation of the coil in this motor.

(2)

1 .....

.....

2 .....

.....

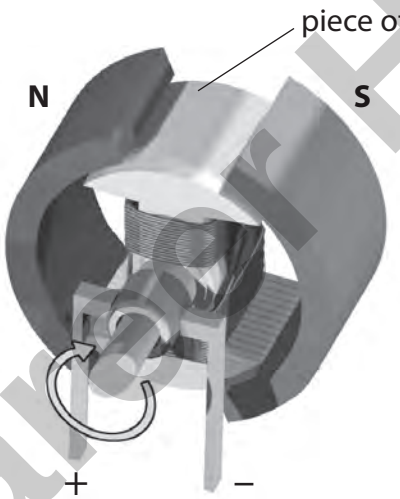
(ii) Suggest how to make the coil spin in the opposite direction.

(1)

.....

.....

(c) In a different motor, the magnets are curved and there is a piece of iron inside the coil. The iron increases the strength of the magnetic field through the coil.



Suggest how the curved magnets and the piece of iron improve the performance of the electric motor.

(2)

.....

.....

.....

.....

.....

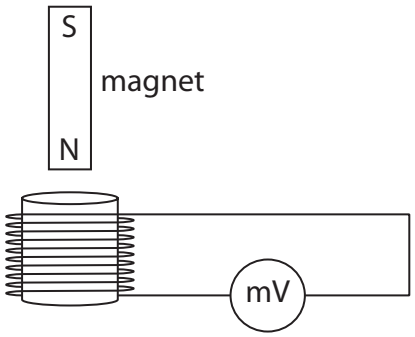
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7 The diagram shows a magnet held above a coil. The coil is connected to a voltmeter.



(a) The magnet is released and falls into the coil.

(i) Explain why the voltmeter shows a reading.

(2)

.....

.....

.....

.....

(ii) The magnet is released from a greater height.

How does this affect the voltmeter?

Explain your answer.

(2)

.....

.....

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(b) State how the voltmeter reading changes when the same magnet

(i) moves more slowly into the coil

(1)

.....

(ii) moves into a coil with more turns

(1)

.....

(iii) is reversed so that the S-pole enters the coil first.

(1)

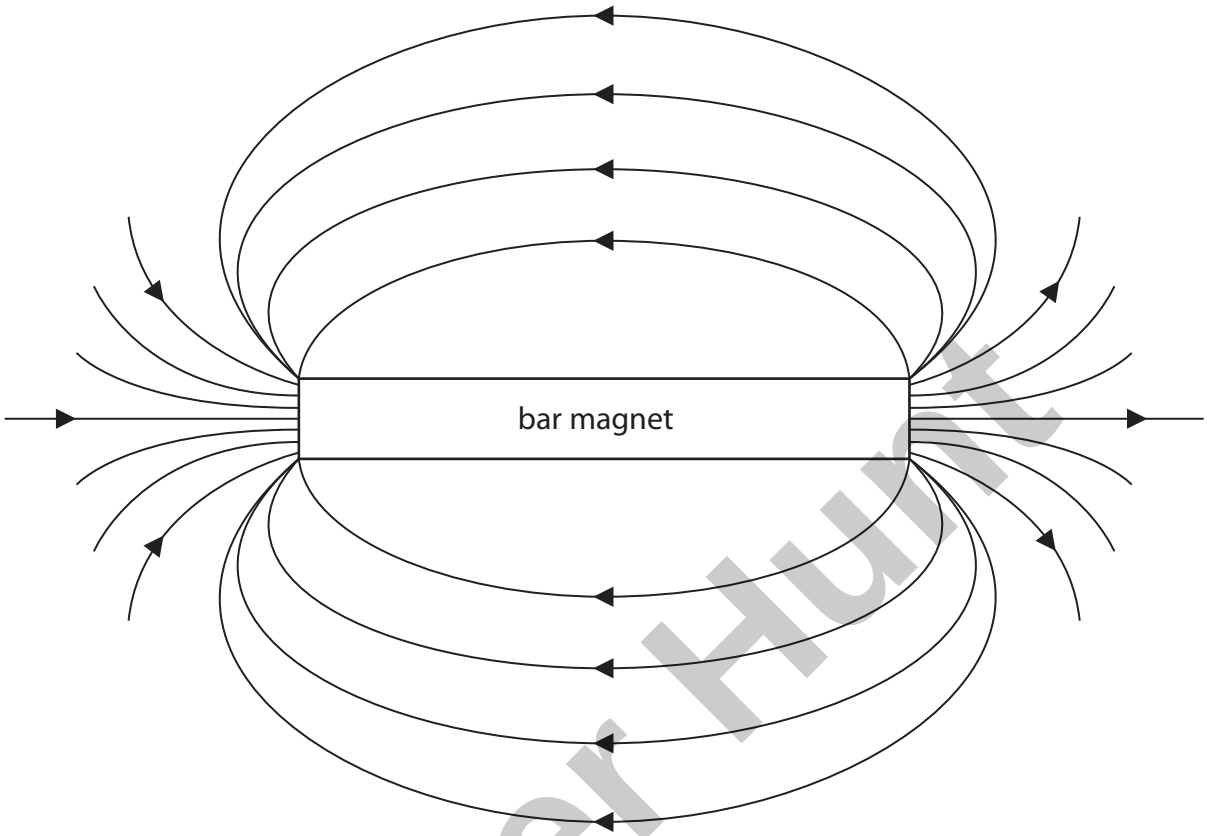
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8 The diagram shows the magnetic field pattern around a bar magnet.



(a) Complete the diagram above by labelling the poles on the bar magnet.

(2)

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(b) Describe an experiment to investigate the shape of the magnetic field pattern of a bar magnet.

You may draw a diagram to help your answer.

(3)

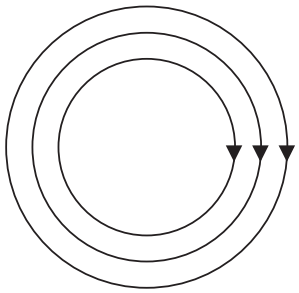
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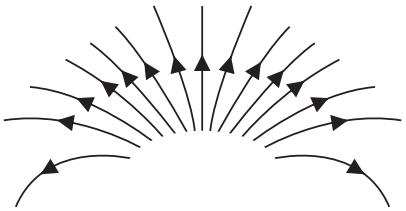
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9 A magnetic field pattern can be shown using lines.

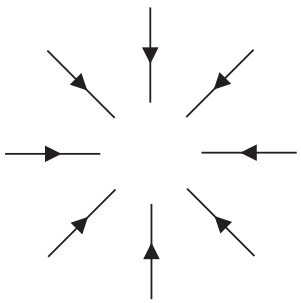
(a) The diagram shows some magnetic field patterns.



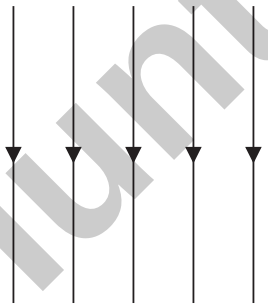
A



B



C



D

Which pattern shows a **uniform** magnetic field? Explain your answer.

(2)

Pattern .....

Explanation .....

.....

.....

(b) Explain how to produce a uniform magnetic field.

(3)

.....

.....

.....

.....

.....

.....

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10

(a) All metals are good conductors of electricity.

Which of these non-metals can conduct electricity?

☒ **A** carbon

☒ **B** chalk

☒ **C** plastic

☒ **D** rubber

(b) The current in a metallic conductor is a flow of

☒ **A** negatively charged electrons

☒ **B** negatively charged protons

☒ **C** positively charged electrons

☒ **D** positively charged protons

(c) Some metals and alloys are magnetic.

Which of these is magnetic?

☒ **A** aluminium

☒ **B** copper

☒ **C** gold

☒ **D** steel

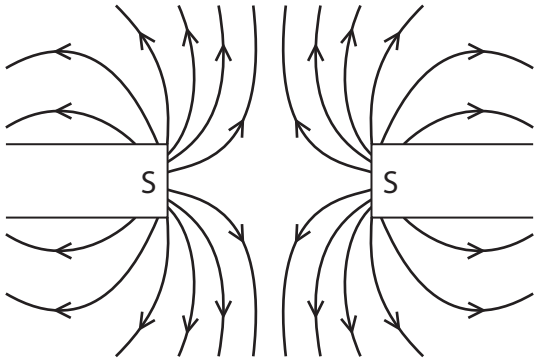
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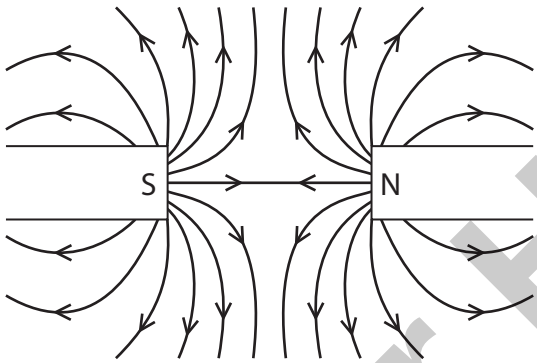
(d) Which of these field patterns is correct?

(1)

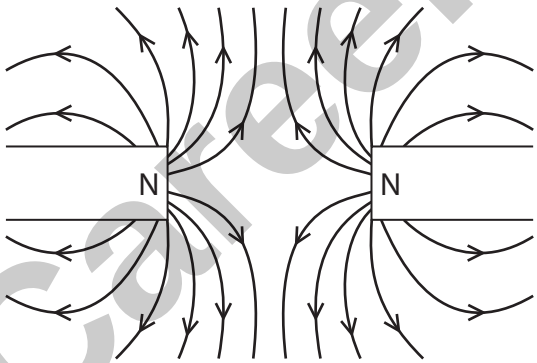
☒ **A**



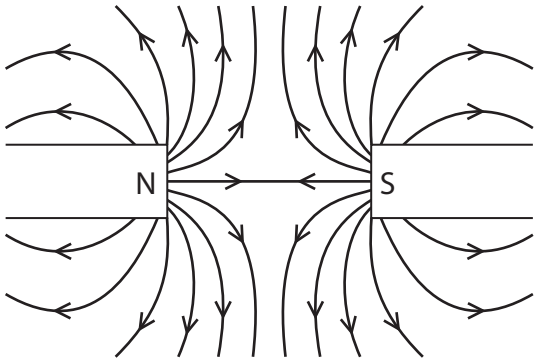
☒ **B**



☒ **C**



☒ **D**



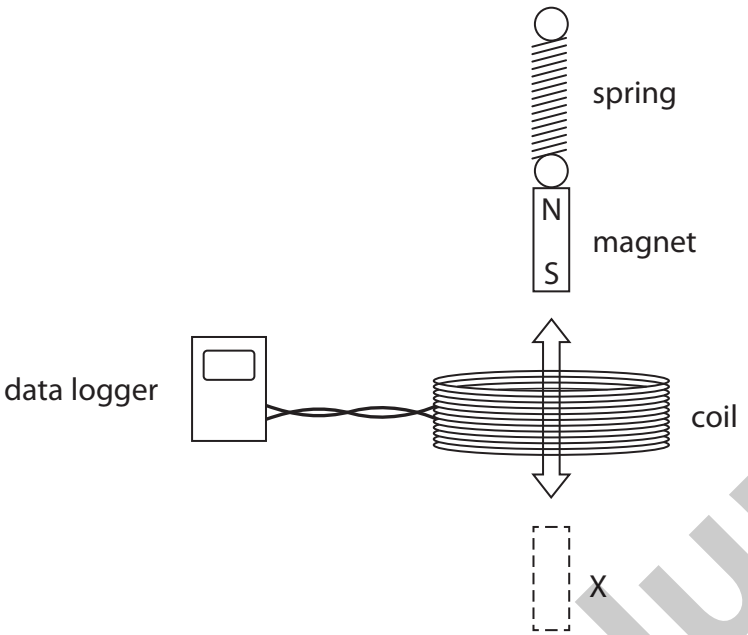
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11 A student investigates how to produce a voltage.

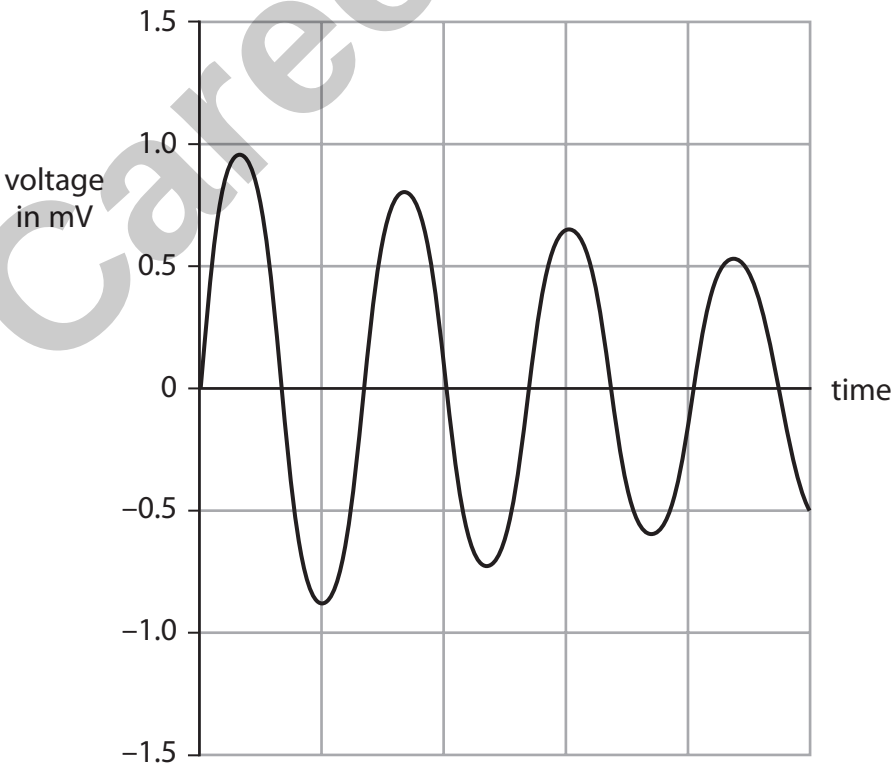
He hangs a magnet from a spring, above a coil that is connected to a data logger.



(a) The student pulls the magnet through the coil to X and then releases it.

The magnet moves up and down through the coil.

The data logger produces this graph of voltage against time.



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(i) Explain why the data logger records a varying voltage.

(2)

(ii) Which feature of the graph shows that the voltage is alternating?

(1)

(iii) Suggest why the voltage changes as shown by the graph.

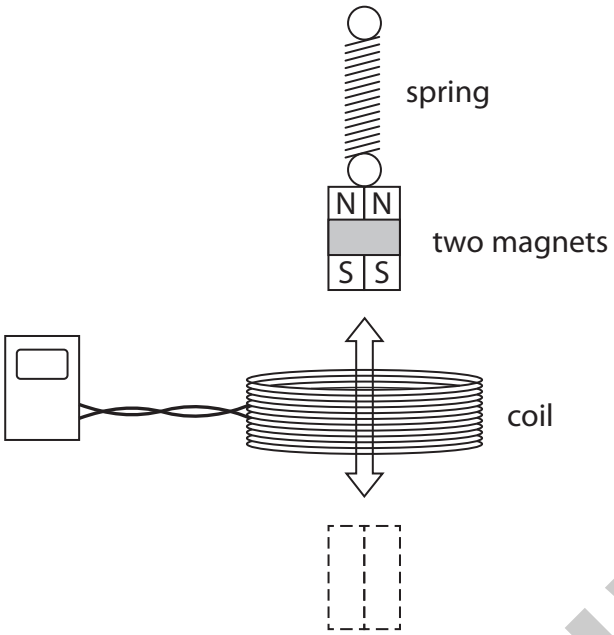
(2)

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(b) The student repeats the experiment using two magnets taped together.

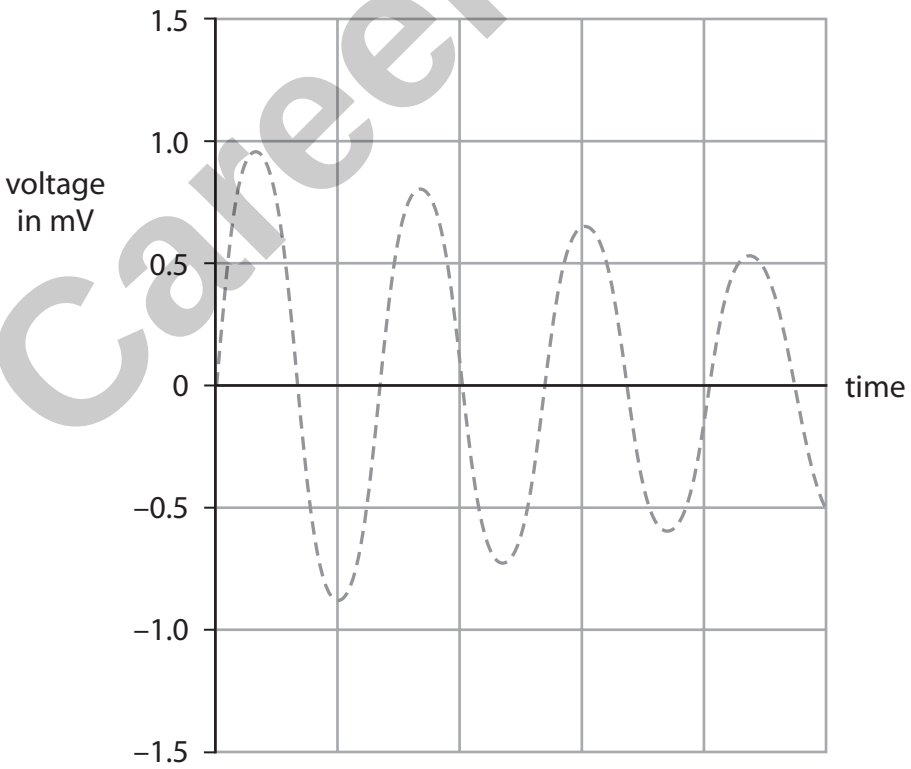


Compared to one magnet, these two magnets take a longer time to move up and down.

The dotted line on the grid shows the original graph for one magnet.

On the same grid, sketch the graph that would be produced using two magnets.

(3)



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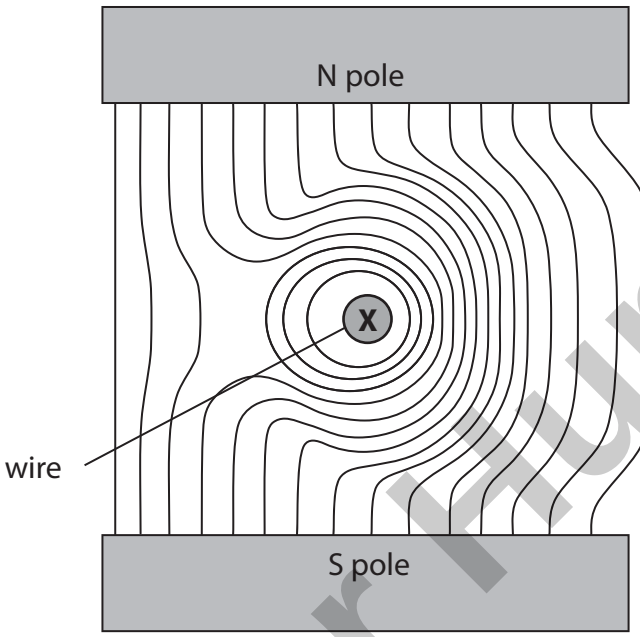
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12 Magnetic field lines show the shape and direction of a magnetic field.

(a) The diagram shows a cross-section through a wire placed between two magnetic poles.

The wire carries electric current into the page at **X**.

The shape of the magnetic field is shown.



(i) Add arrows to two of the magnetic field lines to show the direction of the magnetic field.

(1)

(ii) Draw an arrow on the diagram to show the direction of the force on the wire.

Label this arrow **F**.

(2)

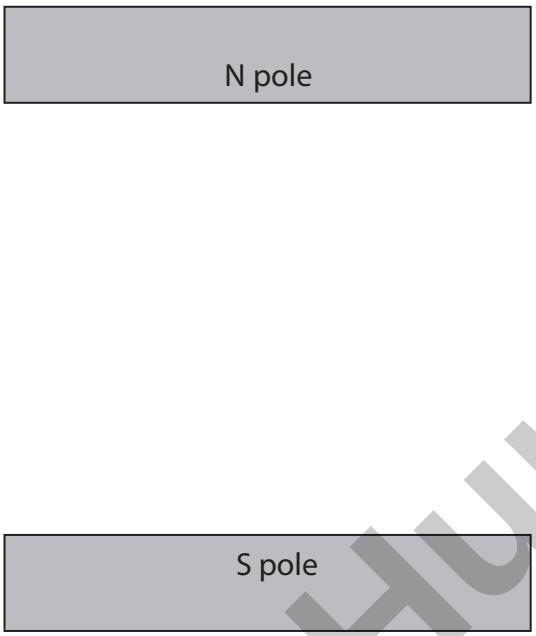
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(b) The wire is removed and the magnetic field between the poles changes.

Sketch the new magnetic field.

(2)



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(c) Explain how you could use a plotting compass to investigate the magnetic field around a bar magnet.

You may draw a diagram to help your answer.

(3)

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13 This photograph shows an electromagnetic device used to keep a door open.



The electromagnet attracts the metal plate to hold the door open.

The electromagnet is connected to a fire alarm circuit.

When the fire alarm sounds, the door is released and it closes.

(a) State why the metal plate is made of iron.

(1)

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(b) Describe the construction of an electromagnet.

You may draw a diagram to help your answer.

(3)

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(c) Describe the changes that allow the electromagnet to release the door when the fire alarm sounds.

(2)

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14 (a) A direct current passes around a flat, circular coil as shown.

On the diagram, sketch the magnetic field caused by the current in the coil.

(3)



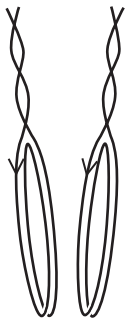
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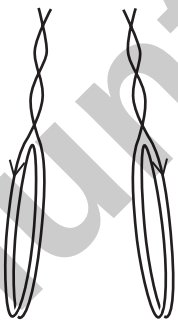
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(b) The coil is suspended vertically so that it is free to swing.
A second, identical coil is placed beside it.

When direct currents pass, as shown, the two coils move together.



When the current in the right-hand coil is reversed, the two coils move apart.



Explain why the coils move in this way.

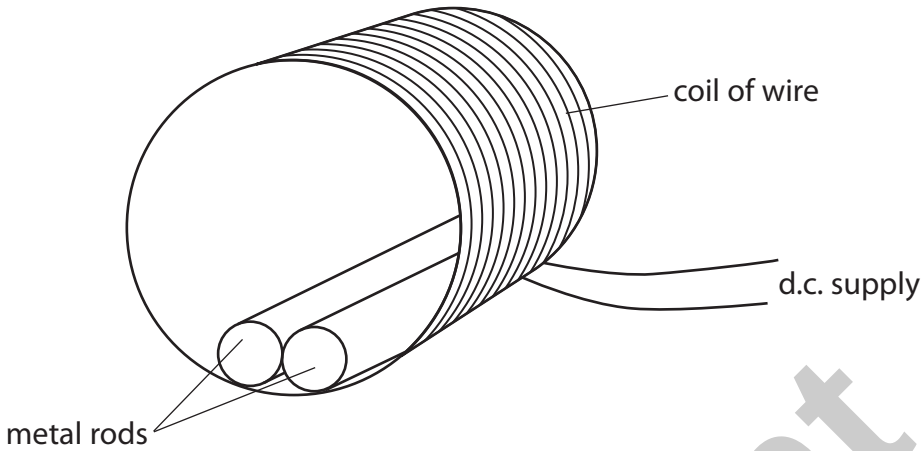
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15 The diagram shows two identical metal rods placed inside a coil of wire.



(a) When a direct current is supplied to the coil, a magnetic field forms and the metal rods move apart.

Explain why the metal rods move apart.

(2)

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(b) When the current is switched off, the metal rods return to their starting places.

Suggest what material the metal rods are made from.

Explain your answer.

(3)

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(c) The direct current in the coil is replaced by an alternating current.

Explain what will happen to the magnetic field.

(2)

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Chapter 6: Magnetism and Electromagnetism Answer

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Question number	Answer	Notes	Marks
1 (a)	any four from: MP1. there is a current in the rod; MP2. (therefore) magnetic field around rod; MP3. magnetic fields interact / overlap; MP4. producing a force (on the rod); MP5. catapult effect / motor effect / LH rule; MP6. rod moves to the right / towards the power supply;	allow 'AB' for rod throughout allow current in the rail ignore references to cutting field lines accept the rod moves sideways / left	4
(b)	any four from: MP1. alternating current changes direction (continuously); MP2. current in coil produces alternating magnetic field/eq; MP3. (producing) force on the coil/cone; MP4. reversing direction of current reverses direction of the force; MP5. hence coil/cone vibrates; MP6. cone vibrates air particles;	allow any marking point if clear from diagram allow changing magnetic field allow coil / cone moves in and out / backwards and forwards total marks = 8	4

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Question number	Answer	Notes	Marks
2 (a)	any two from: MP1. reverse the magnet (N into coil); MP2. reverse the connections at the ammeter; MP3. move the magnet out of coil;	ignore all references to • speed of movement • numbers of turns on the coil CARE that candidate does not conflate MP2 and 3 to negate their answer allow for MP2 invert the coil	(2)
(b) (i)	Y= magnet; Z = coil (of wire);		(2)
(ii)	(±)1.6 (V);		(1)
(iii)	reading of time for 1 cycle ; evaluation; e.g. 0.04s 25 (Hz)	no mark for eqn as it is given time can be assumed if f= 1/0.04 seen allow for 1 mark 50, 12.5 (Hz)	(2)
(iv)	C higher higher ;		(1)
(v)	any one from stronger magnet; more turns on the coil;	ignore bigger magnet condone more coils	(1)
(c) (i)	rearrangement of eqn; substitution; evaluation; e.g. work done (energy output) = power x time (=) 3.1 x 290 900 (W)	Accept 899 (W)	(3)
(ii)	efficiency = $\frac{\text{useful energy output}}{\text{total energy input}}$	accept standard abbreviations rearrangements with factor of X 100	(1)
(iii)	substitution; rearrangement of eqn; evaluation; e.g. input energy = $\frac{\text{output energy}}{\text{efficiency}}$ = $\frac{899\ (W)}{0.72}$ = 1200 (J)	ECF from ci allow 900 for 899 1245, 1250, 1300 (J)	(3)

Total for Question 2 = 16 marks

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Question number	Answer	Notes	Marks
3 (a) (i)	Any two of: MP1. Idea of marking the line/points; MP2. Idea of moving the compass (to a new point along the line); MP3. Idea of starting a new line from a different place;	accept a labelled diagram allow use of iron filings use a compass allow • tapping paper to line up iron filings • multiple compasses	2
(ii)	Any two of: MP1. Correct shape **only;** MP2. lines not crossing each other; MP3. correct direction arrow shown on at least one line;	all field lines must be correct minimum of two curved lines of correct shape added anywhere in the field reject for MP3 any conflict of arrows	2
(b)	MP1 **all** field lines between the poles shown parallel and straight (by eye); MP2 minimum of 3 straight lines evenly spaced (by eye) between the poles; MP3 Opposite poles shown adjacent;	ignore arrows can only be given if minimum of 2 lines shown	3

Total 7 marks

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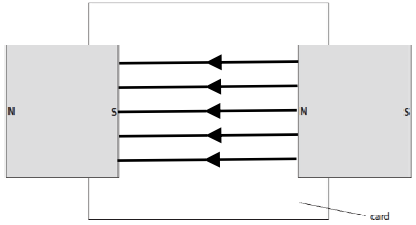
Question number	Answer	Notes	Marks
4(a) (i)	MP1. minimum of 3 straight lines evenly spaced (by eye); MP2. at least one arrow showing direction from N to S;	ignore field outside the rectangle defined by the magnets	2
(b) (i)	any sensible suggestion; e.g. otherwise large heat loss/overheating thin wire would melt to reduce the resistance so it does not sag/bend/eq		1
(ii)	any 3 of: MP1. magnetic field of wire/current; MP2. interacts with; MP3. magnetic field of (2) magnets; MP4. Fleming's left hand rule;	For MP1 and MP3 must refer to what is causing the magnetic field	3
(iii)	MP1. reduce current; MP2. use less powerful magnets/greater separation of magnets;	ACCEPT Use thinner wire, switch off, reduce voltage not 'smaller' magnets allow rotate the wire so that the angle with the magnetic field is smaller	2

Total 8 marks

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Question number	Answer	Notes	Marks
5 (a) (i)	1. at least one arrow showing direction from N to S (right to left); 2. one **horizontal** line between shaded faces; 3. minimum of 3 horizontal lines evenly spaced (by eye); e.  	Reject contradictory arrows For MP2,3 ignore any lines outside the rectangle between the shaded faces allow field lines that almost touch the faces	3
(ii)	1. a method **to show shape**; e. use compass(es) Use of iron **filings/ powder** 2. Use f (plotting) compass **to show direction**; 3. further **method detail**; e. mark card /move compass/multiple compasses idea of another line or lines added sprinkle (iron filings evenly on card) tap card (to distribute iron filings)	**Ignore** Position of card /Cling film **Ignore** pour/place/ drop /spill	3

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Question number	Answer	Notes	Marks
(b)	any **two** of 1. (Fleming's) Left Hand (Motor) rule OR (current generates) magnetic field **around** the rod; 2. Idea that there is a force (on rod); 3. (translational) movement of rod; 4. Correct direction given, i.e. out of the paper;	allow LHM rule/LH rule/motor rule/ motor effect **Ignore** upwards rod is magnetic	2
		Total	**8**

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Question number		Answer	Notes	Marks
6 (a)		any three of MP1 idea that there is **current** (in the wire/coil); MP2 idea that (the coil has) a **magnetic field**; MP3 idea that coil's magnetic field **interacts** with field of permanent magnet; MP4 idea that there is a **force** on the coil/wire; MP5 Idea that current or force **reverses** every half turn;	 Allow ideas of electromagnetic field, electromagnet Allow - 'magnetic fields touch / overlap' Ignore - 'cutting of magnetic fields' Allow ideas of LHM rule, Fleming's LHR, catapult field, attraction, repulsion Allow action of a commutator described	3

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(b)	(i)		any two of MP1 increase magnetic field(e.g. stronger magnets or magnets closer or magnets curved round coil); MP2 increase current OR voltage Or more cells; MP3 increase number of turns (on coil); MP4 a sensible alternative suggestion e.g. use two or more sets of coils at angles, lubricate axle;	 Allow “use thicker wire” Ignore “stronger battery” Allow idea of 3 phase supply, iron stator	2
	(ii)		Suggestion that clearly results in reversal of the current OR the cell connections OR the magnet’s field;		1
(c)			any two of MP1 Idea that force is increased (by stronger field); MP2 Idea of radial magnetic field (rather than a uniform one); MP3 Coil remains in the field for a longer time;	 Allow idea that iron is magnetised Allow idea that magnetic field acts “all the way around” Allow idea that force acts over a larger part of a cycle	2

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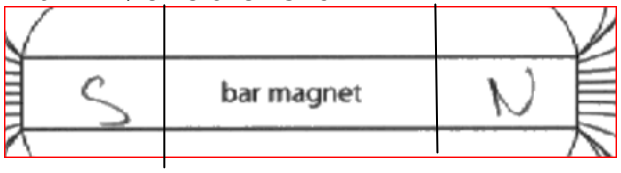
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Question number	Answer	Notes	Marks
7(a) i	there is a voltage; And one of (because there is a) change of flux OR field (lines) are cut; (which is) an induced voltage / emf;	 Allow induced current	2
ii	greater deflection/voltage; Idea that rate of change of flux (linkage) is greater; eg more magnetic field lines cutting coil (per second)	 ignore speed of magnet	2
(b) i	Idea that deflection is smaller;		1
ii	Idea that deflection is greater;		1
iii	Idea that deflection is in opposite direction;		1
		Total	**7**

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Question number	Answer	Notes	Marks
8 (a)	Position of poles indicated correctly near end of magnet; S on L AND N on R ;	Allow at the end of the magnet within ¼ or either end  	2
(b)	Any suitable method, e.g. • Place plotting compass at side/end of magnet; • Mark position of end of compass; • Move end of compass needle to new mark (and repeat); OR o Place magnet under paper / plastic; o Sprinkle iron filings over; o Tap paper gently (to reveal pattern);	allow suitably clear diagram(s) reject for one mark 'charges' ignore comments about finding the direction of the field allow: steel dust for iron filings place for sprinkle	3

Total 5 marks

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Question number	Answer	Notes	Marks
9 (a)	parallel field (DOP)	ACCEPT equally spaced and straight / equally spaced and do not change direction	2
(b)	two (permanent / bar) magnets pole pieces arranged correctly e.g. North facing South idea of magnets being the correct distance apart	ACCEPT points made on an annotated diagram REJECT description of poles as positive / negative ACCEPT “close together”, “not touching” ACCEPT idea that field is produced in the space between the N pole of one magnet and the S pole of the other REJECT answers that are clearly referring to electromagnets	3

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Question number	Answer	Notes	Marks
10(a)	A carbon;		(1)
(b)	A negatively charged electrons;		(1)
(c)	D steel;		(1)
(d)	C 2 N poles facing;		(1)

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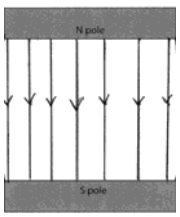
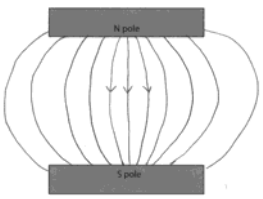
Question number	Answer	Notes	Marks
11 (a) (i)	any two ideas from:- MP1. voltage / current is <u>induced</u>; MP2. (because) field in coil is changing / field (lines) cut; MP3. current/voltage changes direction when magnet does; MP4. magnet slows down causing decrease in amplitude;	allow voltage for amplitude	2
(ii)	Either of - (voltage/current) changes direction; Positive <u>and</u> negative (voltage/current);	Ignore "wave"	1
(iii)	any two of - MP1. direction of magnet changes; MP2. amount of field (lines) cut changes / rate of flux cutting; MP3. direction of flux cutting changes; MP4. speed of magnet changes / slows down; MP5. as movement diminishes, so does voltage;		2
(b)	Any three of - MP1. Alternating trace that diminishes; MP2. Amplitude is larger; MP3. Frequency is lower;		3

Total 8 marks

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Question number	Answer	Notes	Marks
12 (a) (i)	arrows on two or more {lines from N to S and/or clockwise on loops around wire};	accept arrows beside lines showing correct directions reject contradicting arrows (i.e. one correct and one incorrect)	1
(ii)	horizontal arrow (by eye); pointing to the left;	accept • arrow not passing through wire • unlabelled arrow if clear DOP	2
(b)	EITHER: **Uniform field drawn** MP1. single straight line drawn perpendicular to and between poles; MP2. additional straight lines drawn either side that are parallel and evenly spaced (by eye); OR **Non-uniform field drawn** MP1. central straight line(s) drawn perpendicular to and between poles; MP2. correctly curved lines drawn either side of the centre and drawn symmetrically (by eye);	Lines can start/end at faces or edges of poles   ignore all arrows on lines	2

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(c)	MP1. place compass around magnet and note / mark its direction; MP2. place compass in **new position** and note / mark its direction again; MP3. directions linked together to find a field line / pattern;	ignore references to iron filings award marks if clear in diagram if contradiction between words and diagram, go by the diagram allow use of additional compass(es)	3

Total 8 marks

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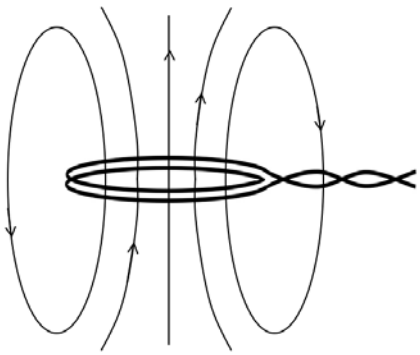
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Question number			Answer	Notes	Marks
13	a		**one** of: iron is (soft) magnetic; iron loses its magnetism easily;	allow RA for steel	1
	b		**these can be shown on a labelled diagram** MP1. current carrying (insulated) wire; MP2. wrapped into coil; MP3. wrapped on **iron** core;	allow wire shown connected to a battery solenoid = MP2 only	3
	c		Any two **ideas** from: MP1. current/ voltage reduces OR eq; MP2. magnetic field of em reduces; MP3. (magnetic) force holding the iron plate to the magnet no longer present;	do not give marks for • 'the door closes'/eq • electricity • power allow current stops circuit broken • iron plate no longer magnetised	2
				total = 6 marks	

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Question number	Answer	Notes	Marks
14 (a)	MP1. at least one straight, vertical central field line; MP2. any field line drawn circling the wire / at least one peripheral field loop; MP3. field directions correct and consistent throughout and shown on at least two lines; 	ignore breaking of field lines as they pass through the centre of the coil by eye condone spiral drawn round wire	3
(b)	any 3 from: MP1. idea of magnetic fields interacting; MP2. idea of (magnetic) attraction or repulsion; MP3. reversing current reverses direction of magnetic field / force; MP4. some comparison with magnets, e.g. like poles repel, unlike poles attract;	allow field lines crossing ignore 'cutting' reject mention of electrostatic force or charge mention of having 'poles'	3

Total 6 marks

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Question number	Answer	Notes	Marks
15 (a)	Rods magnetised; And repel;	Reject ideas of charge for one mark only	2
(b)	MP1. A named magnetic material e.g.(soft) iron; MP2. because the material is capable of being magnetised; MP3. DOP (iron only) but does not retain its magnetism;	ACCEPT steel, mu-metal, nickel, cobalt accept RA steel would stay magnetised/apart	3
(c)	any two from- MP1. field (in coil) switches polarity; MP2. field (in rods) weaker; MP3. (since) field alternates with current or at 50 Hz; MP4. rods may not have time to become fully magnetised;	allow • 100 times a second or mains frequency • hysteresis ideas • domain theory • reluctance ideas	2

Total 7 marks

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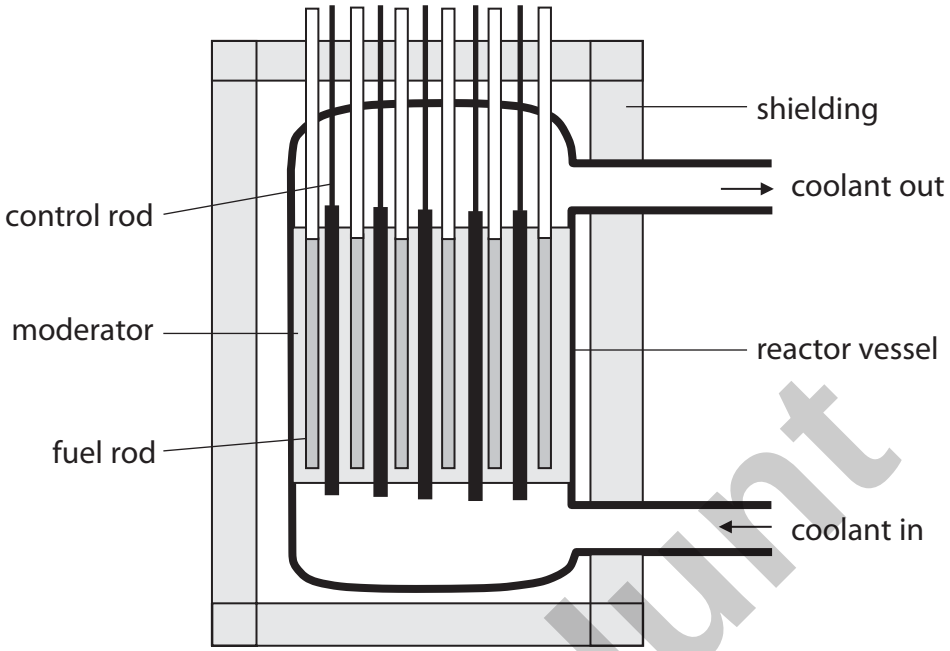
Chapter 7: Radioactivity and Particles Question

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1 The diagram shows the main parts of a nuclear reactor.



(a) Draw a line linking each part of the reactor with its main function.

The first one has been done for you.

(2)

part of reactor	**main function**
control rod	controls the rate of fission
coolant	absorbs dangerous radiation
fuel rod	contains uranium for fission
shielding	removes energy from the reactor

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(b) State the type of energy released in a fission reaction.

(1)

(c) Explain the role of the moderator in a fission reaction.

(2)

(d) Explain, in terms of neutrons, what is meant by controlled nuclear fission.

(3)

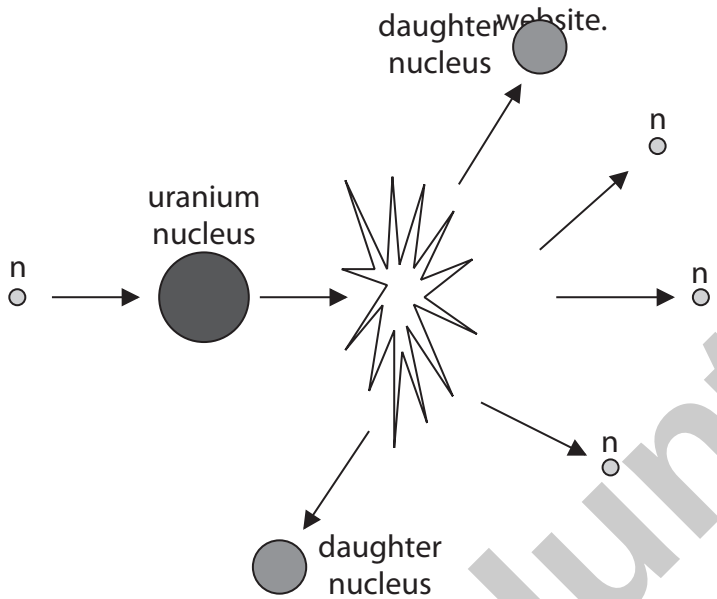
(Total for Question 1 = 8 marks)

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2 A student finds this representation of nuclear fission on a website.



(a) Describe what happens when nuclear fission of uranium occurs.

(3)

.....

.....

.....

.....

.....

.....

(b) The daughter nuclei move off with high speed.

Name the type of energy that this gives them.

(1)

.....

(Total for Question 2 = 4 Marks)

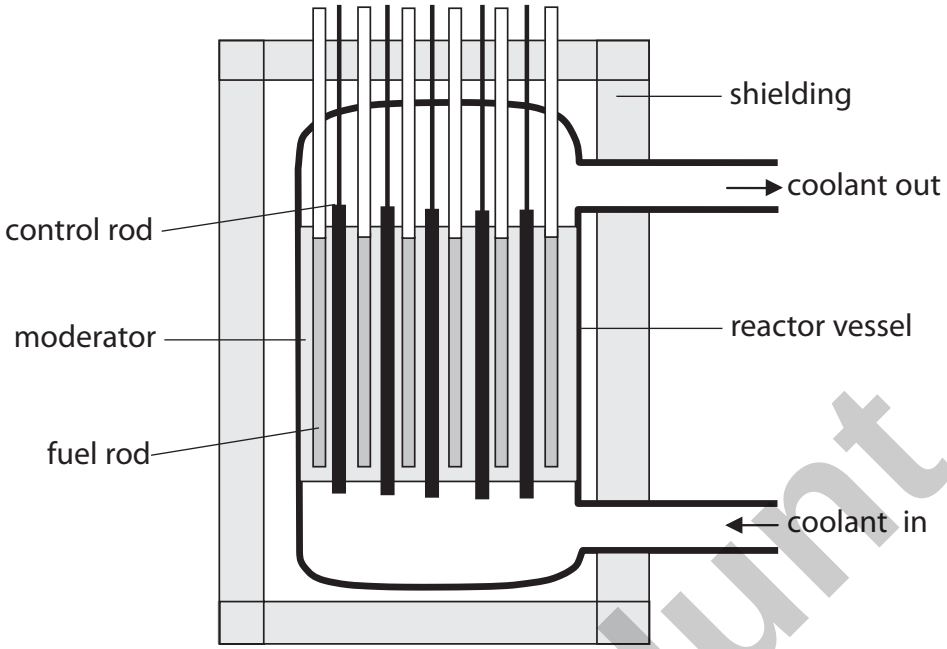
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3 The diagram shows the main parts of a nuclear reactor.

In the nuclear reactor uranium-235 nuclei undergo fission in a controlled chain reaction.



(a) Describe nuclear fission and how the chain reaction is controlled.

Use terms from the diagram to help you.

(5)

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(b) State the form of energy that is released during fission.

(1)

.....

(c) How does the shielding improve safety?

(1)

.....

.....

(Total for Question 3 = 7 marks)

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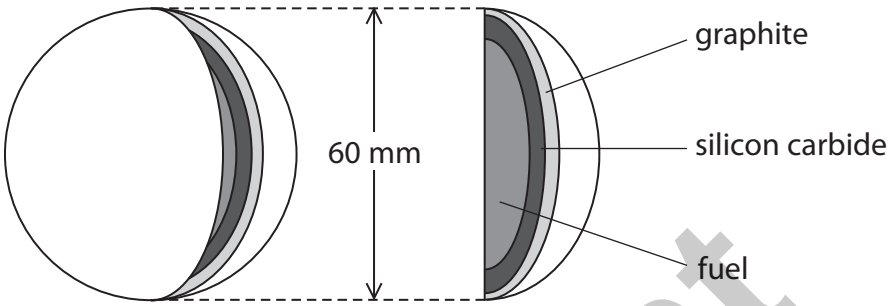
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4 (a) The diagram shows the fuel used in some nuclear reactors.

The fuel is contained inside spheres.

The silicon carbide layer of each sphere is designed to contain the fission products for at least one million years.



section through a fuel sphere

(i) Give the name of a fuel that could be used.

(1)

.....

(ii) Explain what is meant by the term **fission products**.

(2)

.....

.....

.....

.....

(iii) Explain why it is important to contain these fission products for such a long time.

(2)

.....

.....

.....

.....

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(iv) The graphite layer in every fuel sphere acts as a moderator.

What is the function of the moderator in a nuclear reactor?

(1)

.....

.....

(v) The nuclear reactor also contains boron control rods.

Explain why it is dangerous to remove most of the control rods from the reactor.

(2)

.....

.....

.....

.....

(b) The reactor is cooled with helium gas.

The gas enters the reactor at 500 °C.

(i) What is this temperature in kelvin?

(1)

temperature = ... K

(ii) Helium gas enters the reactor at a pressure of 8.40 MPa and leaves the reactor at a temperature of 1170 K.

Calculate the pressure of the helium gas as it leaves the reactor.
[assume the volume of the gas does not change]

(3)

pressure = ... MPa

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5 In a nuclear reactor, a uranium-235 nucleus absorbs a neutron and fission occurs.

(a) Complete the equation below that shows a typical fission reaction.

(2)

$$\begin{matrix}235\\92\end{matrix}\mathrm{U} + \begin{matrix}1\\0\end{matrix}\mathrm{n} \rightarrow \begin{matrix}142\\\end{matrix}\mathrm{Ba} + \begin{matrix}\\36\end{matrix}\mathrm{Kr} + 3\begin{matrix}1\\0\end{matrix}\mathrm{n}$$

(b) Explain how nuclear fission can lead to a chain reaction.

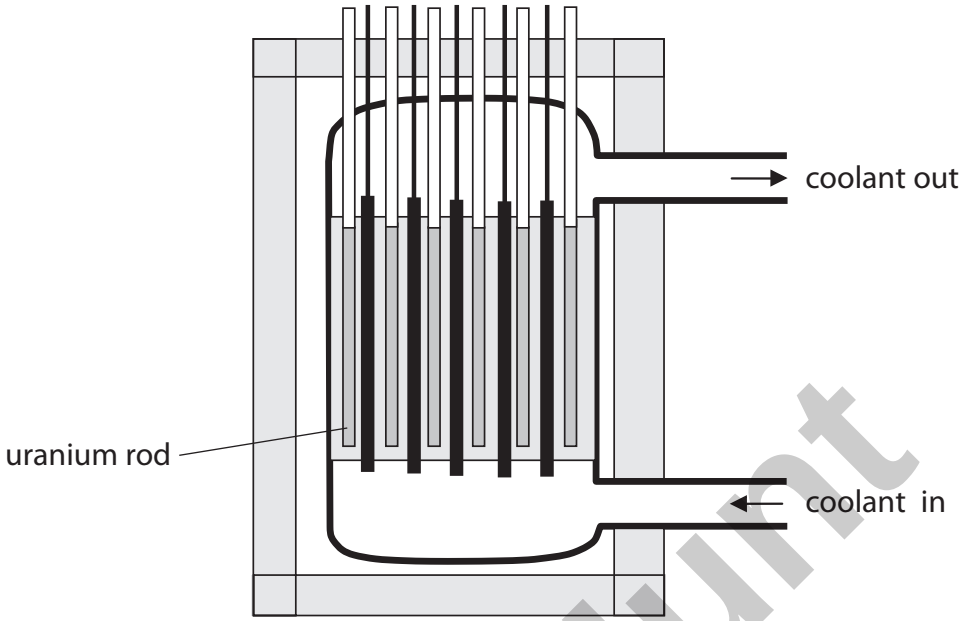
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(c) The diagram shows a nuclear reactor.



(i) On the diagram, label the control rods and the shielding.

(2)

(ii) Explain why the shielding is needed.

(2)

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6 The table describes the nuclei of four atoms.

uranium-234	uranium-235	plutonium-238	americium-238
$^{234}_{92}U$	$^{235}_{92}U$	$^{238}_{94}Pu$	$^{238}_{95}Am$

(a) Atoms contain electrons.

Which nucleus needs the largest number of electrons to form a neutral atom?

(1)

- ☒ **A** uranium-234
- ☒ **B** uranium-235
- ☒ **C** plutonium-238
- ☒ **D** americium-238

(b) (i) Which two nuclei have the same number of protons?

(1)

..... and .....

(ii) Which two nuclei have the same number of nucleons?

(1)

..... and .....

(iii) Which two nuclei have the same number of neutrons?

(1)

..... and .....

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(c) All of the nuclei are unstable and have a different half-life.

(i) Explain what is meant by the term **unstable**.

(1)

.....

.....

(ii) Explain what is meant by the term **half-life**.

(2)

.....

.....

.....

.....

(d) When plutonium decays, it emits an alpha particle and a gamma ray.

(i) Complete the decay equation for plutonium-238.

(4)

$$\begin{matrix}238\\94\end{matrix}\mathrm{Pu} \longrightarrow \begin{matrix}4\\\square\end{matrix}\alpha + \begin{matrix}\square\\\square\end{matrix}\mathbf{X} + \begin{matrix}\square\\0\end{matrix}\gamma$$

(ii) Use information from the table to identify element X.

(1)

element X = ...

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(e) The nucleus of americium-238 can absorb an electron.

When this happens, one of the protons in the nucleus becomes a neutron.

This equation describes the process.

$$\begin{array}{ccccc} 1 & & 0 & & 1 \\ p & + & e & \longrightarrow & n \\ 1 & & -1 & & 0 \end{array}$$

(i) Describe how this process affects the proton number and the nucleon number of the nucleus that absorbs the electron.

(2)

.....

.....

.....

.....

(ii) Identify the new nucleus formed by this process.

(1)

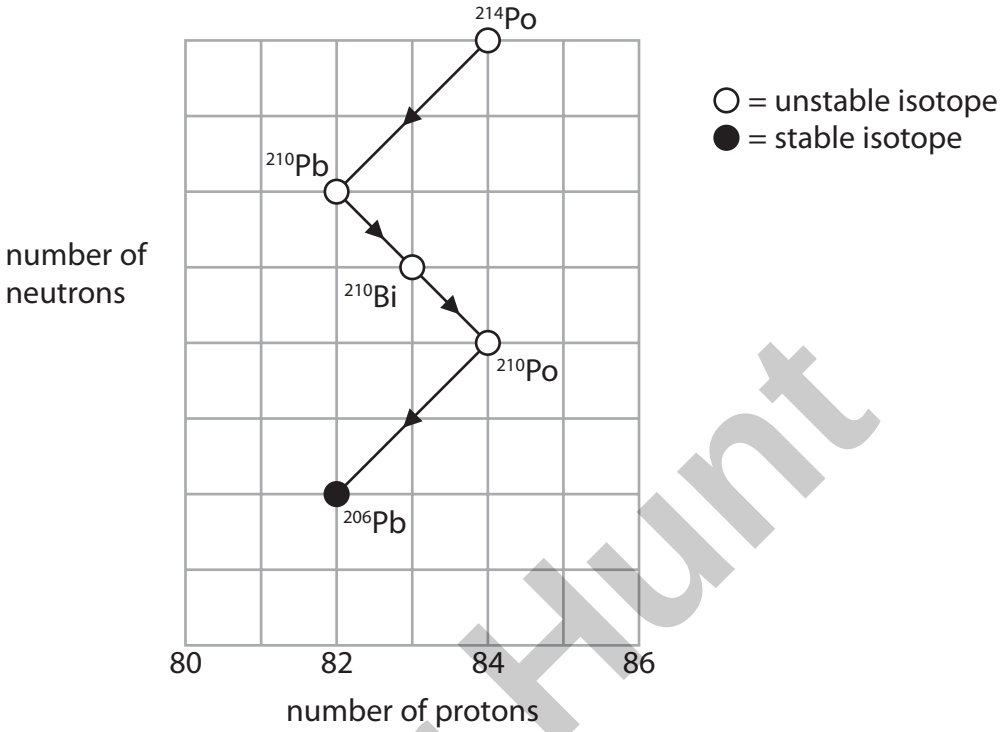
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7 The grid shows the number of neutrons and the number of protons in some isotopes formed during successive radioactive decays.



(a) (i) What are **isotopes**?

(2)

.....

.....

.....

.....

(ii) Why are some isotopes described as **stable**?

(1)

.....

.....

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(b) (i) Use the grid to **calculate** the number of neutrons in a ^{210}Po nucleus.

(1)

number of neutrons = ...

(ii) Describe what happens to the number of protons and the number of neutrons when a nucleus of ^{210}Pb decays to form ^{210}Bi.

(2)

.....

.....

.....

.....

(iii) State the type of decay that occurs when ^{210}Pb decays to form ^{210}Bi.

(1)

.....

(c) Explain why the mass (nucleon) number and the atomic (proton) number do not change when a gamma ray is emitted from a nucleus.

(2)

.....

.....

.....

.....

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8 Radon is a gas produced by some types of rocks.

(a) Radon is a natural source of radioactivity.

What is the name for this radioactivity?

(1)

- ☒ **A** background radiation
- ☒ **B** chain reaction
- ☒ **C** radioactive dating
- ☒ **D** radiotherapy

(b) There are two sources of alpha radiation in some houses:

- radon gas in the air
- solid americium in a smoke alarm

The alpha particles from radon are a greater risk to health than the alpha particles from americium.

Explain why.

(2)

.....

.....

.....

.....

.....

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(c) Radon-222 and radon-220 are both isotopes of radon.

(i) A nucleus of radon-222 has 86 protons.

How many protons are there in a nucleus of radon-220?

(1)

- ☒ **A** 86
- ☒ **B** less than 86
- ☒ **C** more than 86
- ☒ **D** none

(ii) A nucleus of radon-222 has 136 neutrons.

How many neutrons are there in a nucleus of radon-220?

(1)

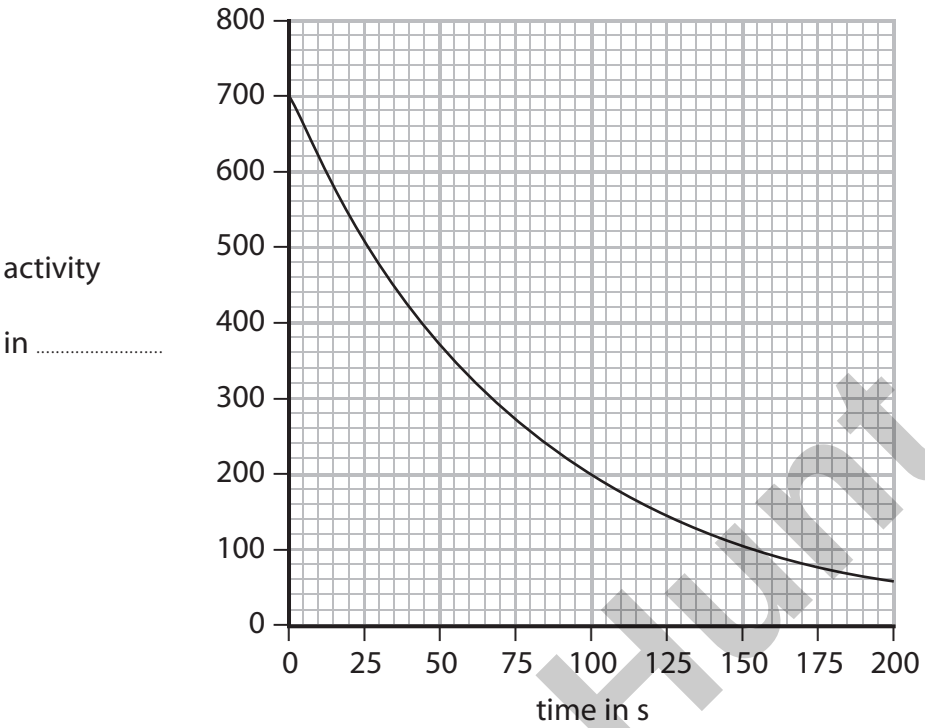
- ☒ **A** 86
- ☒ **B** 134
- ☒ **C** 136
- ☒ **D** 220

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(d) The graph shows how the activity of a sample of radon-220 changes with time.



(i) Complete the graph by adding the missing unit for activity.

(1)

(ii) Explain what is meant by the term **half-life**.

(2)

.....

.....

.....

(iii) Use the graph to find a value for the half-life of radon-220.

(2)

Half-life = ... s

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9 Scientists use the term radiation in different ways.

Sometimes radiation means streams of particles and sometimes radiation means high frequency waves.

(a) Draw a straight line from each description to the type of radiation it describes.

(3)

description	type of radiation
electromagnetic waves	alpha
particles with a negative charge	beta
particles with a positive charge	gamma
	neutron

(b) Alpha, beta and gamma radiations are described as ionising.

(i) Complete the table to show alpha, beta and gamma radiations in order of increasing ionisation.

(1)

least ionising → most ionising

(ii) Describe two ways in which these ionising radiations can cause harm.

(2)

1. .....

.....

2. .....

.....

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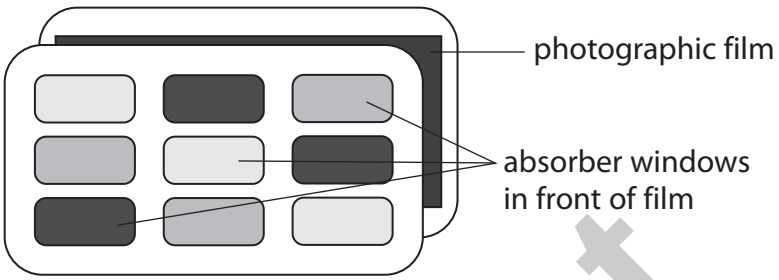
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(c) People who work with ionising radiations need to measure the amount of radiation they are exposed to.

For many years, a film badge was used to detect the radiations.

The diagram shows how a film badge is constructed.



Each absorber window is made from different thicknesses of paper, aluminium or lead.

Complete the table to show if alpha, beta and gamma radiations penetrate each material. Some have been done for you.

Use the words 'goes through' or 'stopped'.

(3)

	0.1 cm paper	**0.5 cm aluminium**	**0.5 cm lead**
alpha radiation			stopped
beta radiation		stopped	
gamma radiation	goes through		

(d) State the name of another device that can be used to detect alpha radiation.

(1)

.....

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10 Alpha particles, beta particles and gamma rays have different properties.

(a) Complete the table by ticking the correct type of radiation for each property.

The first one has been done for you.

(2)

Property	Type of radiation		
	alpha particles	**beta particles**	**gamma rays**
most ionising	✓		
largest mass			
most penetrating			
highest speed			
negatively charged			

(b) The symbol for the structure of an alpha particle is

$$^{4}_{2}\alpha$$

(i) State the number of neutrons and the number of protons in an alpha particle.

(2)

number of neutrons .....

number of protons .....

(ii) Suggest why alpha radiation is more ionising than beta or gamma radiation.

(1)

.....

.....

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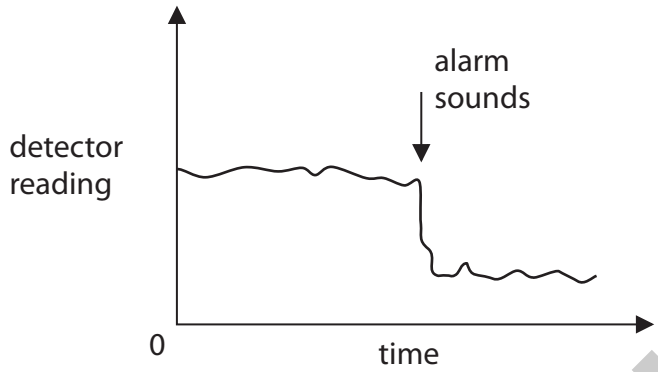
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(c) A smoke alarm contains a source of alpha particles and a detector.

The alpha particles reach the detector through a sample of air from the room.

The alarm sounds if there is a sudden drop in the detector reading.

This graph shows changes in the detector reading.



(i) Why is the detector reading never zero?

(1)

.....

.....

(ii) Why is the detector reading never constant?

(1)

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(iii) Suggest why fewer alpha particles reach the detector if there is a fire.

(2)

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11 A scientist placed a radioactive source in front of a Geiger-Muller detector and measured the count rate every 20 minutes.

The table shows her data.

Time in minutes	Count rate in counts per minute	Corrected count rate in counts per minute
0	660	630
20	462	432
40	330	300
60	240	210
80	180	150
100	142	112

(a) The scientist corrects the count rate readings to allow for background radiation.

(i) State two sources of background radiation.

(2)

1 .....

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2 .....

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(ii) Describe how the scientist should measure the background radiation and correct the count rate readings.

(3)

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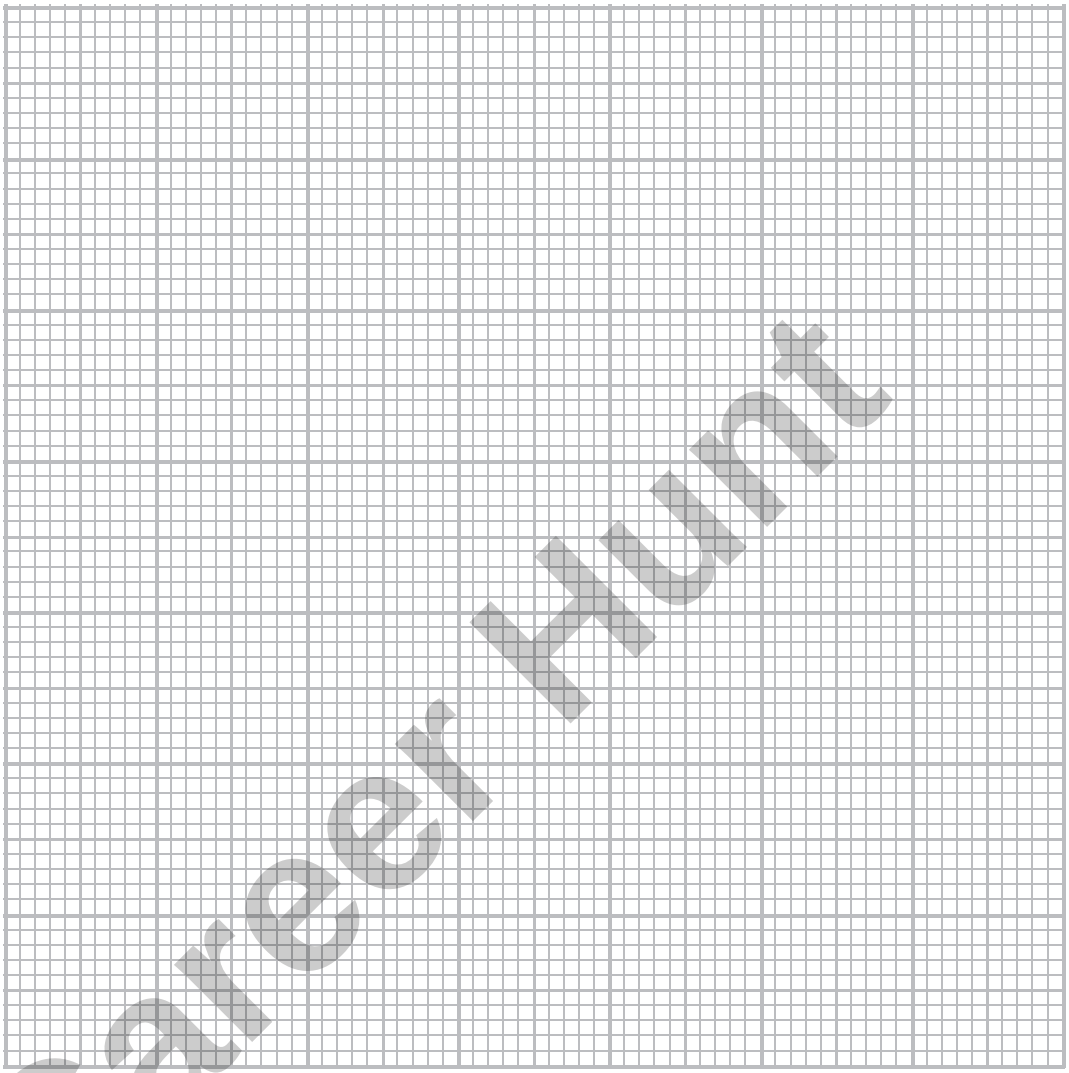
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(iii) Plot a graph of corrected count rate against time and draw the curve of best fit.

(5)



(iv) Use your graph to find the half-life of the radioactive source.

(2)

half-life = ... minutes

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(b) The radioactive nuclei in the source emit beta radiation.

What effect does the emission of a beta particle have on a nucleus?

(2)

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.....

(c) The scientist needs to reduce the risks when working with radioactive sources.

(i) Explain why radioactive sources can be dangerous.

(2)

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(ii) Describe how the risks of working with radioactive sources can be reduced.

(3)

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12 Carbon-14 is a radioactive isotope of carbon.

It has the symbol

$$^{14}_{6}C$$

(a) (i) The number of **nucleons** in a carbon-14 nucleus is

(1)

- ☒ **A** 6
- ☒ **B** 8
- ☒ **C** 14
- ☒ **D** 20

(ii) The number of **neutrons** in a carbon-14 nucleus is

(1)

- ☒ **A** 6
- ☒ **B** 8
- ☒ **C** 14
- ☒ **D** 20

(iii) The number of **electrons** in a neutral carbon-14 atom is

(1)

- ☒ **A** 6
- ☒ **B** 8
- ☒ **C** 14
- ☒ **D** 20

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(b) When carbon-14 decays it emits a beta particle.

What is a **beta particle**?

(1)

- ☒ **A** an electron
- ☒ **B** a neutron
- ☒ **C** a nucleus
- ☒ **D** a proton

(c) Carbon-14 has a half-life of 5700 years.

A sample of cloth contains 6.0 g of carbon-14.

What mass of carbon-14 will remain in the cloth after 11 400 years?

(1)

- ☒ **A** 1.5 g
- ☒ **B** 2.0 g
- ☒ **C** 2.5 g
- ☒ **D** 3.0 g

(d) The carbon atoms in the cloth are mainly atoms of carbon-12, a different isotope of carbon.

What are **isotopes**?

(2)

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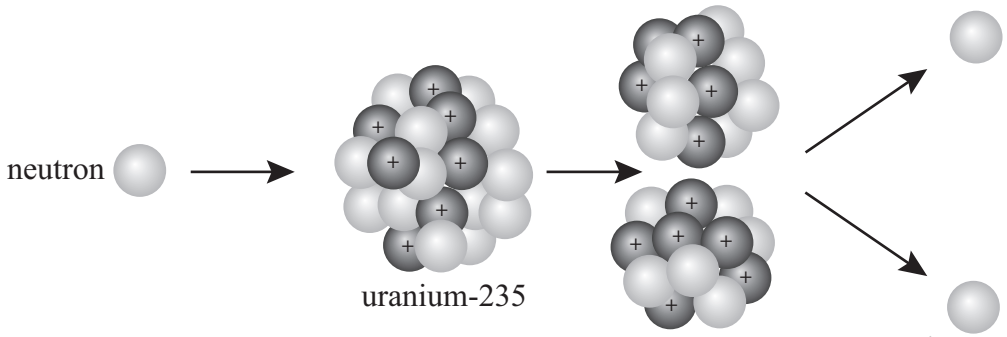
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13 The diagram shows a neutron colliding with a nucleus of uranium-235, producing a number of products.



(a) Name the process shown in the diagram.

(1)

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(b) Explain how the process shown in the diagram can lead to a chain reaction.

(3)

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(c) This process releases energy.

Explain the form that this energy takes.

(2)

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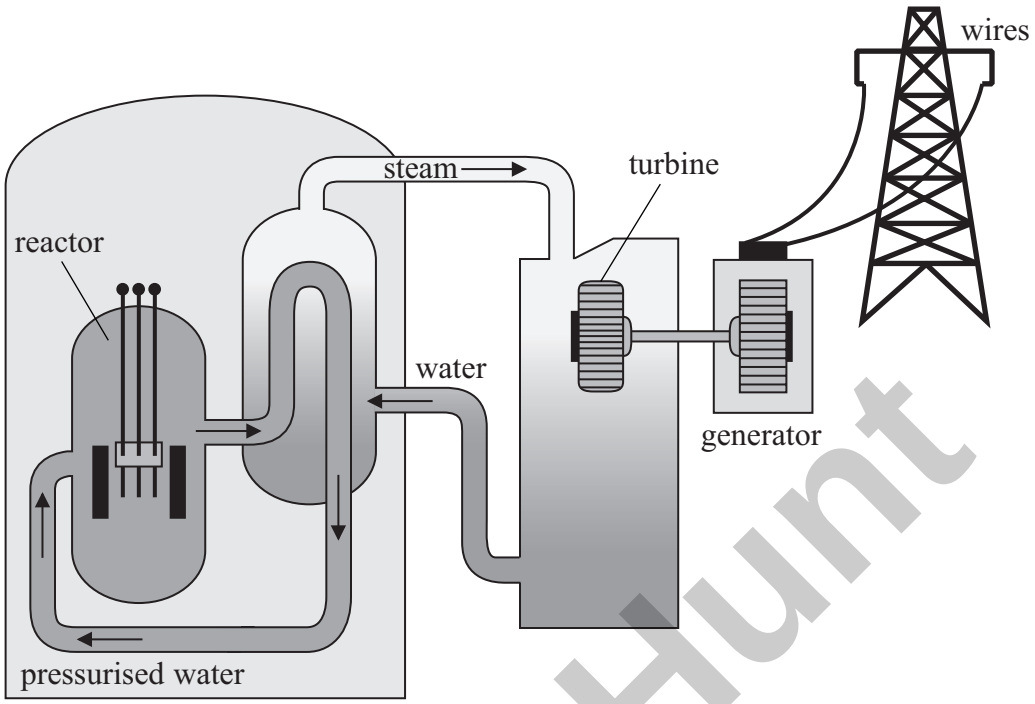
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(d) The energy released in this process can be used in a nuclear power station.



(i) The pressurised water acts as a coolant. It also acts as a moderator.

What is the purpose of a **moderator**?

(1)

.....

.....

(ii) Complete the chart below to show the main useful energy transfers in a nuclear power station.

(4)

Heat energy released by reactor	⇒ ..... energy in water/steam	⇒ ..... energy in turbine	⇒ ..... energy in generator	⇒ ..... energy in wires

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14 A teacher shows his class how to investigate the half-life of a radioactive source.



(a) The readings from the counter need to be corrected for background radiation.

(i) State **one** source of background radiation.

(1)

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(ii) Describe the method the teacher should use to correct for background radiation.

(3)

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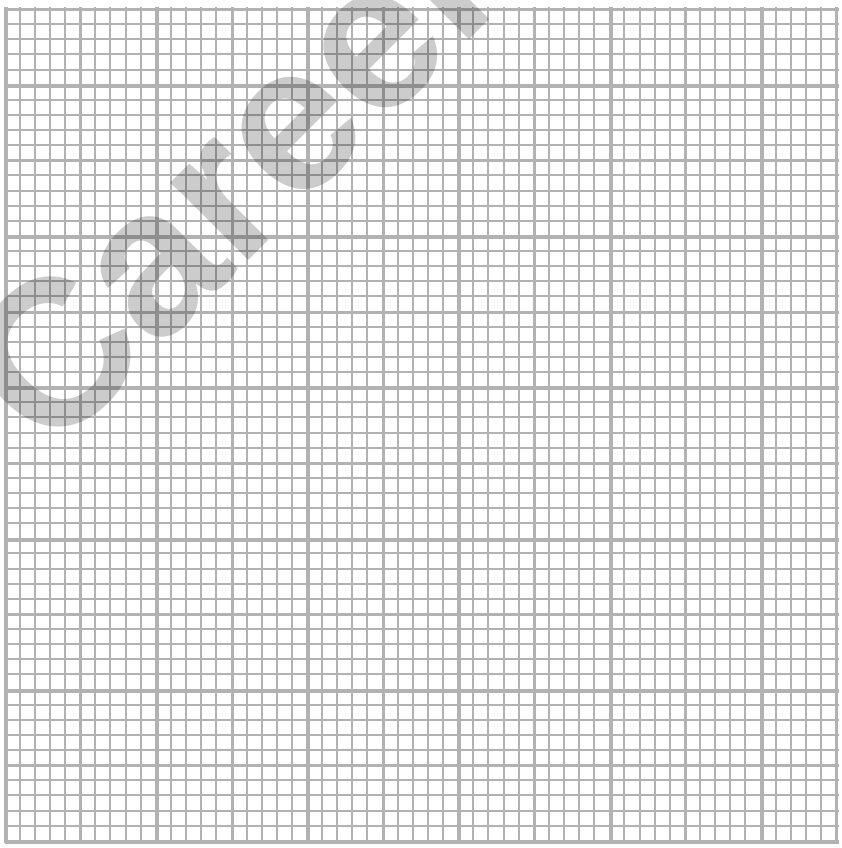
(b) Every half a minute, the teacher records the count rate.

He corrects for background radiation and produces this results table.

Time in minutes	Corrected count rate in Bq
0	49
0.5	30
1.0	24
1.5	18
2.0	15
2.5	11
3.0	10
3.5	9
4.0	5
4.5	6

(i) Draw a graph of corrected count rate against time for these results.

(5)



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(ii) Use your graph to estimate the half-life for this material.

(1)

Half-life = ... minutes

(c) The isotope technetium-99 is a gamma emitter with a half-life of 6 hours. It is used as a radioactive tracer in medicine.

The technetium-99 is injected into a patient's bloodstream and carried around the body by the blood. The radiation it emits is detected outside the body.

Explain why technetium-99 is suitable for use as a tracer in this way.

(3)

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15 John Leslie was a scientist who investigated heat and thermometers.

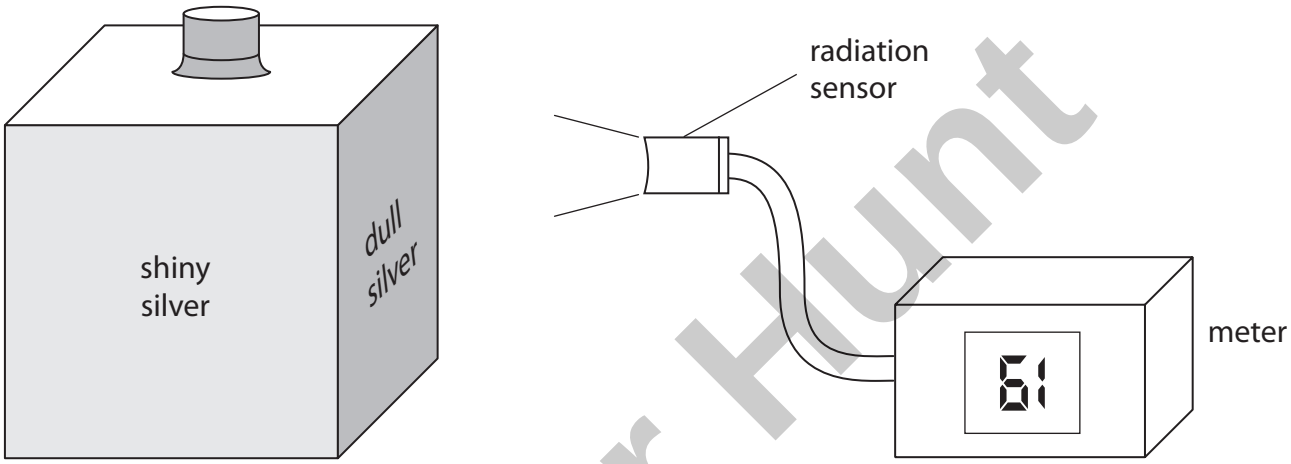
He experimented with a hollow metal cube. The cube had different surfaces on each side and was filled with boiling water.

(a) A student uses a modern version of Leslie's cube to investigate how the surface of a hot object affects the radiation emitted.

She uses a cube with four different vertical surfaces.

She fills the cube with boiling water so that the temperature of each surface is the same.

She uses the radiation sensor to measure the radiation emitted from each surface.



(i) The student's results are shown below.

Draw a line linking each surface colour with its correct meter reading.

One has been done for you.

(2)

surface colour	meter reading
shiny black	87
dull black	61
dull silver	70
shiny silver	47

(ii) The temperature of each surface is the same, but the radiation sensor gives a different reading for each surface.

What can you conclude from this?

(1)

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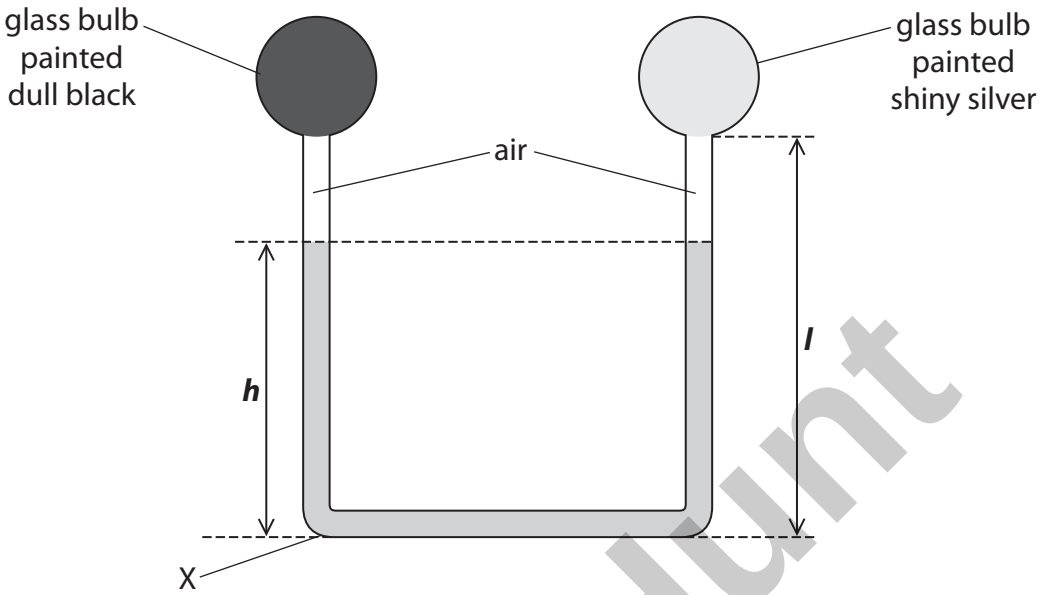
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(b) John Leslie also invented a differential thermometer.

The diagram shows this thermometer.

The bulbs are filled with air and are connected by a tube which contains liquid.



(i) State the equation linking pressure difference, height, density and *g*.

(1)

(ii) The density of the liquid is 1260 kg/m^3.

Calculate the pressure due to the liquid at X when the height, *h*, of the column of liquid is 0.25 m.

Give the unit.

(3)

pressure = ... unit .....

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(iii) The student places the differential thermometer in bright sunlight for a few minutes.

She observes that the liquid level

- falls on the side of the dull black bulb making *h* lower
- rises on the side of the shiny silver bulb

Use ideas about heat transfer and particle theory to explain these observations.

(3)

(iv) Explain what would happen to the levels of the liquid if the student repeated the experiment with a denser liquid in the thermometer.

(2)

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(v) Two students discuss the effect of changing the length, *l*, of the tube on both sides, while keeping the total volume of liquid constant.



If the length of the tube is increased, the thermometer can measure higher temperatures.



Changing the length of the tube will not make any difference to the range of temperatures that the thermometer can measure.

Explain which of these ideas is correct.

(2)

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16 Unstable nuclei can emit particles.

(a) Which of these particles has the largest charge?

(1)

☒ **A** alpha particle

☒ **B** beta particle

☒ **C** neutron

☒ **D** proton

(b) Which of these particles has the largest mass?

(1)

☒ **A** alpha particle

☒ **B** beta particle

☒ **C** neutron

☒ **D** proton

(c) The maximum range of a beta particle in air is about

(1)

☒ **A** 50 mm

☒ **B** 50 cm

☒ **C** 50 m

☒ **D** 50 km

(d) When a nucleus emits a beta particle

(1)

☒ **A** the nucleon number decreases by 1

☒ **B** the nucleon number increases by 1

☒ **C** the proton number decreases by 1

☒ **D** the proton number increases by 1

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17 The photograph shows an old camera lens that contains several pieces of glass.



One of the pieces of glass includes a radioactive isotope, thorium-232.

(a) Thorium-232 undergoes alpha decay and produces an isotope of radium, Ra.

Complete the equation for this decay.

(2)

$$\begin{matrix}232\\90\end{matrix}\mathrm{Th} \longrightarrow \begin{matrix}\square\\\square\end{matrix}\mathrm{Ra} + \begin{matrix}4\\\square\end{matrix}\alpha$$

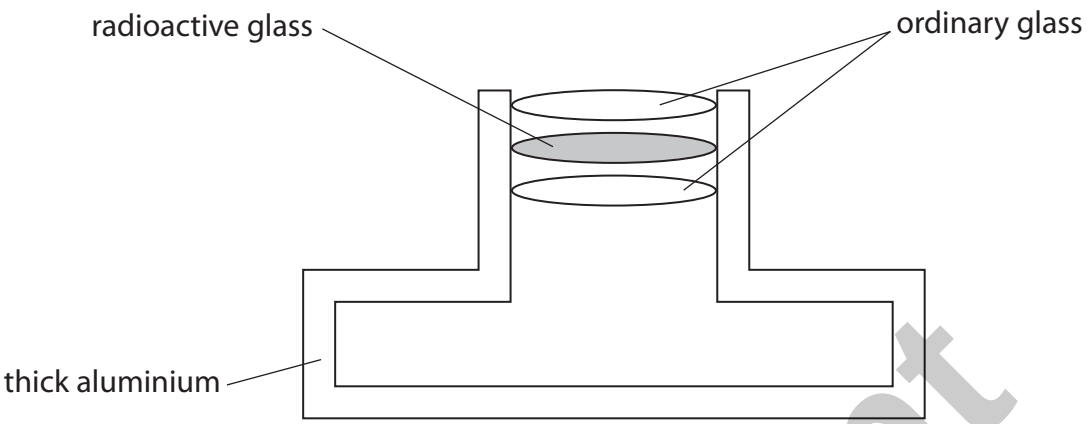
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(b) The radioactive glass also emits beta particles from a different isotope.

The diagram shows the position of the radioactive glass in the camera.



(i) Suggest why it is safe to use radioactive glass in the camera as shown.

(1)

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.....

(ii) Amateur astronomers sometimes remove an old camera lens to use as a lens in a homemade telescope.

Suggest why an astronomer should not use a lens with radioactive glass close to their eye.

(2)

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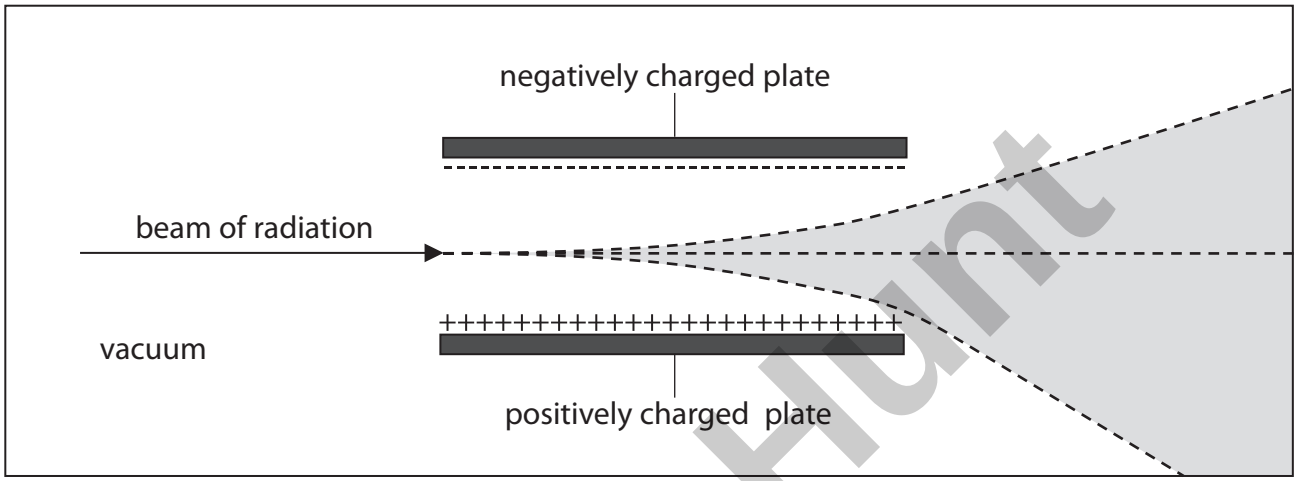
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18 (a) Scientists use deflection in an electric field to help distinguish between different radiations.

The diagram shows a beam containing several types of radiation. This beam travels in a vacuum between two charged plates.

Some of the radiations are deflected upwards, some are deflected downwards and some are not deflected at all.



Put one tick in each row to show the correct deflection for each type of radiation.

One has been done for you.

(4)

Type of radiation	Deflected upwards	Deflected downwards	Not deflected
alpha	✓		
beta			
gamma			
neutrons			
protons			

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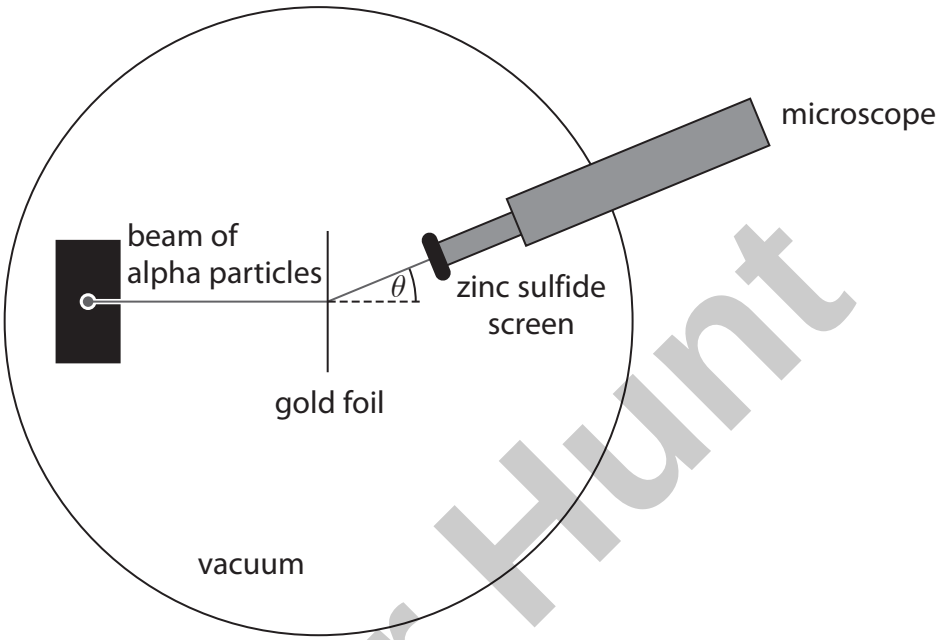
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(b) The diagram shows the apparatus Geiger and Marsden used to investigate the structure of an atom.

They aimed a beam of alpha particles at a very thin sheet of gold foil.

They used a zinc sulfide screen to detect the alpha particles.



(i) Suggest why Geiger and Marsden removed the air from the apparatus.

(1)

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(ii) Describe Geiger and Marsden's results.

(2)

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(c) Rutherford produced a model of the atom.

Describe how Rutherford's model explains Geiger and Marsden's results.

You may draw a diagram to help your answer.

(4)

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19 In 2013, the UK Government decided to build another nuclear power station at Hinckley Point. Hinckley Point is in Somerset, a major agricultural area of the UK.
This will be the third nuclear power station at the site.



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Discuss the advantages and disadvantages of nuclear power stations and biomass power stations.

(6)

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20 Use the following information to help you answer the questions.

The gold foil experiment

Scientists used to think that electrons were spread out through a positively charged atom.

They called this the 'plum pudding' model.

To test this idea, scientists aimed alpha particles at thin gold foil. They expected the alpha particles to pass straight through.

The results showed that **almost** all the alpha particles did pass straight through, but a few did not. About 1 in every 8000 was deflected away at a very large angle.

It was these 'anomalous' results that led to a new understanding of the atom.

(a) What was the prediction in this experiment?

(1)

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(b) (i) What do scientists mean by **anomalous results**?

(1)

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(ii) How should scientists deal with anomalous results?

(1)

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(c) Describe how a teacher should measure the activity of a radioactive source using a Geiger-Muller detector.

(4)

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21 Alpha and beta particles may be emitted by unstable nuclei.

(a) (i) When an unstable nucleus emits an alpha particle, its atomic (proton) number **(1)**

- ☒ **A** increases by 1
- ☒ **B** stays the same
- ☒ **C** decreases by 2
- ☒ **D** decreases by 4

(ii) When an unstable nucleus emits an alpha particle, its mass (nucleon) number **(1)**

- ☒ **A** increases by 1
- ☒ **B** stays the same
- ☒ **C** decreases by 2
- ☒ **D** decreases by 4

(b) Compared to a beta particle, an alpha particle **(1)**

- ☒ **A** causes less ionisation
- ☒ **B** has less charge
- ☒ **C** has less mass
- ☒ **D** has less penetrating power

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(c) Describe how a teacher should measure the activity of a radioactive source using a Geiger-Muller detector.

(4)

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22 These questions are about radioactivity.

(a) Which of these is measured in becquerel (Bq)? **(1)**

- ☒ **A** activity
- ☒ **B** frequency
- ☒ **C** half-life
- ☒ **D** radiation

(b) Which of these has a mass (nucleon) number of 4? **(1)**

- ☒ **A** alpha particle
- ☒ **B** beta particle
- ☒ **C** gamma ray
- ☒ **D** x-ray

(c) Which of these is the same as an electron? **(1)**

- ☒ **A** alpha particle
- ☒ **B** beta particle
- ☒ **C** gamma ray
- ☒ **D** x-ray

(d) Which of these is the most ionising? **(1)**

- ☒ **A** alpha particle
- ☒ **B** beta particle
- ☒ **C** gamma ray
- ☒ **D** x-ray

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23 The table shows the nature of alpha and beta particles.

Particle	Nature
alpha	helium nucleus
beta	tron

Explain why alpha particles and beta particles have different penetrating powers.

(5)

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24 A teacher investigates the half-life of a radioactive isotope that decays quickly.

(a) The teacher measures the background activity.

Explain how this value should be used in the investigation.

(1)

.....

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(b) Explain what is meant by the term **half-life**.

(2)

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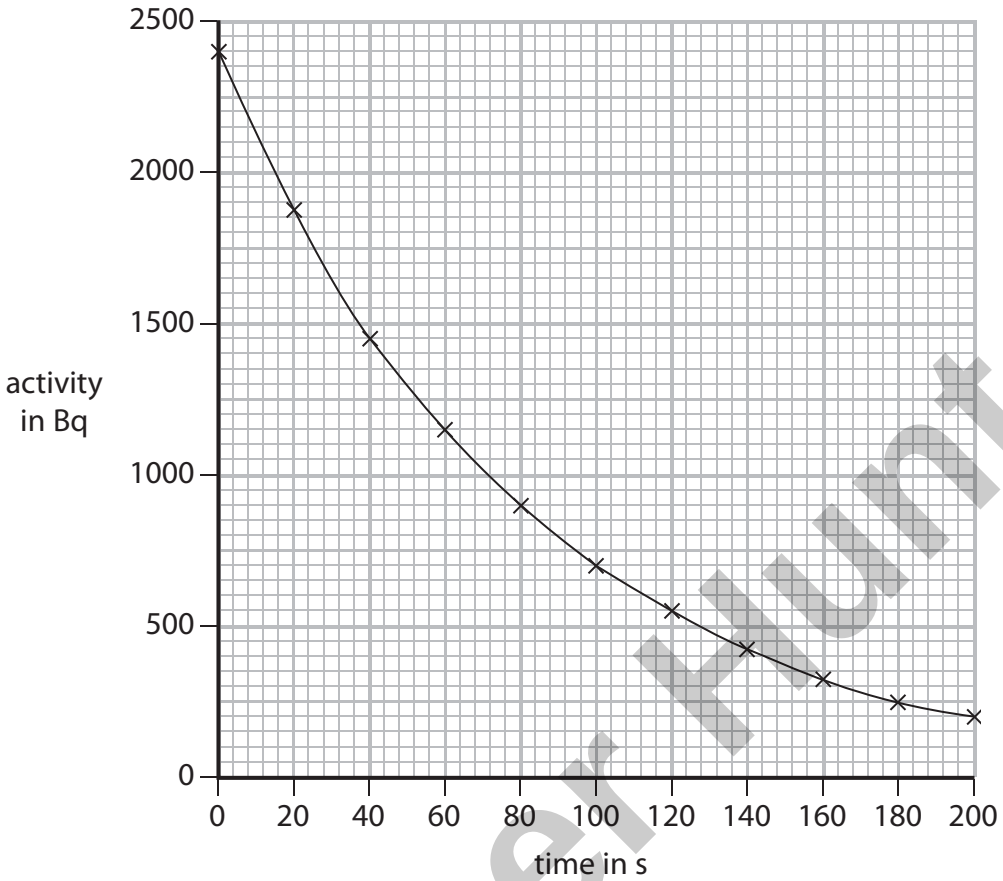
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(c) The graph shows how the activity of a sample of the radioactive isotope changes with time.



(i) Use the graph to find the half-life of the isotope.

(2)

half-life = ... s

(ii) The teacher takes a new reading every 20 s.

Suggest why the teacher measures the activity so frequently.

(1)

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25 An unstable isotope of strontium has a half-life of 28.8 years.

It is a beta emitter and can be represented by this symbol.

$$^{90}_{38}\text{Sr}$$

(a) (i) What is the mass number of this isotope?

(1)

.....

(ii) Explain the meaning of the term **half-life**.

(2)

.....

.....

.....

.....

(iii) A person can absorb strontium atoms, which stay in their bones.

Explain why strontium-90 in the bones is a serious health hazard.

(2)

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(b) When a strontium-90 nucleus emits a beta particle, it decays to form yttrium-90.

(i) Complete the equation for this decay.

(2)

$$\square^{90}_{38}\text{Sr} \rightarrow \square^{\square}_{39}\text{Y} + \square^{\square}_{\square}\beta^-$$

(ii) Yttrium-90 is also an unstable isotope.

Explain why strontium-90 and yttrium-90 can both be described as isotopes, even though they have different numbers of protons.

(2)

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26 Iodine-131 is a radioactive isotope that emits beta particles.

(a) The equation for this decay is

$$^{131}_{53}\mathrm{I} \rightarrow {}^{A}_{Z}\mathrm{Xe} + {}^{0}_{-1}\mathrm{e}$$

(i) The atomic (proton) number for iodine-131 is

(1)

☒ **A** 0

☒ **B** 53

☒ **C** 78

☒ **D** 131

(ii) The mass (nucleon) number for Xe is

(1)

☒ **A** –1

☒ **B** 0

☒ **C** 53

☒ **D** 131

(b) Iodine-131 is used to treat thyroid cancer.

This radioactive isotope is allowed to enter the tumour.

Explain why iodine-131 is suitable for this treatment.

(2)

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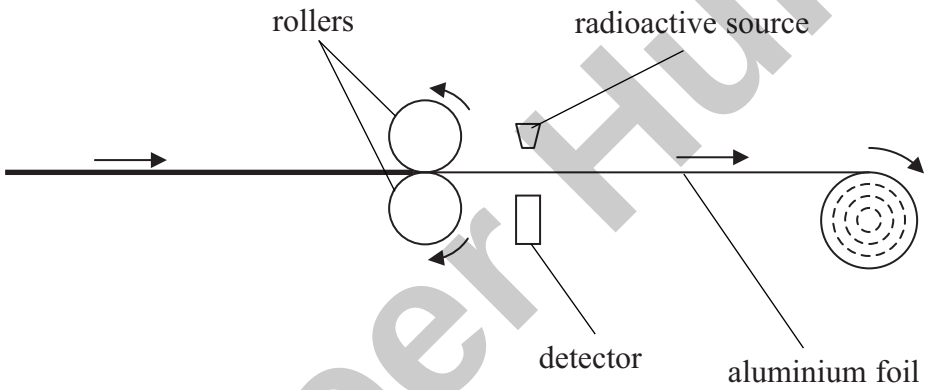
27 There are different types of ionising radiation.

(a) Complete the table to show the properties of each type. **(2)**

Type of ionising radiation	Charge	Emitted by
alpha particle		unstable nuclei
beta particle		unstable nuclei
gamma ray	0	

(b) The diagram shows a machine which makes aluminium foil.

The machine uses a radioactive source to measure the thickness of the foil.



The radioactive source emits beta particles.

The output from the detector indicates the thickness of the foil.

Explain why beta particles are used, rather than alpha particles or gamma rays.

(3)

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(c) The radioactive source contains strontium-90.

A strontium-90 nucleus emits a beta (β) particle.

(i) Complete the equation to show how strontium-90 decays.

(1)

$$^{90}_{38}\text{Sr} \longrightarrow \text{.....}^{\text{.....}}\text{Y} + {}^{0}_{1}\beta$$

(ii) Which of these describes what happens to the strontium-90 nucleus when it emits a beta (β) particle?

(1)

☒ **A** the number of protons stays the same

☒ **B** the number of protons increases

☒ **C** the number of neutrons stays the same

☒ **D** the number of neutrons increases

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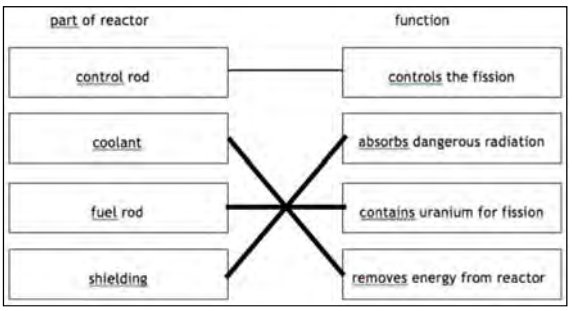
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Chapter 7: Radioactivity and Particles Answer

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Question number	Answer	Notes	Marks
1 (a)	All lines correct = 2 marks Any correct added line = 1 mark  		2
(b)	kinetic energy;		1
(c)	slows neutrons/reduces KE of neutrons; and any one from (which)allows fission to continue; (which) causes (induced) fission; (so) neutrons can be absorbed by uranium;	makes the neutrons thermal/eq ignore moderator absorbs neutrons ignore • neutrons collide with uranium • successful collisions	2
(d)	any three of - MP1 each fission (of a nucleus) caused by a single neutron; MP2 each fission releases more than one neutron; MP3 excess neutrons can speed up the reaction; MP4 (more) fissions release excess energy; MP5 control rods absorb neutrons; MP6 control rods regulate the rate of fission/reaction;	e.g. a nucleus splits when neutron has been absorbed ignore 'block'/ eq allow control rods speed up/slow down rate of fission	3

Total 8 marks

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Question number	Answer	Notes	Mark
2 (a)	any 3 of: MP1. neutron absorbed by (U) **nucleus**; MP2. (U nucleus) splits; MP3. (producing 2) daughter nuclei; MP4. extra **neutrons** released;	 accept collides with/hits/bombards/eqn for neutron condone breaks up must be plural reject 'daughter cells' for MP3 must be plural	3
(b)	kinetic (energy)	accept phonetic spellings e.g. 'kenetic'	1

Total 4 marks

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Question number		Answer	Notes	Marks
3 (a)		A description to include any 5 of MP1 nucleus absorbs neutron OR nucleus hit by neutron; MP2 splits into (two) fragments/parts OR daughter atoms OR daughter nuclei; MP3 extra neutrons released; MP4 (kinetic) energy released; MP5 released neutrons hit further nuclei OR uranium nuclei; MP6 moderator slows down the neutrons/ makes it more likely for a neutron to be absorbed; MP7 control rods absorb extra neutrons; MP8 idea that control rods help prevent a "runaway" chain reaction;	Correct process using consistently incorrect particle instead of neutron (e.g. electron) = max 4 NB uranium, U-235 or nucleus must be mentioned Reject cells, molecules, more uranium Ignore heat allow atoms OR uranium atoms	5
(b)		kinetic/movement energy;		1
(c)		Idea that the shielding **absorbs** radiation / particles / energy;	Allow "stops radiation /particles from escaping" Ignore "radioactvity" escaping	1
			Total	**12**

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Question number	Answer	Notes	Marks
4 (a) (i)	uranium/plutonium;	allow chemical symbols	1
(ii)	(particles) formed **after** fission/**after** U breaks up; plus any **one** from:- neutron; daughter nuclei; named products;	do not allow after decay allow gamma (radiation)	2
(iii)	MP1 they are (still) radioactive/ emit ionising radiation /eq; MP2 they last for a very long time/have a long half-life/eq;	allow harmful to people/environment	2
(iv)	it slows down neutrons/eq;	ignore absorbs neutrons	1
(v)	any two ideas from:- MP1 fewer neutrons would be absorbed; MP2 fission rate would increase / /(reactor) become critical ; MP3 too much energy produced (too fast); MP4 meltdown of core/reactor;	more neutrons available the reaction would go out of control do not accept “turns into a bomb” meltdown of ‘it’	2

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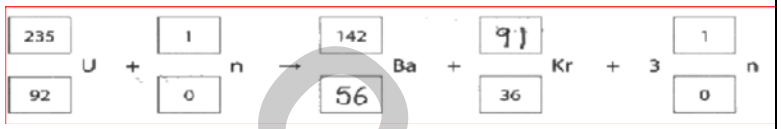
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(b) (i)	773(K);		1
(ii)	substitution; rearrangement; evaluation; e.g. $\frac{8.4}{773} = \frac{P_2}{1170}$ $P_2 = \frac{8.4 \times 1170}{773}$ 13 (MPa)	no mark for the equation rearrangement and substitution in either order 12.7 allow ecf from (b)(i) for all 3 marks if calculation seen with °C for T_1 instead of K, then max mark = 2 answer of 19.7 (MPa) with no working = 1 mark total marks = 12	3

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Question number	Answer	Notes	Marks
5 a	91; 56;  		1 1
b	Three FROM – MP1. Neutrons released; MP2. neutrons slowed by moderator; MP3. Can be absorbed by **other** (U) **nuclei**; MP4. Causing further fissions;	ignore comments about control rods collide or react for absorb if MP3 or 4 or both not given then award 1 mark for a description of a first absorption	3
c i	Correct labels for – Control rods; Shielding;	Accept • lines with or without arrow heads (in either direction) • any part of control rod (black in diagram) • any part of external box for shielding	1 1 2

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ii	Two from: MP1. Reactor material / waste is **radioactive**; MP2. (radiation) ionises cells/ tissues / organs / body or causes cancer; MP3. radiation is very penetrating;	allow damages for ionises NOT ALLOW bald 'it is dangerous' do not award marks for 'shielding prevents escape of radiation'/eq	

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Question number	Answer	Notes	Marks
6 (a)	D americium-238;		1
(b) (i)	either order: uranium -234, uranium-235;	accept symbols but not just the numbers	1
(ii)	either order: plutonium-238, americium-238	accept symbols	1
(iii)	either order: uranium-235, americium-238	accept symbols	1
(c) (i)	will decay/ emit radioactive particles (or gamma);	allow named particles 'they are radioactive' 'they emit radioactivity'	3

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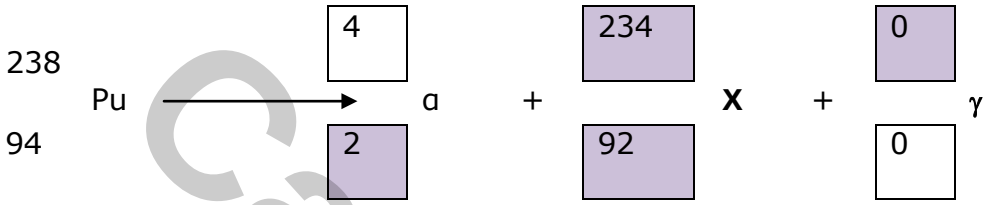
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(ii)	time taken; and either • For **half** of (radioactive) nuclei / atoms /isotope to decay; OR • For (radio)activity to halve;	allow how long it takes Ignore particles /molecules 'break down' 'reactivity' **Reject** for ONE mark ideas of • half of a time • half a nucleus/ an atom • complete decay	

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Question number	Answer	Notes	Marks
(d) (i)	 one mark for alpha correct; one mark for gamma correct; one line for **balancing** the top line; NB ECF from alpha and or gamma one mark for **balancing** the bottom line; NB ECF from alpha and or gamma		4
(ii)	Uranium;		1
(e) (i)	proton number / atomic number decreases by 1; nucleon number /mass number remains unchanged (as p and n have same mass);		2
(ii)	plutonium -238;	condone plutonium without nucleon number	1

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Question number	Answer	Notes	Marks
7(a) i	(Nuclei / atoms) with same number of protons OR same atomic number; different number of neutrons OR different mass number;	Ignore electrons Allow "(nuclei) of the same element" Allow different number of nucleons	2
ii	(stable isotopes) do not emit (ionising) radiation OR (stable isotopes) do not emit alpha, beta and gamma radiation ;	Ignore "radioactive", "decay" ignore idea of remaining the same element for ever	1
(b) i	210 – 84 OR 126		1
ii	ideas that proton number increases by 1; neutron number decreases by 1;	allow a calculation / nuclear equation Ignore discussion of "number of nucleons"	2
iii	beta decay	allow β **or** β^- **or** β^+	1
(c)	Any two of idea that gamma is not a particle; e.g. gamma rays have no (rest) mass gamma rays do not have a proton number gamma rays do not contain any protons or neutrons gamma rays are electromagnetic radiation OR energy; no particles are lost (from the nucleus) when a gamma ray is emitted;	Allow photons	2
		Total	**9**

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Question number	Answer	Notes	Marks
8 (a)	A (background radiation)		1
(b)	Any TWO of 1. Range / penetration of alpha radiation is low; 2. R on (is a gas so) particles /atoms mobile OR americium (solid so) particles / atoms stay in place; 3. R on can be inhaled / damage internal tissue OR radiation from americium stays within smoke detector / absorbed by the plastic;	WTTE throughout this part ACCEPT 'cannot penetrate skin' / 'travel a few cm in air' ACCEPT 'all around us', 'more likely to come into contact', ACCEPT 'contained', 'stays in detector' ACCEPT 'can be breathed in', 'can get inside body', 'can damage (internal) cells /organs' ACCEPT 'high up', 'far from people'	2
(c) (i)	A (86)		1
(ii)	B (134)		1
(d) (i)	Bq / becquerel(s);	ACCEPT approximate / phonetic spellings of becquerel / Becquerel / bekerel REJECT B, BQ, bQ, bq	1

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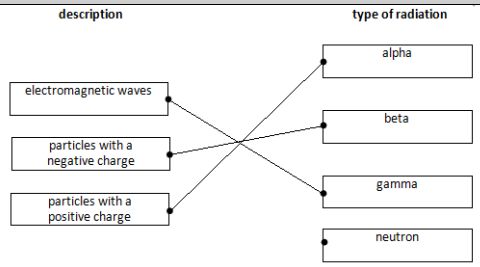
Question number	Answer	Notes	Marks
(ii)	Time for halving / time for 50% decrease; of the (radio)activity / no of (radioactive) atoms / no of (radioactive) nuclei /emissions;	ACCEPT Number of radon-220 nuclei IGNORE references to 'mass'	2
(iii)	55±4 (s);;	Answer in tolerance, but without obvious working gain full marks IGNORE misread from graph if answer within tolerance If final value missing or outside tolerance, look for evidence of using graph correctly for one mark e.g. appropriate use of activity axis such as lines across at 600 Bq and 300 Bq. or single line across at 350 Bq)	2

Total 10 Marks

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Question number	Answer	Notes	Marks
9 (a)	 positive charge to alpha; negative charge to beta; electromagnetic waves to gamma;	One mark for each correct line Minus one mark for two lines from any one box on the left	(3)
(b) (i)	in this order only: gamma, beta, alpha;		(1)
(ii)	any two from: can damage cells; can cause mutation; can cause cancer;	allow kill cells/tissues radiation burns radiation poisoning change genes	(2)
(c)	<table><tr><th></th><th>0.1 cm paper</th><th>0.5 cm aluminium</th><th>0.5 cm lead</th></tr><tr><td>alpha radiation</td><td>stopped</td><td>stopped</td><td>stopped</td></tr><tr><td>beta radiation</td><td>goes through</td><td>stopped</td><td>stopped</td></tr><tr><td>gamma radiation</td><td>goes through</td><td>goes through</td><td>goes through</td></tr></table> Each row correct for 1 mark;;;		(3)
(d)	any suitable device e.g. (thin window) GM tube; cloud chamber; spark chamber; semiconductor detector;	accept spelling mistakes Geiger counter NB do not accept repeat of stem (film badge or photographic film)	(1)

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Question number	Answer	Notes	Marks
10 (a)	3 or 4 ticks correct;; OR 2 ticks correct; **ignore top line as this is given**		2
(b) (i)	Number of neutrons = 2; Number of protons 2;	Allow same ideas expressed in words	2
(ii)	Any one of- MP1. Charge is larger (than other radiations); MP2. Mass is larger (than other radiations);	comparative statement needed ignore • incorrect terminology e.g. more powerful • references to protons and neutrons no RA unless particles/radiation specified condone 'alpha particles have more momentum'	1
(c) (i)	Idea of background radiation;	Allow Idea that some alpha particles (from source) will get through smoke air is all around = insufficient	1
(ii)	Idea that radioactivity is random;	allow • fluctuates • source emits different numbers of alphas • background radiation varies ignore • random movement of particles	1
(iii)	Idea that α particles are absorbed / deflected /stopped / scattered; Idea that α particles are affected by <u>smoke</u>;	allow for both marks smoke blocks the (alpha) particles	2

Total 9 marks

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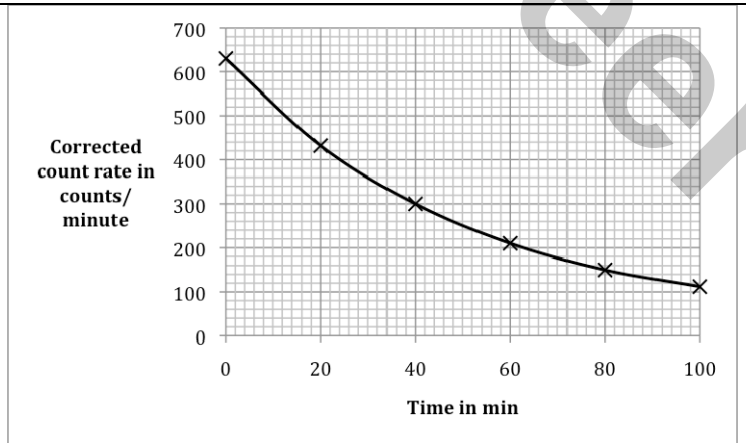
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Question number			Answer	Notes	Marks
11	(a)	(i)	Any **two** sources: MP1. radiation from rocks/buildings/radon gas; MP2. cosmic radiation / radiation from the Sun / stars; MP3. radiation from medical sources; MP4. nuclear waste / accidents; MP5. some foods e.g. coffee, bananas;	Ignore : cosmic <u>microwave</u> (background) radiation /<u>cmbr</u> allow named radioactive isotopes accept fire / smoke detector	2
		(ii)	Any three of MP1. Remove the radioactive source; MP2. Measure the (background) count rate; MP3. Repeat the measurement / measure for a long time; MP4. Background radiation is 30 (counts per minute); MP5. Subtract this value from (each) reading(s);	Accept standard abbreviations e.g. cpm Allow for 2 marks: measure the count rate without the source	3

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Question number			Answer	Notes	Marks
	(a)	(iii)	scale; at least half the paper axes labelled including units; Plotting to nearest sm sq;; Best fit line to include at least 5 points;	-1 each plotting error, minimum 0 for plotting	5
					
		(iv)	Evidence of correct graph use; Correct value;	Allowed range is 35-42	2

Time in min	Corrected count rate in counts/minute
0	30
20	432
40	300
60	210
80	150
100	12

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Question number			Answer	Notes	Marks
	(b)		**correct statement about a neutron;** e. neutron changes neutron number decreases by 1 **correct statement about a proton / atomic / number of positive charges in nucleus;** e. (neutron changes) into a proton proton number increases by 1 number of positive charges increases by 1	ignore : 'it becomes unstable' Accept answers in terms of quarks (down to up) or anti-neutrinos allow for 1 mark if no other mark gained: nucleus becomes another/new element it loses energy nucleus recoils reject: all implication that nucleus becomes ionised	2
	(c)	(i)	MP1. (they emit) ionising radiation; plus any one of - MP2. Cannot be seen; MP3. Can damage/harm cells; MP4. Can cause tumours / cancer;		2
		(ii)	Any three suitable, e.g. MP1. Reduce exposure time; MP2. Handle with tongs/use robotic handling/keep at distance /eq; MP3. Use shielding / work in fume cupboard /eq MP4. Wear film badge / monitor;	NB reduction of risks when WORKING with sources, not how to keep sources safe etc refs to gloves, mask etc are considered as shielding allow keep source in lead container when not in use	3

Total 19 marks

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Question number	Answer	Notes	Marks
12 (a) i)	C - 14		1
(ii)	B - 8		1
(iii)	A - 6		1
(b)	A - An electron		1
(c)	A - 1.5 g		1
(d)	Atoms/nuclei with same number of protons / same atomic number / same element; Different numbers of neutrons / different mass number / different atomic mass;	ALLOW 'different mass' for second mark if it's clear they are comparing atoms within the same element rather than different elements IGNORE references to electrons if possible, but if candidates makes an incorrect reference to electrons then list principle applies for that mark (e.g 'same number of protons but different number of neutrons and electrons' = 1)	1 1
		Total	**7**

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Question number		Answer	Notes	Marks
13	(a)	(nuclear) fission;	DO NOT ALLOW fusion	1
	(b)	<u>Nucleus</u> splits; Releasing <u>neutrons</u>; Which (hit / are absorbed by) different (uranium) <u>nuclei</u>;	PENALISE ONCE if 'atom' used for 'nucleus'	3
	(c)	Kinetic (energy of particles) Of (fission) products / (daughter) nuclei / neutrons	DO NOT ALLOW 'movement' for kinetic	1 1
	(d) (i)	Slow down <u>neutrons;</u>	DO NOT ALLOW 'movement' for kinetic	1
	(ii)	Kinetic/heat/thermal; Kinetic; Kinetic/electrical; Electrical;	ALLOW 'electric' for 'electrical'	4
			Total	**11**

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Question number	Answer	Notes	Marks
14 (a) (i)	rocks / radon (gas) / space / cosmic / Sun / medical sources / from carbon atoms in living things	REJECT named radiation e.g. gamma	1
(ii)	Any three from Remove source / with no source present; measure background / count; repeat / find mean / average value; subtract (background value) from experimental values (with source);	ACCEPT take readings (of background) / read background	Max 3
(b) (i)	GRAPH S A P P L	Orientation unimportant Quantity and unit on both axes Single smooth curve	5
(ii)	value consistent with graph (should be 0.9 – 1.4 minutes)		1
(c)	(gamma) can be detected outside the body /can pass through; half life related to use – long enough to get around the body (for use as tracer); half life related to patient safety - falls to low levels soon after use;	Ignore ionising ability Reject "cause less damage" without reference to activity or time	3

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Question number	Answer	Notes	Marks
15 (a) (i)	surface colour: shiny black, dull black, dull silver, shiny silver sensor reading: 87, 61, 70, 47 any one correct; all 3 correct;;		2
(ii)	(different surfaces) emit heat at different rates/eq;	allow emit different amounts of heat / radiation	1

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Question number	Answer	Notes	Marks
(b) (i)	P = ρ x g x h ;	do not accept: • gravity for g • 10 for g • d for density accept: • word equations and rearrangements • for h allow height / depth / height difference	1
(ii)	sub into eqn for P; evaluation; unit; e.g. (P=) 1260x10x0.25 3150 Pa	no POT error as 'g' used allow 9.8(1) for g 1260x9.8x0.25 3090 allow • N/m^2 • matching unit e.g. 3.15 kPa	3

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(iii)	any THREE from: MP1. black absorbs IR/heat; MP2. black heats up more than shiny; MP3. gas particles on black side move faster/get hotter/have more KE/move apart; MP4. pressure on left/black side increases;	Allow RA where appropriate allow gas expands allow force(/area) for pressure ignore: ideas of collisions	3
(iv)	difference in liquid height is less; more difficult/harder to move ;	height goes down less /decrease in h is less allow: argument in terms force /pressure	2

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(v)	MP1 it will give a bigger temperature (range)/eq; AND DOP a suitable comment e.g. MP2 a larger difference in water level; MP3 a larger difference in air volume; MP4 a larger difference in (kinetic) energy of air/gas molecules/particles; MP5 idea of upper limit to range;	Allow the girl is right amount of water for water level amount of air for air volume speed of molecules /particles water would reach the bulb if the second statement is chosen, no marks	2

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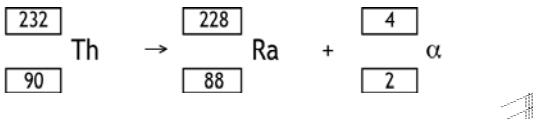
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Question number	Answer	Notes	Marks
16 (a)	A – alpha particle;		1
(b)	A – alpha particle;		1
(c)	B – 50 cm;		1
(d)	D - the proton number increases by 1;		1

Total 4 marks

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Question number	Answer	Notes	Marks
17 (a)	top line correct e.g. 228; bottom line correct e.g. 88 and 2; e. 		2
(b) (i)	idea that {alpha/beta} is {absorbed by / unable to penetrate} {aluminium / glass};	allow stops / blocks for absorbs ignore references to paper, air, lead ignore references to gamma, unqualified 'radiation'	1
(ii)	any 2 of: MP1. idea of radiation being ionising; MP2. (radiation) causes cancer / cell mutation / kills cells / blindness; MP3. {alpha / beta} will travel this short distance (between lens and eye); MP4. idea that astronomer is likely to suffer prolonged exposure;	ignore references to gamma allow (eye) within penetrating range of {alpha / beta}	2

Total 5 marks

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Question number			Answer	Notes	Mark
18	a		<table><tr><th>Type of radiation</th><th>Deflected upwards</th><th>Deflected downwards</th><th>Not deflected</th></tr><tr><td>alpha</td><td>(✓)</td><td></td><td></td></tr><tr><td>beta</td><td></td><td>✓</td><td></td></tr><tr><td>gamma</td><td></td><td></td><td>✓</td></tr><tr><td>neutrons</td><td></td><td></td><td>✓</td></tr><tr><td>protons</td><td>✓</td><td></td><td></td></tr></table> each correct ;;;;		4
	b	i	any sensible suggestion (however phrased); e.g. • alpha has a small range in air • alpha would not hit the gold leaf • alpha would be deflected • alpha would collide with the air {particles/molecules/RA} • alpha would ionise the {air/ particles/molecules}	**Allow RA** condone phrases such as • air particles interact with alpha • air particles interfere with alpha ignore • react • diffracting • to create a vacuum	1
		ii	any TWO **results** from: MP1. most went (straight) through; MP2. (the paths of)a **few** were deflected at an **acute/small angle**; MP3. (the paths of) **very few** were {deflected through an **obtuse angle / backscattered**};	NB: no mark for structure of atom or deductions allow bent allow for obtuse • large • >90° for backscattered • bounced off the gold foil	2
	c		**MP 2, 4 can be shown on a diagram** any FOUR explanations or deductions from: MP1. Small nucleus; MP2. mostly empty space; MP3. because not many α deflected / because most α go straight through; MP4. Positive OR high mass nucleus; MP5. which causes deflection of **positive** (or **low mass**) α;	Ignore ALL comments about electrons **NB to get MP 3, 5 a causal link is needed** allow protons are in the centre repulsion, recoil idea that α same charge as nucleus	4
				total = 11 marks	

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Question number	Answer	Notes	Marks
19	6 marks from with a MAX of 2 from any one area **benefits of nuclear fuel** MP1. no CO_2 emitted / no smoke emitted; MP2. does not contribute to global warming; MP3. reliable/not weather dependant; MP4. small volume of waste; MP5. concentrated energy source/ not much transport costs to bring fuel; MP6. power stations are relatively small; **disadvantages of nuclear fuel** MP7. difficult to dispose of **waste**; MP8. accidents can spread radiation widely / risk of radiation leak; MP9. nuclear fuel is toxic / harmful / radioactive / difficult to handle / long half-life; MP10. decommissioning costs are very high; MP11. increased security risk/ terrorist attack; **benefits of biomass** MP12. abundant sources / uses waste products from farms /houses/renewable; MP13. uses materials which would produce CO_2 anyway, so no net emission; MP14. can be used to create different products (e.g. manure) as well as energy; MP15. reduces landfill; MP16. (source is) relatively cheap; **disadvantages of biomass** MP17. relatively inefficient; MP18. can increase methane in atmosphere/can increase green-house gases; MP19. may require more land; MP20. high transport costs to collect raw material; MP21. can be smelly; MP22. often seasonal power source /variable output source; MP23. can be storage costs for biogas;	allow other sensible points no green-house effect Allow waste causes acid rain	6
		total = 6 marks	

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Question number	Answer	Notes	Marks
20(a)	(All) the alpha particles would go (straight) through (the foil);	Reject idea that not all alpha particles will go through so do not accept e.g. some, most, nearly all	1
(b) (i)	Idea that result(s) does not fit/match/concur with the pattern/trend;	Ignore • 'unexpected' or 'different' unless correctly qualified • references to alpha particle scattering Allow idea related to a graph, e.g. results far away from the line of best fit Accept outlier	1
(ii)	Either (check and) repeat the measurement/experiment ; OR Work out why the anomalous result(s) occurred;	Accept idea of discarding/excluding from average or graph formulate a new theory	1
(c)	(there is a large) repulsion; OR like charges repel; Idea that charge is concentrated (at the centre of the atom);	Ignore deflection as it is the stem on page 8 Allow idea of a region of high charge density	2

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(d)	Any TWO reasonable ideas e.g. to make (new) discoveries; to check/validate (existing) theories; to disprove (existing) hypotheses/theories; to confirm (other scientists') findings; to test (new) hypotheses; to develop (better) understanding; to improve (students) skills; to gather (new) evidence;	Allow to give (practical) demonstrations; accept similar appropriate ideas Allow prove for validate	2

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Question number		Answer	Notes	Marks
21 (a) (i)		C (decreases by 2)		1
(ii)		D (decreases by 4)		1
(b)		D (has less penetrating power)		1
(c)		Any four of: MP1 Use of ratemeter / scaler / counter; MP2 Idea of measuring <u>background</u> radiation e.g. background count / correction /subtraction; MP3 A safety precaution (based on distance or absorption) e.g. use of tongs / shielding; MP4 A controlled variable (time / distance / positioning) e.g. "source near/by/to detector", "for a minute"; MP5 A practical consideration e.g. repeat / average / reset (scaler); MP6 Mention of becquerel / Bq	Allow description e.g. "**count** the clicks" Allow Geiger **counter** Ignore GM **detector** or **tube** Ignore descriptions of GM tube Allow "stand back", "wear gloves / protective clothing" "do not point source at people" Ignore "counts per minute" Ignore: mention of anomalies Accept phonetic spellings	4

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Question number	Answer	Notes	Marks
22 (a)	A activi y		1
(b)	A alpha particle B beta particle		1
(c)			1
(d)	A alpha particle		1
		Total	4

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Question number	Answer	Accept	Reject	Marks
23	An explanation including any five of these ideas (in any order): MP1 alpha particles have less penetrating power /less range ; MP2 alphas have more charge; MP3 alphas cause more ionization; MP4 alphas are bigger / have more mass; MP5 (slowing) force on alpha particles is larger; MP6 (kinetic) energy of alpha lost quickly causing ionization; MP7 (larger) alpha particles are more likely to collide with atoms;	Accept reverse arguments, e.g. beta particles have more penetrating power etc Ignore comparisons of energy/ velocity/ momentum		5

Total 5 marks

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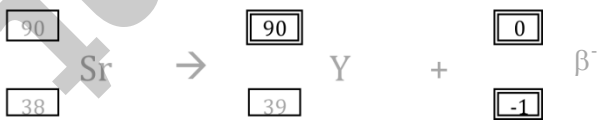
Question number	Answer	Notes	Marks
24 (a)	idea that background activity should be subtracted (from each reading);		1
(b)	time taken; and either for amount of (radioactive) nuclei / atoms / isotope to halve; OR for (radio)activity to halve	allow "how long it takes" allow • decay by half • decay to half ignore particles / molecules, "breakdown", "reactivity" reject if implies a single nucleus/atom	2
(c) (i)	evidence of use of graph; 56 ± 3 (s);	e.g. lines to two correct points on graph or appropriate subtraction shown in working	2
(ii)	any 1 from: MP1. idea of {more accurate / smoother} curve; MP2. idea that activity changes quickly; MP3. idea that decay takes very little time;	allow more points to plot on graph decays quickly (sample has) short half life	1

Total 6 marks

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Question number	Answer	Notes	Marks
25 (a) (i)	90		1
(ii)	time; either for amount of (radioactive) isotope to halve; or for (radio)activity to halve;	Allow for amount - (number of un-decayed) nuclei/atoms/molecules (un-decayed) mass of isotope	2
(iii)	Any two of – MP1 Idea that (beta) radiation causes a stated hazard; MP2 Idea that strontium-90 has a long half-life; MP3 Idea that <u>all</u> beta emission will be absorbed by the body;	 e.g. causes cancer, kills cells, mutates DNA, ionises tissue Accept lasts a long time Accept answers in terms of range	2
(b) (i)	90 and 0; -1; 	Must have both Minus is essential	2
(ii)	Any two ideas from – MP1 They are isotopes of different elements; MP2 Strontium-90 (nucleus/atom) has the same number of protons as other strontium (nuclei/atoms); MP3 Yttrium-90 (nucleus/atom) has the same number of protons as other yttrium (nuclei/atoms);	 Allow use of proton number data (38) Allow use of proton number data (39)	2

Total 9 marks

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Question number	Answer	Notes	Marks
26 (a) (i)	B (53)		1
(ii)	D (131)		1
(b)	Any two of - MP1 Beta is (moderately) ionising; MP2 Beta has a short range; MP3 idea that I-131 has a short half-life; MP4 idea that iodine is absorbed (easily) by the thyroid; MP5 (hence) reduces damage to healthy cells; MP6 (hence) does not penetrate out of the body; MP7 (therefore) kills (only) tumour cells;	Ignore I-131 is radioactive, it emits beta	2

Total 4 marks

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Question number			Answer	Accept	Reject	Marks
27	(a)		<table><tr><td>Type of radiation</td><td>Charge</td><td>S</td></tr><tr><td>Alpha particle</td><td>**(+)2**</td><td>Unstable nucleus</td></tr><tr><td>Beta particle</td><td>-</td><td>Unstable nucleus</td></tr><tr><td>Gamma ray</td><td>0</td><td>**Unstable nucleus**</td></tr></table> (As shown) 2 ; Unstable nucleus;	++ Unstable nuclei	-	2

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Question number			Answer	Accept	Reject	Marks
	(b)		Any three of: MP1 - Idea that alpha particles would not penetrate (enough); e.g. alpha particles absorbed / stopped by {aluminium / foil / a few cm air / paper / card} MP2 - Idea that gamma rays would be too penetrative; e.g. gamma rays {are not absorbed / are unaffected} MP3 - Idea that some beta particles will pass through the foil; e.g. not all of the beta particles are absorbed MP4 - Idea of a correlation between thickness and absorption; e.g. thinner aluminium absorbs fewer beta particles	Ignore references to danger or harm All ideas may be expressed in terms of penetration or absorption. No need to see the word "aluminium," provided the meaning is clear. Accept paper or card will stop alpha for MP1 Accept comparisons of aluminium thickness for MP4		3
	(c)	(i)	$^{90}_{39}Y$ both 90 and 39 for mark			1
		(ii)	B (the number of protons increases);			1
					Total	**7**

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Chapter 8: Astrophysics Question

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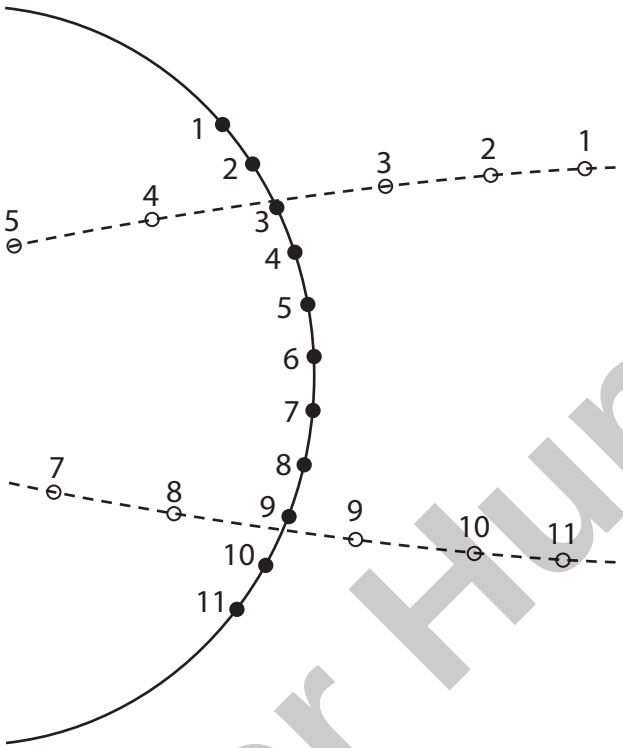
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1 A comet passes close to the Earth.

An astronomer observes the position of the comet and the Earth on the same day each week for several weeks.

(a) The diagram shows her observations for weeks 1 to 11.



Path of Earth	———
Path of comet	- - - - - - - - -
Position of Earth week 1	1●
Position of comet week 1	1○

(i) Complete the path for the comet between week 5 and week 7.

(1)

(ii) Mark an X on the diagram to show the position of the Sun.

(1)

(iii) Suggest why the astronomer did not observe the comet during week 6.

(1)

.....

.....

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(iv) The observation showing the comet nearest to the Earth was made during

(1)

- ☒ **A** week 7
- ☒ **B** week 8
- ☒ **C** week 9
- ☒ **D** week 10

(v) Explain how the diagram shows that the speed of the comet changes as it moves from position 1 to position 5.

(2)

.....

.....

.....

.....

(vi) Suggest why the speed of the comet changes.

(1)

.....

.....

(b) The Earth orbits the Sun once in 365 days.

The radius of the Earth's orbit is 150 000 000 km.

Calculate the orbital speed of the Earth in kilometres per hour.

(3)

orbital speed = ... kilometres per hour

(Total for Question 1 = 10 marks)

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2 (a) These sentences are about astronomy.

Complete the sentences by writing words in the blank spaces.

(4)

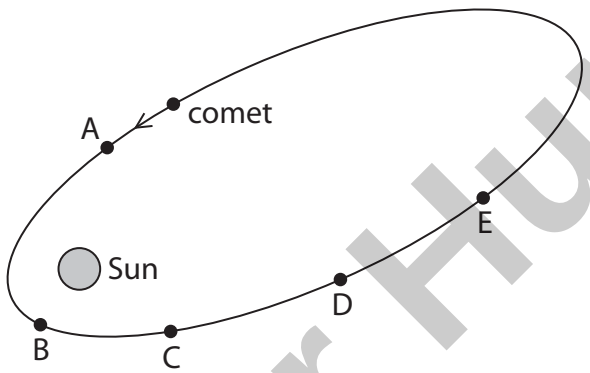
The Earth is an astronomical object.

One astronomical object smaller than the Earth is ..... .

Two astronomical objects larger than the Earth are ..... and ..... .

The Milky Way is the name given to our..... .

(b) The diagram shows the path followed by a comet as it moves around the Sun.
A, B, C, D and E are points on the comet's orbit.



(i) State the name of the force that causes the comet to orbit the Sun.

(1)

.....

(ii) At which of the points shown is the force on the comet greatest?

(1)

.....

(iii) Draw an arrow at point D to show the direction of the force acting on the comet.

(1)

(iv) At which of the points shown does the comet have the greatest kinetic energy?

(1)

.....

(Total for Question 2 = 8 marks)

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3 (a) Which list gives the astronomical objects in order of size, starting with the largest?

(1)

- ☒ **A** galaxy – Solar System – planet – Sun
- ☒ **B** galaxy – Solar System – Sun – planet
- ☒ **C** planet – galaxy – Solar System – Sun
- ☒ **D** planet – Solar System – Sun – galaxy

(b) The Earth and Mars are planets in our Solar System.

(i) State two ways in which the orbits of Earth and Mars are similar.

(2)

1 .....

.....

2 .....

.....

(ii) State one way in which the orbits of Earth and Mars are different.

(1)

.....

.....

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(c) Deimos is a moon that orbits the planet Mars.

The radius of its orbit is 23 500 km and its time period is 1.26 days.

Calculate the orbital speed of Deimos.

Give your answer to 2 significant figures.

(3)

orbital speed = ... km / day

(d) Enceladus is a moon that orbits the planet Saturn.

Enceladus has a similar orbital period to that of Deimos, but its orbital speed is about 10 times larger.

Explain how this is possible.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 3 = 9 marks)

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4 The table shows some data about planets in our Solar System.

Planet	Diameter in km	Distance from Sun in 10^6 km	Time of orbit in Earth days or Earth years	Mass of planet in 10^{24} kg
Mercury	4 880	58	88 d	0.33
Venus	12 100	108	224 d	4.9
Earth	12 800	150	365 d	6.0
Mars	6 790	228	687 d	0.64
Jupiter	143 000	778	11.9 y	1 900
Saturn	121 000	1 427	29.5 y	570
Uranus	51 000	2 870	84 y	87
Neptune	50 000	4 497	165 y	100

Use data from the table to answer these questions.

(a) Which planet has about the same diameter as the Earth?

(1)

.....

(b) Jupiter has the largest gravitational field strength.

Suggest a reason for this.

(1)

.....

.....

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(c) (i) State the equation linking density, mass and volume.

(1)

(ii) Calculate the density of Neptune in kg/km^3.

You may assume that Neptune is a sphere and that its volume is given by

$$\text{volume} = \frac{4\pi r^3}{3}$$

(3)

density = ... kg/km^3

(d) Calculate the orbital speed of Earth in km/s.

(3)

orbital speed = ...km/s

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(e) A student says

'The smaller the planet, the shorter its period of orbit.'

Use data from the table to evaluate this statement.

(3)

(Total for Question 4 = 12 marks)

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5 This question is about the Solar System.

(a) The object at the centre of our Solar System is

(1)

- ☒ **A** a comet
- ☒ **B** the Earth
- ☒ **C** the Moon
- ☒ **D** the Sun

(b) Earth and Mars are planets in our Solar System.

The table shows some data for these planets.

planet	radius of orbit in km	time of orbit in days
Earth	150 000 000	365
Mars	250 000 000	690

(i) Calculate the orbital speed of Mars in km / day.

(2)

speed = ... km / day

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(ii) The distance between Earth and Mars varies between 100 million km and 400 million km.

Explain why this distance is not constant.

You may draw a diagram to help your answer.

(2)

.....

.....

.....

.....

.....

(c) Visible light from Mars reaches the Earth.

The speed of light is 300 000 km/s.

(i) Show that when the planets are 170 000 000 km apart, it takes about 600 s for light to travel this distance.

(3)

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(ii) Scientists land a remote-controlled vehicle on Mars.

The vehicle sends images back to Earth showing its surroundings on Mars.

Sometimes these images show rocks ahead that could damage the vehicle.

A scientist on Earth sends radio signals that control this vehicle.

The speed of the vehicle is limited to 0.04 m/s.

Suggest why the speed is kept low.

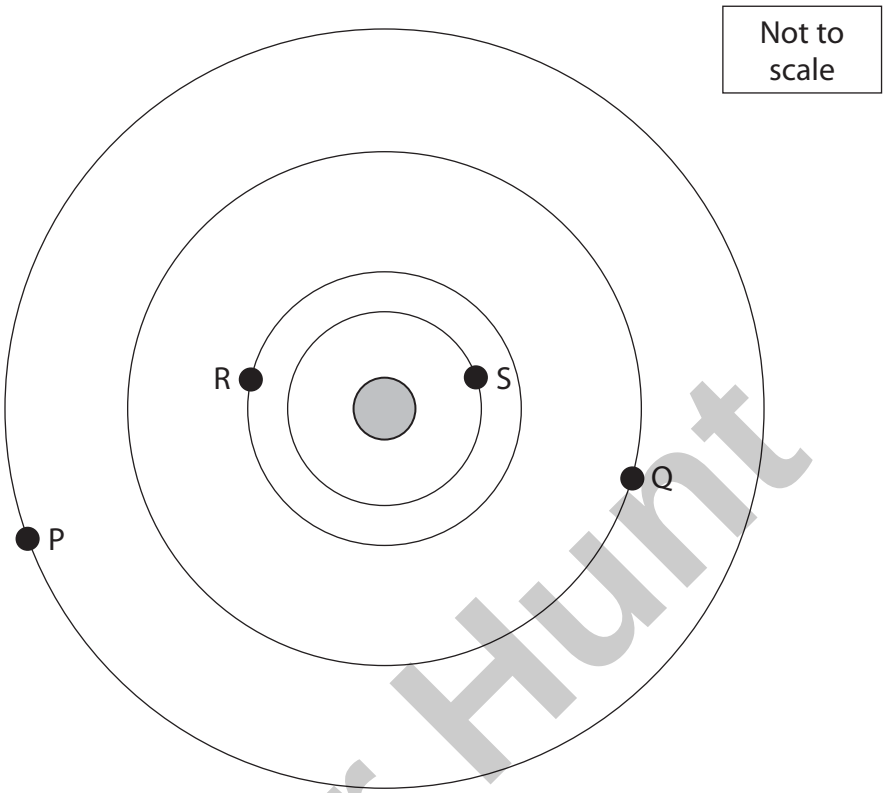
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6 The diagram shows four planets, P, Q, R and S, orbiting a star.



(a) This combination of planets and a star is most like

(1)

- ☒ **A** a galaxy
- ☒ **B** the Milky Way
- ☒ **C** the Solar System
- ☒ **D** the universe

(b) Planet Q has a moon.

On the diagram, draw the orbit of this moon.

(1)

(c) On the diagram, draw the orbit of a comet.

(2)

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(d) Planets nearer to the star take less time to orbit the star.

(i) Suggest why.

(1)

.....

.....

(ii) Planet P makes one complete orbit.

During this time

(1)

- ☒ **A** planet R makes more orbits than S
- ☒ **B** planet R makes fewer orbits than Q
- ☒ **C** planet S makes more orbits than P
- ☒ **D** planet Q makes fewer orbits than P

(e) As the planets orbit the star, the distances between the planets change.

Planet **P** is 200 million km from the star and planet **R** is 50 million km from the star.

(i) Calculate the maximum distance between planet P and planet R.

(1)

maximum distance = ... million km

(ii) Calculate the minimum distance between planet P and planet R.

(1)

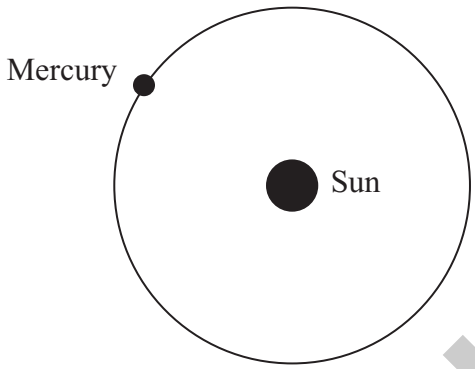
minimum distance = ... million km

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7 The planet Mercury orbits the Sun.



(a) Mercury takes 88 days to orbit the Sun.

The average radius of the orbit is 58 million km.

Calculate the average orbital speed of Mercury.

Give the unit.

(3)

Average orbital speed ..... Unit .....

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(b) Comets also orbit the Sun.

(i) Name the force that causes comets and planets to orbit the Sun.

(1)

.....

(ii) Add to the diagram opposite to show the orbit of a typical comet.

(1)

(iii) The speed of a comet changes during its orbit.

On the orbit you have drawn, label with the letter **X** the position where the comet travels at its **fastest** speed.

(1)

(iv) Explain why the comet travels fastest at point **X**.

(2)

.....

.....

.....

.....

.....

.....

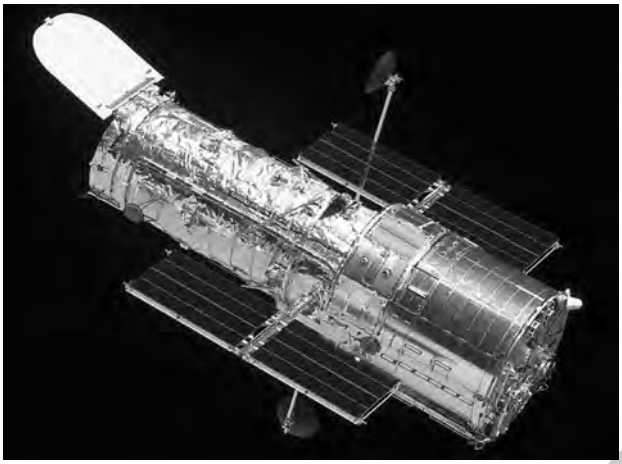
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8 The Hubble Space Telescope is in orbit around the Earth.

It detects visible light from distant objects.



(a) Name the force that keeps the telescope in orbit around the Earth.

(1)

.....

(b) The Hubble Space Telescope moves in a circular orbit.

Its distance above the Earth's surface is 560 km.

(i) The radius of the Earth is 6400 km.

Calculate the radius of the orbit of the Hubble Space Telescope.

(1)

Radius = ... km

(ii) The Hubble Space Telescope completes one orbit in 96 minutes.

Calculate its orbital speed in m/s.

(3)

Orbital speed = ... m/s

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(c) The Chandra Telescope also orbits the Earth, but does not move in a circular orbit.

Its distance from the Earth and its speed change as it orbits the Earth.

It travels fastest when it is closest to the Earth.

Use ideas about energy to explain why.

(3)

(d) The Chandra Telescope detects X-rays from distant objects.

(i) State the name of the type of wave that includes X-rays and visible light.

(1)

(ii) Describe **two** differences between X-rays and visible light.

(2)

1

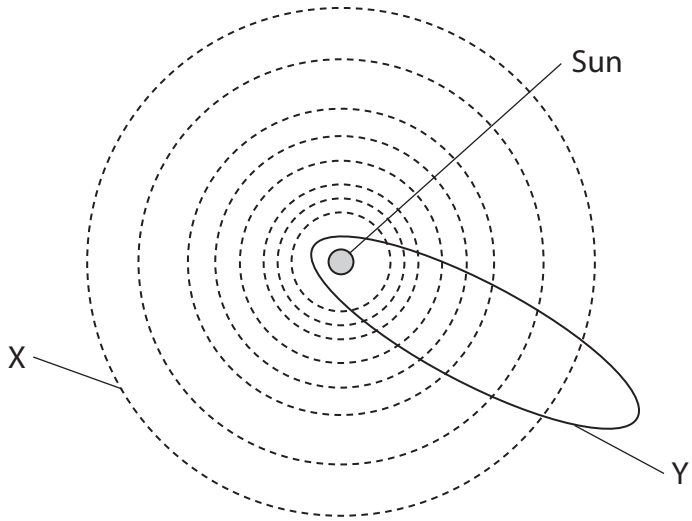
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9 The diagram shows the orbits of some objects in the Solar System.



(a) (i) Path X is the orbit of a

(1)

- ☒ **A** comet
- ☒ **B** galaxy
- ☒ **C** planet
- ☒ **D** star

(ii) Path Y is the orbit of a

(1)

- ☒ **A** comet
- ☒ **B** galaxy
- ☒ **C** planet
- ☒ **D** star

(b) The objects are held in orbit by

(1)

- ☒ **A** electrostatic force
- ☒ **B** frictional force
- ☒ **C** gravitational force
- ☒ **D** magnetic force

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10 Planets and comets in our Solar System orbit the Sun.

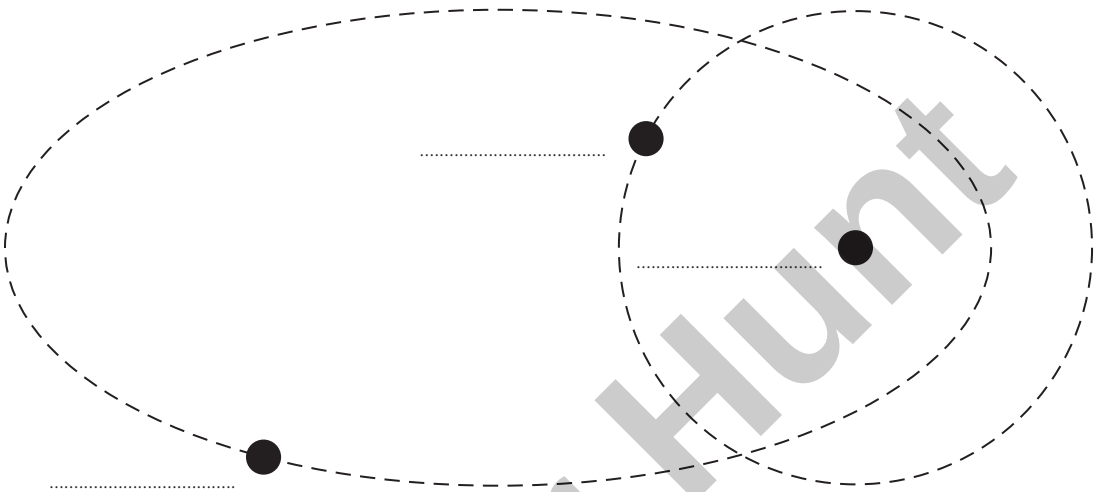
(a) Which force causes planets and comets to orbit the Sun?

(1)

.....

(b) The diagram shows the orbits of a planet and a comet around the Sun.

[not to scale]



(i) On the diagram, label the planet, the comet and the Sun.

(1)

(ii) Explain why it is possible for a planet and a comet in our Solar System to collide.

(2)

.....

.....

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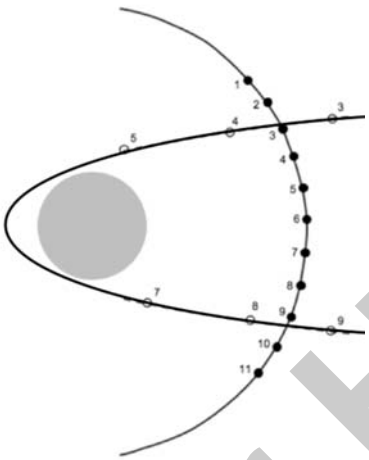
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Chapter 8: Astrophysics Answer

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Question number	Answer	Notes	Marks
1 (a) (i)	omet orbit behind Sun completed correctly;	Dashed or solid curved line	
(ii)	X marked anywhere in grey area; e.g. 	No need to label X as "Sun" X should be left of the imaginary 5-7 line, reject X placed outside the orbit the curve should be 'pointy' not a part of a circle, such that distance week6-week 5 > distance week 5-week4	1
(iii)	Any one of the following ideas- MP1. comet was behind/near the Sun; MP2. comet was obscured/eclipsed by Sun; MP3. light from comet could not reach astronomer; MP4. Sun too bright to allow observation; MP5. we should not look directly at the Sun;	Allow labelled sketch	1
(iv)	C – week 9;		1
(v)	Any two of - MP1. Same time between observations; MP2. Different distances between observations; MP3. Speed = distance ÷ time;	Allow specific reference to 'a week' as the same time between observations	2

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(vi)	Any one of - Energy argument – transfer of GPE to KE (ORA); Force argument, e.g. pulled by the Sun's gravitational force;	 Ignore • unqualified 'pulled by gravity' • gravitation from other bodies	1
(b)	Substitution into given formula; Conversion from days to hours; Calculation; e.g. v = 2 × π × 150 000 000 ÷ (365 x 24) = 110 000 (km/hour)	 24 seen 107 589/108 000 (km/hour) Allow due π (ONLY) a number that rounds to 110 000 2 582 130 = 2 (no 24 hr) 43 036 =2 (used 60 instead of 24)	3

Total 10 marks

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Question number	Answer	Notes	Marks
2 (a)	any suitable from: e.g. • asteroid; • meteor(ite); • (artificial) satellite; • a moon; • comet; • named planet; • dwarf planet e.g. Pluto; • neutron star; • white dwarf; any two suitable from: • (the) Universe; • galaxy; • solar system; • star / Sun; • named planet (1); • named planet (2); galaxy;	accept appropriate correct answers planets: • Mercury • Venus • Mars 'Sun and star' is 1 mark only planets should be gas giants: • Jupiter • Saturn • Uranus • Neptune	4
(b) (i)	gravitational force / gravitational pull / (force of) gravity;		1
(ii)	B;		1
(iii)	single straight arrow directed towards the Sun;	judge by eye	1
(iv)	B;	total marks = 8	1

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Question number	Answer	Notes	Marks
3 (a)	**B** galaxy – solar system – Sun – planet		1
(b) (i)	MP1. Idea that (orbit) shapes both (approximately) circular; MP2. Idea that both planets orbit the same star /Sun; MP3. similar plane of orbit; MP4. Same direction of orbit;	accept elliptical, oval, eccentricity Allow "Sun is at centre of orbit"	2
(ii)	different orbital radii ;	Allow • Earth (orbit) radius < Mars orbit radius • different time period • correct reference to speed of orbit • different circumference reject incorrect comparisons	1
(c)	Substitution into correct equation; Evaluation; Answer to two significant figures; e.g. $v = \frac{2 \times \pi \times 23\,500}{1.26}$ (1 mark) = 117 000 (2 marks) =120 000 (km/day) (3 marks)	$2\pi r/T$ ONLY NO mark for equation as it is given on page 2 Bald correct answer to 3 or more s.f. scores 2 marks, e.g. 117186	3
(d)	MP1. Idea that the **orbital** radii of the two Moons are different; MP2. Idea that **orbit** radius of Enceladus is larger;	Ignore references to gravity ORA NB MP1 will be subsumed within MP2 response e.g orbit radius of Enceladus is ten times as big (ORA) gets both marks Allow response in terms of **orbit** / **orbit** diameter / **orbit** circumference	2

Total 9 marks

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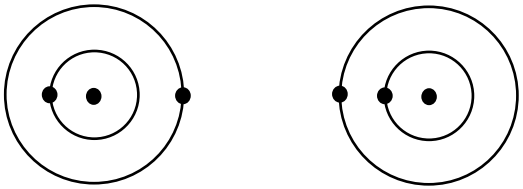
Question number	Answer	Notes	Marks
4 (a)	Venus;		1
(b)	because it has the largest mass;	ignore references to diameter/size	1
(c) (i)	density = $\frac{\text{mass}}{\text{volume}}$;	in words or accepted symbols e.g. $\rho = m/V$ condone D for density	1
(ii)	changing diameter to radius; substitution; evaluation; e.g. $\rho = \frac{100 \times 10^{24}}{[4/3 \times 3.14 \times 25000^3]}$ 1.5×10^{12} (kg/km^3)	if diameter used instead of radius (gives 1.9×10^{11}) max 2 -1 for POT error allow answers rounding down to 1.5×10^{12} (kg/km^3)	3
(d)	change of time into seconds (seen anywhere); use of orbital radius as 150×10^6 km; evaluation; e.g. $v = \frac{2 \times 3.14 \times (150 \times 10^6)}{365 \times 24 \times 60 \times 60}$ 29.9 (km/s)	no mark for eqn as this is given allow 30 (km/s)	3
(e)	an evaluation to include 3 of: MP1. identifying period as time of orbit; MP2. correct **detail** of why statement is right/wrong; MP3. correct use of data comparing 2 planets; MP4. period depends on distance from the Sun;	can refer to either mass or diameter of planet for 'size' must name planets must name planets	3

Total 12 marks

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Question number	Answer	Notes	Marks
5(a)	D – the Sun		1
(b) (i)	Substitution; Calculation; speed = $\frac{2 \times \pi \times 250\,000\,000}{690}$ = 2 300 000 (km/day) (correct to 2SF)	If answer given to more than 2SF, then allow range of 2 275 000 → 2 280 000 max 1 for POT error in bald answer	2
(ii)	Any two of 1. Idea of different speeds; 2. idea of different orbits /radii; 3. Idea of variable relative motion, e.g. both on the same side of the Sun and then on opposite sides of the Sun; 4. Appropriate calculation e.g. difference or sum of radii, attempt to calculate speed of Earth; e.g. Diagram showing understanding of MP2 and MP3  Earth Sun Mars Mars Earth Sun	**Accept** appropriate labelled diagrams **Allow** for one mark: elliptical if no other mark scored e,g, orbit of Mars is more elliptical than Earth's **ignore** Mars labelled inside Earth's orbit	2

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Question number	Answer	Notes	Marks
(c) (i)	Working;; e. 300 000 = 170 000 000 / t 1 working mark (sub ONLY) t = 170 000 000 / 300 000 both working marks (sub AND rearrange) Calculation; e. = 570 (566.7) (s) 1 mark (ans to > 1 SF)	'show that' question, working must be shown for full marks REVERSE CALCS: maximum mark =2 (correct calc plus a comparison statement e.g. 283 333 ≡ 300 000 180 000 000 ≡ 170 000 000) Allow (without the subject of the equation) for 2 marks, 170 000 000 / 300 000	3

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Question number	Answer	Notes	Marks
(c) (ii)	Any **two** of 1. IDEA of HOW THE LOW SPEED AFFECTS DRIVING; **low speed** reduces stopping distance **low speed** helps to avoid obstacle 2. IDEA of THE EFFECT OF LOW SPEED ON COLLISION; momentum /low speed / low (kinetic) energy reduces damage if in collision 3. IDEA of WHAT THE TIME DELAY DOES; **time delay** affecting reaction time / stopping distance / steering 4. IDEA of WHAT THE TIME (DELAY) IS; it takes a **long** time to get the signal (the communication delay is) ≈ **1200** (s) (we see images which are) **600s** delayed light and radio waves travel at the same speed in a vacuum	Allow idea that rover could travel up to 48 m between commands RA ignore better photos/detail of the planet /eq	2
		Total	**10**

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Question number	Answer	Notes	Marks
6 (a)	C the Solar System;		(1)
(b)	small circle centred on Q;		(1)
(c)	correct shape; correct orbit, star is clearly not at the centre of the orbit;	accept • 'open' ellipse /eq • oval • hyperbola it is not necessary that perihelion < orbital radius of S	(2)
(d) (i)	Any one comparison from: MP1. smaller {orbital path/ distance travelled} for close planets; MP2. larger speed for close planets;	Allow reverse arguments accept smaller orbital radius ignore lack of gravity all refs to time	(1)
(ii)	C planet S makes more orbits than P;		(1)
(e) (i)	250 (million km);		(1)
(ii)	150 (million km);		(1)

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Question number	Answer	Notes	Marks
7 (a)	(speed = 2πr/T is given) use of equation; final value; matching unit; e. Speed = (2 x π x 58 000 000) / (88 x 24 x 60 x 60) Speed = (2 x π x 58 000 000) / (88 x 24 x 60 x 60) = 47.9 km/s	alternatives - 88 days, 2112 hours, 126720 minutes, 7603200 seconds 47930 m/s, 172439596 m/hr, 172548.596 km/hr, 4138560 km/day	3
(b) (i)	Gravitational;	ALLOW 'gravity'	1
(ii)	Ellipse added to diagram with Sun nearer one focus of the ellipse;	DO NOT ALLOW symmetrical ellipse with Sun at the centre ALLOW incomplete ellipse (i.e. path around the Sun shown with orbit extending beyond the diagram space)	1
(iii)	Point closest Sun labelled X / ecf from the ellipse drawn	Should ideally extend from outside Mercury orbit to inside Mercury orbit ALLOW a tolerance on the position of X in line with the drawing skill	1
(iv)	Close / closest / closer to Sun; Gravitational force strongest;	ALLOW '(force of) gravity greater' ALLOW Answer based on gpe/ke	1 1
		Total	**8**

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Question number			Answer	Notes	Marks
8	(a)		gravity		1
	(b)	(i)	6960 (km)		1
		(ii)	equation quoted (NO MARK) conversion of km OR min; v = (2 x π x 6 960 000) / (96 x 60); 7600;	 ECF on (i) Allow for rounding errors	3
	(c)		EITHER grav pe reduces when closer; (so) ke increases; because total energy conserved; OR gravitational attraction / field strength increases when closer; mass remains constant; so accelerates;	 Grav force increases so ke increases = 1 (mixing arguments) REJECT 'gravity higher' 'gravity stronger' ACCEPT 'pull of gravity' 'force of gravity'	3
	(d)	(i)	electromagnetic (spectrum)	Accept transverse (waves)	1
		(ii)	Any **two** from X-rays have shorter wavelength; ORA X-rays have higher frequency; ORA X-rays have higher energy; ORA X-rays have greater penetration range; ORA X-rays have greater effects on living tissue; ORA	Idea of comparison must be there REJECT 'visible light can be seen' / eq	2

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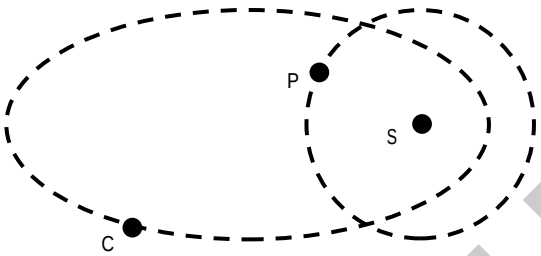
Question number	Answer	Accept	Reject	Marks
9 (a) (i)	C (planet);			1
(ii)	A (comet);			1
(b)	C (gravitational force);			1

Total 3 marks

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Question number	Answer	Notes	Marks
10(a)	Gravitational (force)	Allow (force of) gravity Gravitational pull Centripetal (force)	1
(b) (i)	All three labels correct;  	C Comet P Planet S Sun	1
(ii)	Any two of - MP1 Idea that orbits cross/meet/ intersect; MP2 Idea that comet and planet can be (at the same place) at the same time; MP3 Idea that orbit time periods are different;	Allow at the same place orbits overlap idea of orbiting at different speeds	2

Total 4 marks

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THE END

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