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OCR GCSE PHYSICS A (J249): QUESTIONS BY TOPIC

Topic P7: Energy (H)

GCSE Physics A Higher Tier (J249) · Topic P7

46 questions · 281 marks · Mark schemes included

OCR GCSE (9–1) Physics A (Gateway Science) J249, June 2018 – June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

46 questions · 281 marks · grouped by sub-topic, lowest tariff first



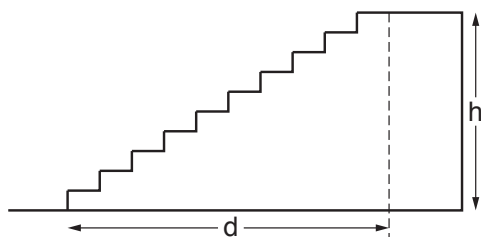
SUB-TOPIC P7.1

WORK DONE

25 questions in this sub-topic · 144 marks · lowest tariff first



- 6 A student of weight W runs up a flight of stairs.



She moves a distance d metres horizontally and h metres vertically.

What is the work done against gravity running up the stairs?

- A** $W \times d$
- B** $W \times h$
- C** $(W \times d) + (W \times h)$
- D** $W \times \frac{h}{d}$

Your answer

[1]

11 A pump lifts 500 kg of water to a water tank at the top of a building.

The water gains 240 000 J of gravitational potential energy.

The gravitational field strength is 10 N/kg.

Use the equation: Potential energy = Mass × Height × Gravitational field strength

Calculate the height of the water tank.

A 4.8 m

B 48 m

C 240 m

D 480 m

Your answer

[1]



8 Which object has the **most** gravitational potential energy?

- A 1 kg bag on a shelf 1 m above the ground
- B 2 kg bag on a shelf 1 m above the ground
- C 2 kg bag on a shelf 2 m above the ground
- D 1 kg bag on a shelf 2 m above the ground

Your answer

[1]



15 A car has a mass of 1000 kg and a kinetic energy of 12 500 J.

Calculate its speed.

Use the equation: kinetic energy = $0.5 \times \text{mass} \times (\text{speed})^2$

A 3.5 m/s

B 5.0 m/s

C 6.3 m/s

D 25.0 m/s

Your answer

[1]



15 An astronaut on the Moon lifts a 5.5 kg object a vertical distance of 50 cm.

Calculate the potential energy gained by the object.

Gravitational field strength on the Moon = 1.6 N/kg.

A 4.4 J

B 8.8 J

C 17.6 J

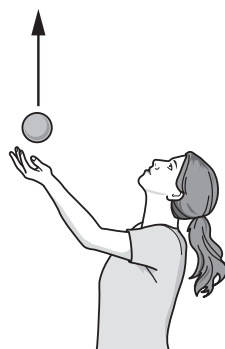
D 440 J

Your answer

[1]



- 4 A ball is thrown vertically into the air.



Energy is transferred from a chemical store.

Where is the useful energy transferred to?

- A A gravitational store and a thermal store only.
- B A gravitational store only.
- C A gravitational store and a chemical store only.
- D A thermal store and a chemical store only.

Your answer

[1]

7 A car has a mass of 1000 kg and is travelling at a speed of 20 m/s.

Calculate the kinetic energy of the car.

A 10 000 J

B 20 000 J

C 200 000 J

D 400 000 J

Your answer

[1]



10 What is the work done when a car is pushed a distance of 0.60 km using a force of 90 N?

- A** 0.15 J
- B** 54 J
- C** 150 J
- D** 54 000 J

Your answer

[1]



14 Two students, **A** and **B**, climb some steps.

- Student **A** has twice the mass of student **B**.
- Student **B** climbs four times higher than student **A**.

Which statement about gravitational potential energy (GPE) is correct?

Use the equation: potential energy = mass $\times$ height $\times$ gravitational field strength

- A** GPE gain of student **B** = $\frac{1}{4} \times$ GPE gain of student **A**
- B** GPE gain of student **B** = $\frac{1}{2} \times$ GPE gain of student **A**
- C** GPE gain of student **B** = $2 \times$ GPE gain of student **A**
- D** GPE gain of student **B** = $4 \times$ GPE gain of student **A**

Your answer

[1]



- 3** A student of mass 65 kg climbs a flight of 50 steps. Each step is 0.30 m high.

What is the gravitational potential energy gained by the student?

Use the equation: potential energy = mass $\times$ height $\times$ gravitational field strength

Gravitational field strength = 10 N/kg.

- A** 195 J
- B** 9750 J
- C** 19500 J
- D** 975000 J

Your answer

[1]



10 The kinetic energy of a car is 180 kJ when its speed is 20 m/s.

What is the mass of the car?

Use the Equation Sheet.

- A** 225 kg
- B** 450 kg
- C** 900 kg
- D** 18 000 kg

Your answer

[1]

- 1 A force of 1200 N moves an object a distance of 16 m.

What is the work done on the object?

Use the equation: work done = force $\times$ distance

- A 75 J
- B 9600 J
- C 19200 J
- D 153600 J

Your answer

[1]

- 7 A motorcyclist has a mass of 80 kg and rides his motorcycle at 25 m/s.

The motorcycle has a mass of 160 kg.

What is the total kinetic energy of the motorcyclist **and** motorcycle?

Use the equation: kinetic energy = $\frac{1}{2} \times \text{mass} \times (\text{speed})^2$

- A 3000 J
- B 25 000 J
- C 75 000 J
- D 150 000 J

Your answer

[1]



- 2 A crane lifts a steel beam of mass 500 kg to the top of a building 50 m high.

What is the **increase** in gravitational potential energy of the beam?

Use the equation: gravitational potential energy = mass $\times$ gravitational field strength $\times$ height

Gravitational field strength = 10 N/kg

- A 2500 J
- B 5000 J
- C 25 000 J
- D 250 000 J

Your answer

[1]



10 Which value is equal to $450\text{ }\mu\text{J}$ of energy?

A $4.5 \times 10^{-6}\text{ J}$

B $4.5 \times 10^{-5}\text{ J}$

C $4.5 \times 10^{-4}\text{ J}$

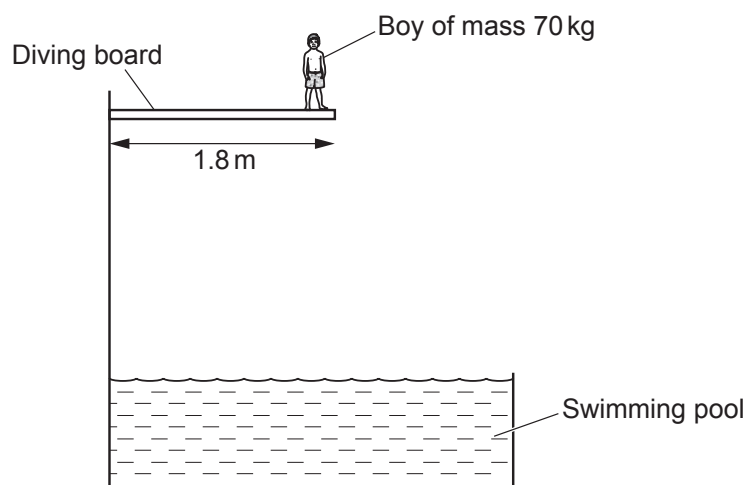
D $4.5 \times 10^{-3}\text{ J}$

Your answer

[1]



- 22** A boy of mass 70 kg stands on the end of a diving board at a distance of 1.8 m from the wall.



- (a)** Calculate the moment of the boy standing on the diving board.
Gravitational field strength on Earth = 10 N/kg.

Moment = ... N m **[4]**

- (b)** The boy dives vertically into the swimming pool. The water in the pool is 3.2 m below the diving board.

Calculate the velocity of the boy when he enters the water.

Use an equation from the data sheet to help you.

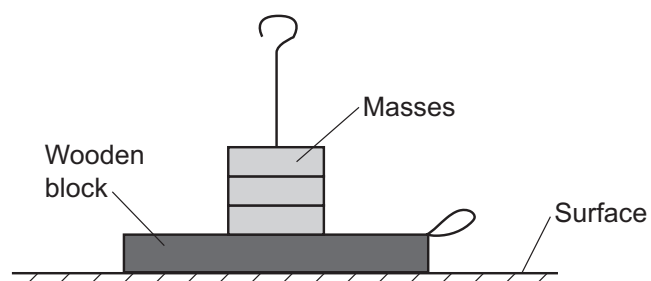
Gravitational field strength on Earth = 10 N/kg.

Velocity = ... m/s **[4]**

16 Fig. 16.1 shows a teacher's experiment.

The teacher pulls a wooden block through a fixed distance and calculates the work done from their measurements.

Fig. 16.1



The table shows the teacher's results.

Mass (kg)	Work done (J)
0.1	1.9
0.2	2.3
0.3	2.8
0.4	3.3
0.5	3.7
0.6	4.3

- (a) Describe how the teacher can do this experiment, including any equipment used. Use the Data Sheet.

.....

.....

.....

.....

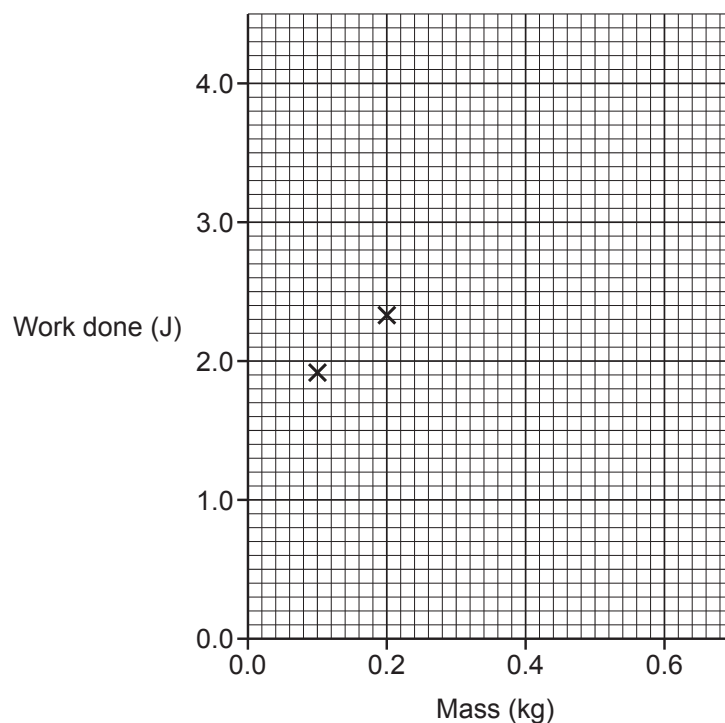
.....

..... [3]

- (b) (i) Plot a graph of the data in the table and draw a line of best fit on **Fig. 16.2**.

Two of the points have already been completed for you.

Fig. 16.2



[3]

- (ii) Describe the relationship between work done and mass.

.....

..... [1]

- (c) The teacher adds a lubricant between the surface and the block.

They keep the mass of the block and distance travelled the same as before.

- (i) Sketch a line on the graph to show how work done varies with mass in this new experiment.
Label this line with the letter **L**.

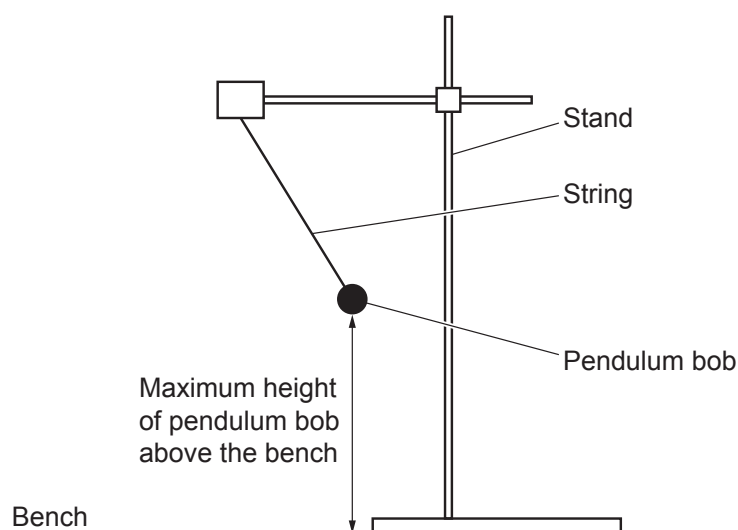
[1]

- (ii) Explain your reason for how you have drawn the line labelled **L** in (c)(i).

.....

..... [1]

- 17 The diagram shows a pendulum bob attached to a stand using string.



A student lifts the pendulum bob to the position shown on the diagram.

The student then releases the pendulum bob so that it swings freely.

- (a) The student notices that the maximum height of the pendulum bob above the bench decreases after each swing.

Explain why the maximum height of the pendulum bob decreases after each swing.

.....

 [2]

- (b) The student holds a metre ruler behind the swinging pendulum bob and measures the maximum height of the pendulum bob above the bench.

- (i) Give **two** reasons why the student's method might **not** give an **accurate** value for the maximum height of the pendulum bob.

1

 2
 [2]

- (ii) Describe **two** ways to improve the student's method to obtain a more accurate value of the maximum height of the pendulum bob at the end of each swing.

1

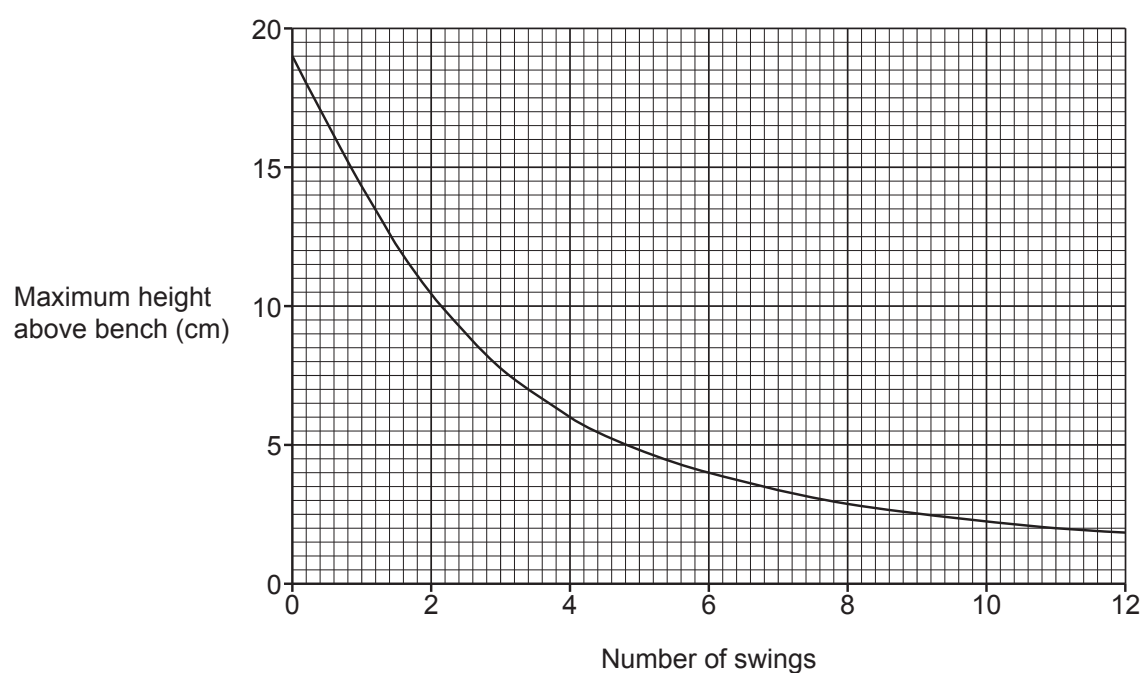
.....

2

.....

[2]

- (c) The graph shows how the maximum height of the pendulum bob above the bench changes as the pendulum bob swings.



The initial release height of the pendulum bob above the bench is 19 cm.

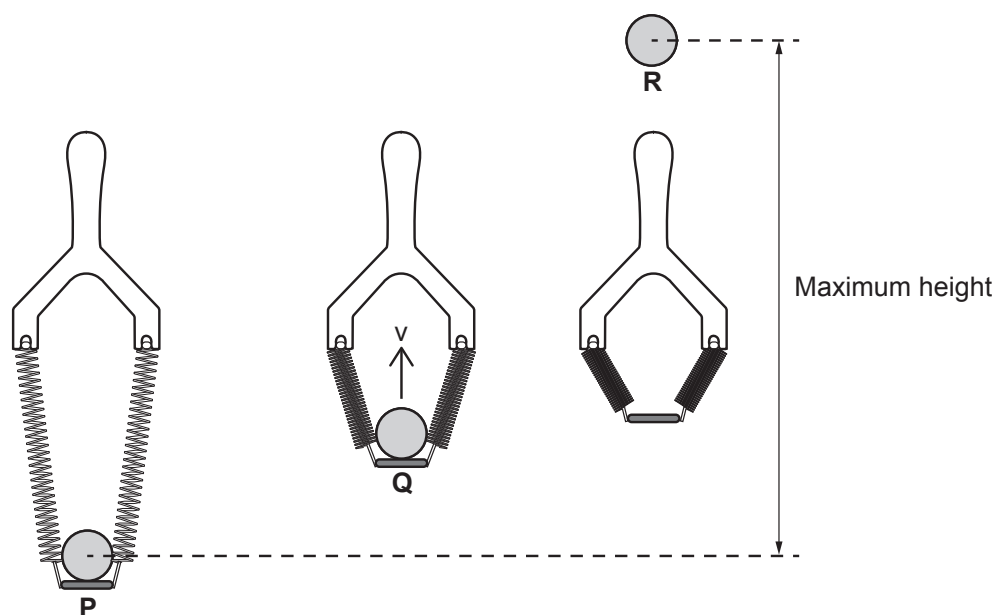
Determine the maximum height after 6 swings as a percentage of the initial release height.

Percentage of the initial release height = ... % [3]



21 Two springs are used to make a catapult. The catapult is used to shoot a ball vertically upwards.

The diagram shows the ball and catapult at different stages:



(a) At **P** the extension of each spring is 0.2 m.

The spring constant of each spring is 40 N/m.

Calculate the **total** elastic potential energy stored in the springs at **P**.

Energy stored = ... J [3]

- (b) At **Q** the ball is released and has maximum kinetic energy. The springs have **no** extension at **Q**.

The kinetic energy of the ball at **Q** is **less** than the value of the elastic potential energy stored in the springs at **P**.

Explain why.

.....
.....
..... [2]

- (c) The springs are stretched to a new extension:

- The total energy stored in the two springs is 2.4 J.
- The mass of the ball is 0.050 kg.
- At **R** the ball reaches maximum height.

Calculate the maximum height reached by the ball.

Use the equation: potential energy = mass × height × gravitational field strength

Maximum height = ... m [4]

- (d) A student investigates how the mass of the ball affects its speed at **Q**.

Describe **one** factor the student should control in their investigation.

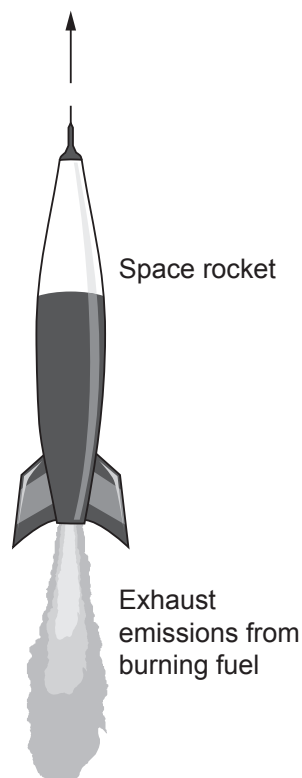
.....
..... [1]



19 A student researches rockets.

Fig. 19.1 shows a rocket burning fuel as it moves away from the Earth.

Fig. 19.1



The rocket accelerates vertically upwards.

Fig. 19.2 shows how the energy in the chemical store of the fuel is transferred to other energy stores in the rocket and in the surroundings.

Fig. 19.2



- (a) The energy in the gravitational potential store of the rocket increases as the rocket accelerates vertically upwards.

Why does the energy in the gravitational potential store of the rocket increase?

..... [1]

- (b) The energy in the thermal store of the rocket increases as the rocket accelerates vertically upwards.

What effect does this have on the rocket?

(c) When the fuel burns, it transfers 510 MJ of energy in one second.

(i) Explain why the total energy gained by other energy stores must also be 510 MJ in one second.

.....
 [1]

(ii) When the fuel burns, 320 MJ of energy is wasted in one second.

Calculate the efficiency of the rocket.

Use the equation: $\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{input energy transfer}}$

Efficiency = ... [3]

(d)

(i) The student finds out that:

- the energy in the kinetic store of the rocket increases by $1.2 \times 10^8 \text{ J}$ every second as the fuel burns
- the initial mass of the rocket is $8.5 \times 10^4 \text{ kg}$.

Calculate the minimum speed of the rocket after the fuel has been burning for 12 seconds if the rocket starts at rest.

Use the equation: $\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{speed})^2$

Speed = ... m/s [4]

(ii) Explain why the actual speed of the rocket after the fuel has been burning for 12 seconds is **greater** than the value calculated in (d)(i).

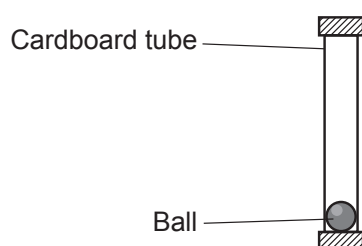
.....

 [2]



22 (a) Fig. 22.1 shows a sealed cardboard tube containing a ball.

Fig. 22.1



The cardboard tube is quickly turned upside down so that the ball falls the whole length of the tube.

Fig. 22.2 shows the energy stores of the ball at the **top** of the tube.

Complete Fig. 22.3 to show the energy stores of the ball before it hits the **bottom** of the tube. [3]

Fig. 22.2

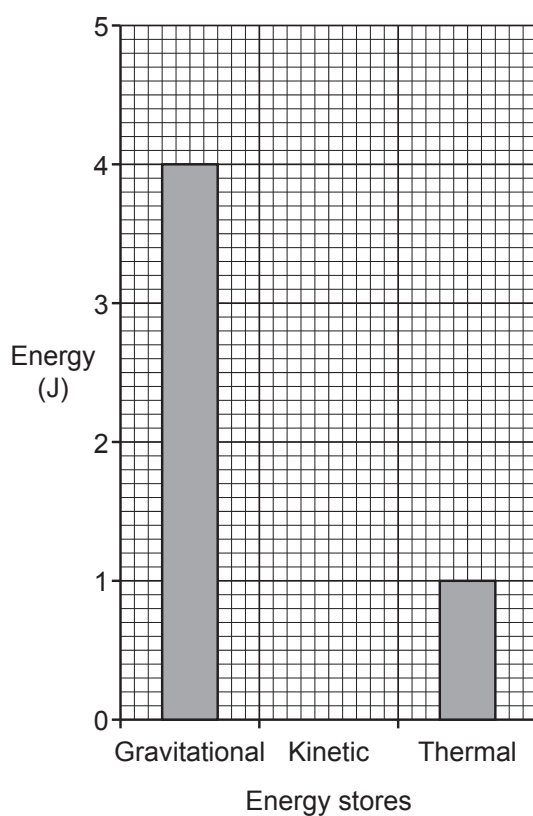
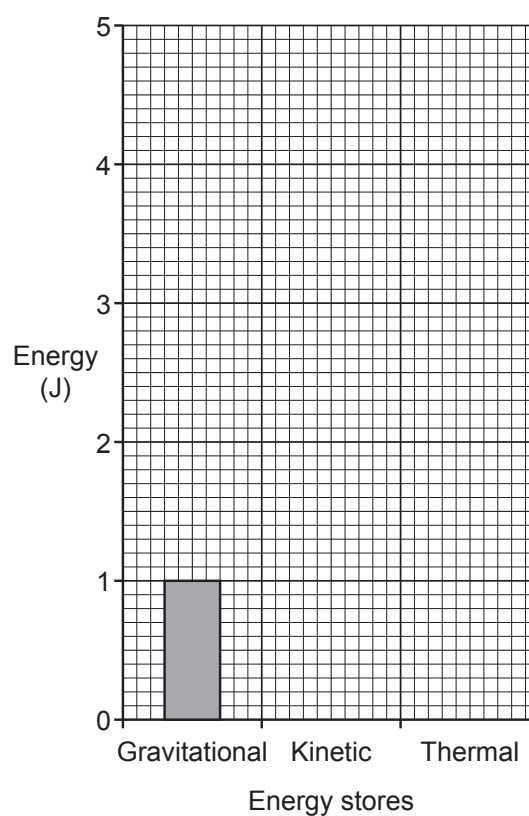


Fig. 22.3

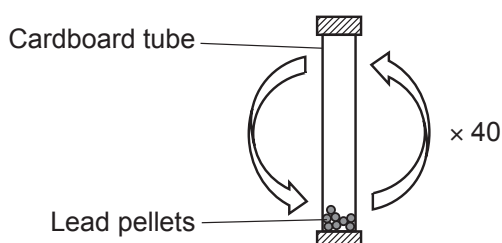


(b) Student **A** and student **B** determine the specific heat capacity of lead using this method.

- Measure the mass and initial temperature of small lead pellets.
- Place the pellets in a sealed cardboard tube.
- Quickly turn the tube upside down 40 times.
- Measure the final temperature of the lead pellets.

Fig. 22.4 shows a diagram of the equipment:

Fig. 22.4



(i) State **one** way to improve the experiment.

.....
 [1]

(ii) Explain why the cardboard tube is turned upside down very quickly.

.....
 [1]

(iii) Student **A** uses 0.030 kg of lead pellets and a 1.5 m long cardboard tube.

Calculate the change in potential energy of the pellets when the tube is turned upside down **once**.

Use the equation: potential energy = mass × height × gravitational field strength

Potential energy = ... J [2]

- (iv) **Student B** repeats the experiment using a different tube.

The total change in potential energy of 0.030 kg of lead pellets for this tube is 21 J.
The temperature change of the lead pellets is 5 °C.

Calculate the specific heat capacity of lead. Include the correct unit.

Use the Equation Sheet.

Specific heat capacity = ... Unit **[4]**

- (v) **Student A** says, 'I think we should use a metal with a higher specific heat capacity. This will give us more accurate results.'

Student B says, 'I think we should turn the tube upside down 100 times. This will give us more accurate results.'

Explain why both student **A** and student **B** are **not** correct.

Student A

.....

.....

.....

Student B

.....

.....

.....

[3]



20 A scientist uses different drivers to test the stopping distances of the same car.

Look at the results.

Driver	Speed (m/s)	Thinking distance (m)	Braking distance (m)
A	8	6	6
B	16	13	24
C	32	24	96
D	16	12	24
E	8	5	6
F	32	30	120

(a) Most of the drivers tested the car on a dry day, on a level road.

Which driver tested the car on an **icy** road?

Driver tested the car on an **icy** road.

[1]

(b) Which driver has the **quickest** reaction time?

Driver has the **quickest** reaction time.

Calculate their reaction time.

Answer = ... s [3]

(c) Give **two** drivers that have the **same** reaction time.

Drivers have the **same** reaction time.

Explain your answer.

.....

.....

..... [2]



(d) Driver **C** travels at 32 m/s on the road and then stops. The car has a mass of 1200 kg.

(i) Show that the **kinetic energy** stored by the car at 32 m/s is 614 000 J.

[2]

(ii) Describe what happens to the kinetic energy of the car as it brakes and stops.

.....

 [2]

(iii) The braking distance of the car is 96 m.

Calculate the **braking force** on the car.

Give your answer to **4** significant figures.

Answer = ... N [3]

(e) Driver **B** travels at 16 m/s on the road. The thinking distance is 13 m and the braking distance is 24 m.

Driver **B** now drives the car **uphill** at the same speed on the same road.

How will driving the car **uphill** affect thinking, braking and stopping distances?

The reaction time will stay the same.

Complete the sentences.

The **thinking distance** will

The **braking distance** will

The **stopping distance** will [2]



- 18 A space mission in 1969 placed an object called a retroreflector on the surface of the Moon.

Fig. 18.1 shows the retroreflector.

Fig. 18.1

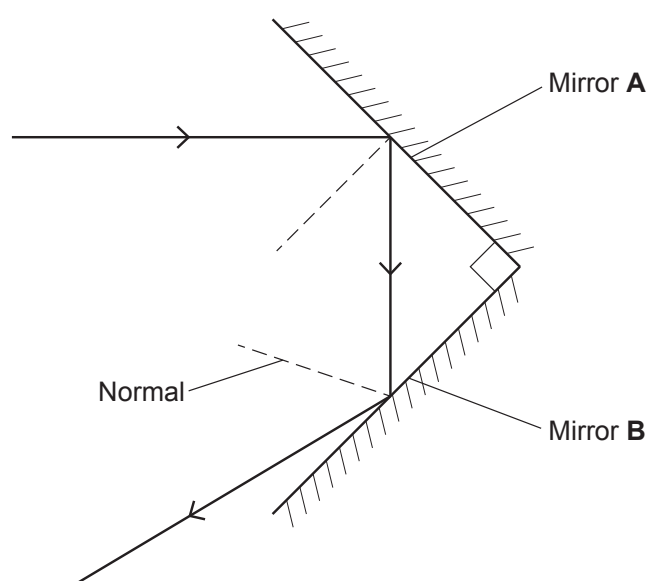


Laser light from the Earth is aimed at the retroreflector and reflects back to the Earth.

- (a) A student draws a simple model of a retroreflector using two plane mirrors at right angles to each other.

Fig. 18.2 shows the student's model.

Fig. 18.2



Identify the **two** mistakes the student has made in Fig. 18.2.

Mistake 1

.....

Mistake 2

.....

[2]

- (b) The retroreflector was placed on a layer of dust on the surface of the Moon.

Since 1969, the efficiency of the retroreflector has decreased and it reflects less light back to the Earth.

Suggest why the retroreflector reflects less light.

.....
 [1]

- (c) The mass of the retroreflector is 77 kg.

An astronaut lifted the retroreflector a vertical distance of 0.50 m on the Moon.

Calculate the gravitational potential energy gained by the retroreflector.

The gravitational field strength on the Moon is 1.6 N/kg.

Use the Equation Sheet.

Gravitational potential energy = ... J [3]

- (d) A green laser emits light with a wavelength of 5.32×10^{-7} m.

The speed of the green light is 3.0×10^8 m/s.

Calculate the frequency of the laser light.

Use the Equation Sheet.

Give your answer to **2** significant figures.

Frequency = ... Hz [4]



- (e) Recently scientists have aimed infrared lasers at the Moon.

Explain why infrared radiation **cannot** be seen in the sky.

.....
..... [1]

- (f) Visible light and infrared radiation are transverse waves.

- (i) Describe the difference between visible light and infrared radiation using the words **frequency** and **wavelength**.

.....
.....
..... [2]

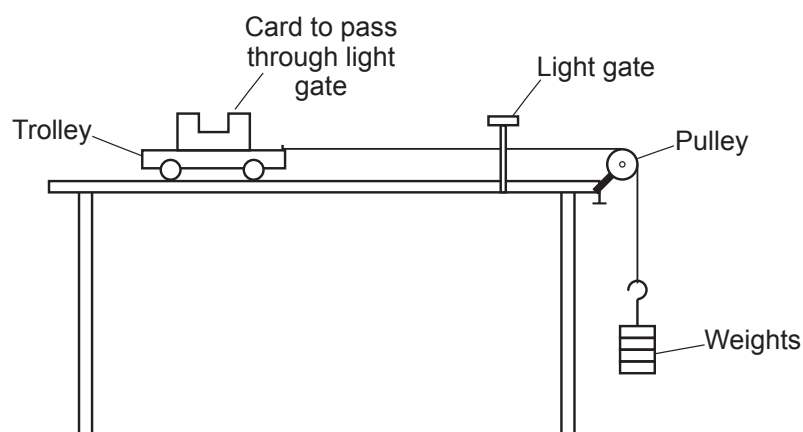
- (ii) Water waves are also transverse waves.

A scientist standing near the sea observes water waves moving past them.

Explain how the scientist can measure the **frequency** of the water waves.

.....
.....
.....
..... [2]

21 A student investigates the acceleration of a trolley.



The trolley is released from a fixed position and accelerates.

The accelerating force is provided by the weights attached to the trolley with string.

Acceleration is measured using a light gate and data logging equipment.

Look at the results from the experiment.

Force (N)	Acceleration
1.0	1.3
2.0	2.9
3.0	4
4.0	5.7
5.0	6.9

(a) The student has made **two** mistakes in their results table. Identify the two mistakes and suggest corrections to them.

Mistake 1:

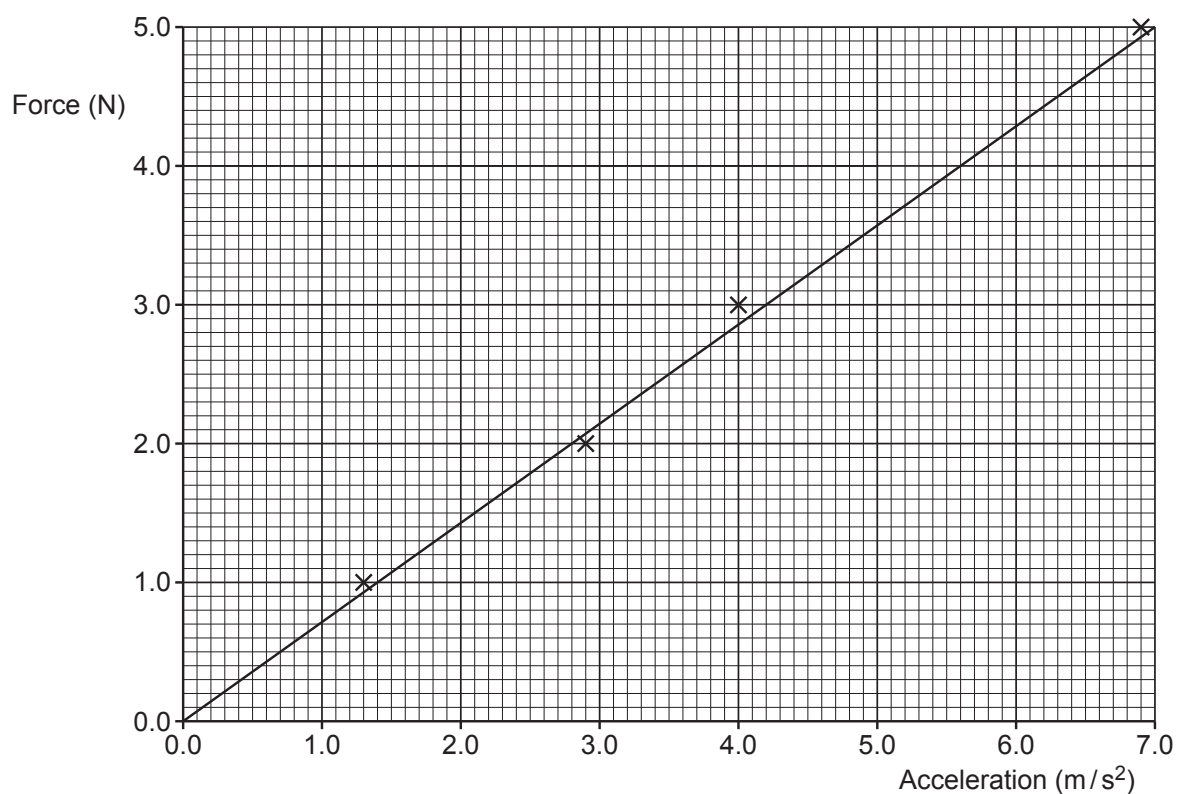
Correction 1:

Mistake 2:

Correction 2:

[4]

(b) The student plots the results on a graph.



(i) One point has not been plotted on the graph. Plot the missing point on the graph. [1]

(ii) Describe the relationship between the two variables on the graph.

.....

 [2]

(iii) Calculate the gradient of the graph and use this to determine the mass of the trolley.

Mass = ... kg [2]



- (iv) The actual mass of the trolley is lower than that found in the experiment. Suggest **two** reasons why.

Use ideas about forces and energy in your answer.

1

.....

2

.....

[2]

- (v) Suggest **two** ways the experiment could be improved.

1

.....

2

.....

[2]

- (c) (i) Describe the energy transfer as the trolley accelerates on the desk.

.....

.....

[1]

- (ii) The trolley moves a distance of 86 cm along the desk.

Calculate the work done when a force of 3.0 N is applied.

Use the equation: work done = force $\times$ distance

Give your answer to **2** significant figures.

Work done = ... J [4]



21 A student investigates how the angle of a ramp affects the final speed of a trolley.

He uses light gates to record the speed of the trolley at the bottom of the ramp.

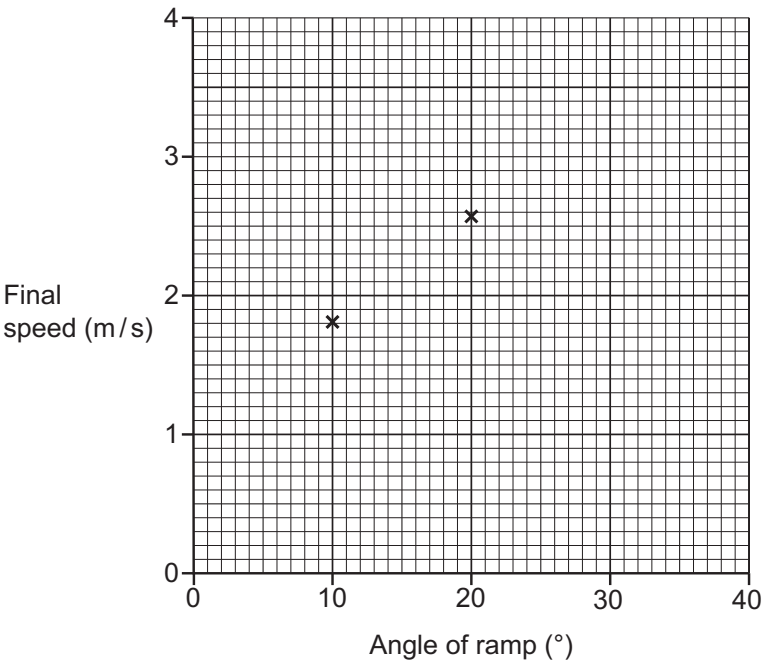
The student releases the trolley from rest at the same point on the ramp each time.

Look at his results.

Angle of ramp (°)	Final speed (m/s)			
	Attempt 1	Attempt 2	Attempt 3	Mean
10	1.81	1.80	1.81	1.81
20	2.58	2.56	2.57	2.57
30	3.1	3.11	3.11	3.11
40	3.52	3.51	3.50	3.51

(a) (i) Plot the results on the graph and draw a line of best fit.

Two results have been plotted for you.



[2]

- (ii) Describe the pattern shown by the results.

Use data from the table or graph in your answer.

.....

.....

.....

.....

.....

..... [3]

- (iii) Explain why the final speed changes when the angle of the ramp increases.

In your answer use ideas about energy.

.....

.....

..... [2]

- (iv) The student made a mistake when recording one of his results.

Identify the mistake **and** explain what he should have done.

.....

.....

..... [2]

- (v) The student thinks this data shows that his results are **reproducible**.

He is **not** correct.

Explain why.

.....

.....

..... [2]

- (b) (i) The mean final velocity for the ramp at a 40° angle is 3.51 m/s . The distance from the top of the ramp to the light gate at the bottom is 1.0 m .

Calculate the acceleration of the trolley when the ramp is at a 40° angle.

Give your answer to **2** decimal places.

Acceleration = ... m/s^2 [5]

- (ii) The trolley has a mass of 2.0 kg .

Calculate the kinetic energy of the trolley at a speed of 3.0 m/s .

Kinetic energy = ... J [3]



SUB-TOPIC P7.2

POWER AND EFFICIENCY

21 questions in this sub-topic · 137 marks · lowest tariff first



10 A gas fire, used to heat a room, has an input energy transfer of 180 000 J per minute.

The fire has an efficiency of 0.8.

Use the equation: $\text{Efficiency} = \text{Useful output energy transfer} / \text{Input energy transfer}$

Calculate the useful output energy transfer per minute.

- A** 600 J
- B** 2400 J
- C** 36 000 J
- D** 144 000 J

Your answer

[1]



14 A boiler has an input power of 12 kW from the gas it burns.

Its efficiency is 0.75.

Which row in the table shows the correct values for this boiler?

	Useful output power (kW)	Wasted output power (kW)
A	3	9
B	8	4
C	9	6
D	9	3

Your answer

[1]

- 2** A student uses 2250 J of energy climbing up steps. It takes the student 15 seconds to climb the steps.

Calculate the power of the student.

Use the equation: power = work done ÷ time taken

- A** 15 W
- B** 150 W
- C** 9000 W
- D** 33750 W

Your answer

[1]



13 A student is measuring power of different machines. Which two measurements show the **same** power measured?

A 10 GW and $1.0 \times 10^{10} \text{ W}$

B 4.0 kW and $40 \times 10^3 \text{ W}$

C 10 mW and $10 \times 10^3 \text{ W}$

D 10 MW and $1.0 \times 10^6 \text{ W}$

Your answer

[1]



5 How can unwanted energy transfer be reduced?

- A** By adding lubrication
- B** By decreasing efficiency
- C** By increasing friction
- D** By removing thermal insulation

Your answer

[1]

- 1 Which row describes the walls of a building with the **lowest** rate of cooling?

	Thickness of walls	Thermal conductivity of walls
A	thick	high
B	thick	low
C	thin	high
D	thin	low

Your answer

[1]

3 Power can be measured in watts (W) or milliwatts (mW).

What is 1.5 mW converted into W?

A $1.5 \times 10^{-6} \text{ W}$

B $1.5 \times 10^{-3} \text{ W}$

C $1.5 \times 10^3 \text{ W}$

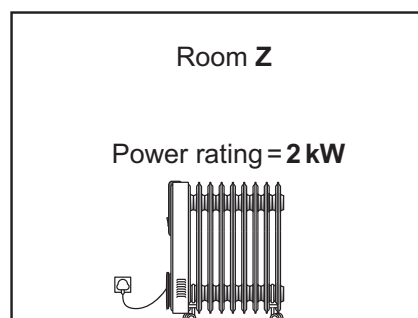
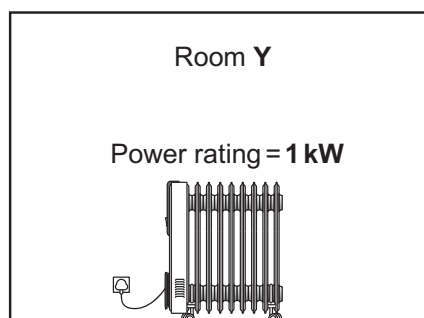
D $1.5 \times 10^6 \text{ W}$

Your answer

[1]



- 13 Room Y and Room Z are identical rooms. No energy can escape from the rooms. The temperature of each room is increased by using a different heater.



The heater in each is turned on for **30 minutes**.

E_Y is the increase in the thermal energy store of Room Y.

E_Z is the increase in the thermal energy store of Room Z.

Which row of the table is correct?

	Change in thermal energy stores
A	$E_Z = E_Y/2$
B	$E_Z = E_Y$
C	$E_Z = 2E_Y$
D	$2E_Z = E_Y$

Your answer

[1]

12 A coal fired power station has an efficiency of 0.4.

What is the input energy needed to obtain a useful output energy of 500 MJ?

Use the equation: $\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{input energy transfer}}$

- A** 200 MJ
- B** 500 MJ
- C** 540 MJ
- D** 1250 MJ

Your answer

[1]



13 In one month a wind turbine on a house generates 300 kWh of useful energy.

The efficiency of the wind turbine is 0.60.

What is the wasted energy in one month?

Use the equation: $\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{input energy transfer}}$

A 120 kWh

B 180 kWh

C 200 kWh

D 450 kWh

Your answer

[1]

16 (a) A TV has a power rating of 0.2 kW.

Calculate the energy transferred, in kWh, if the TV is switched on for 4 hours.

Energy transferred = ... kWh [3]

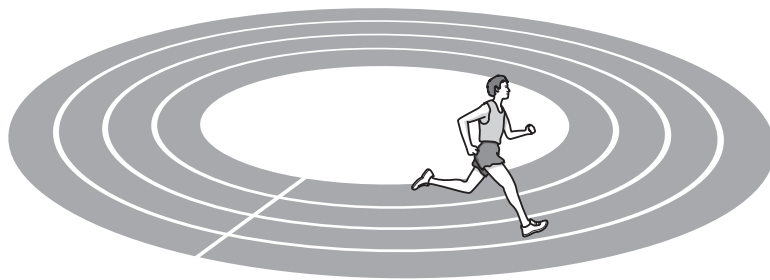
(b) A different TV works with a 12.0 V battery. It has a current of 3.19 A.

Calculate the power rating of the TV.

Power = ... W [3]



- 22** An athlete runs around a circular running track at a constant speed.



- (a)** Explain why the athlete's velocity is not constant.

.....
 **[1]**

- (b)** The work done by the athlete after completing one lap of the track is 3000 J. It takes the athlete 60 s to complete one lap.

Calculate the power of the athlete.

Power = ... W **[3]**

- (c)** After the lap, the athlete slows down from a velocity of 5 m/s to a velocity of 1 m/s. The deceleration of the athlete is 0.4 m/s^2 .

Calculate the time taken for the athlete to change velocity.

Use the equation: acceleration = change in velocity/time

Time taken = ... s **[3]**



17 A TV has the label below on it.

OCR TV

Voltage: 230 V

Power: 65 W

Frequency: 50 Hz

(a) Calculate the **current** in the TV when it is turned on.

Use the equation: power = potential difference $\times$ current

Give your answer to **2** significant figures.

Current = ... A [4]

(b) The TV is turned on for 30 minutes.

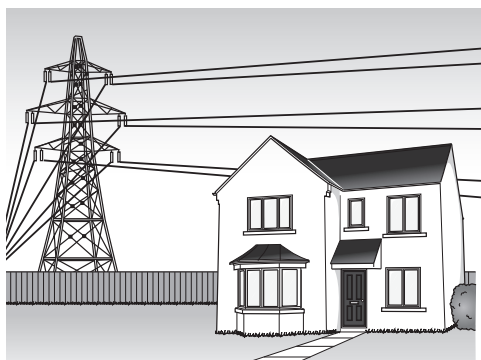
Calculate the energy transferred by the TV.

Energy used = ... J [4]



20 Energy is transferred at high voltages in the national grid.

(a) This house is near to a transmission line.



Explain why radio waves may be produced by the transmission line.

.....
.....
..... [2]

(b) Explain why it is more efficient to transfer energy at high voltages.

.....
.....
..... [2]

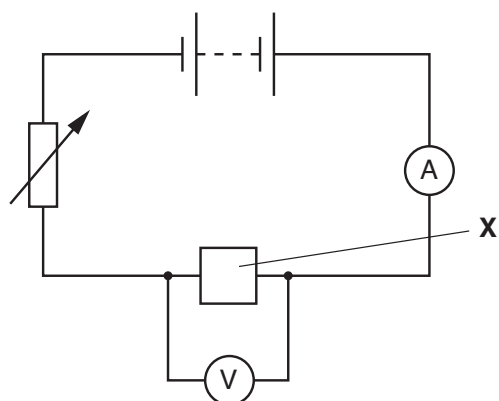
(c) The transmission line has a power loss of 6.156 kW.

Its resistance is $15.39\ \Omega$.

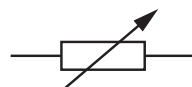
Calculate the current in the transmission line.

Current = ... A [5]

16 A student builds a circuit to investigate the resistance of component **X**.



(a) (i) What is the name of this component?



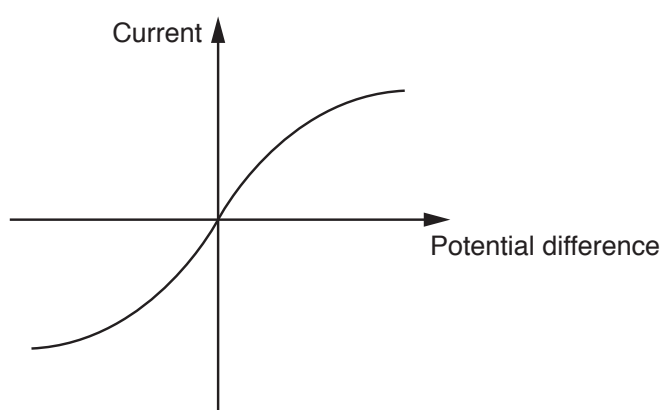
..... [1]

(ii) Why is this component needed in this circuit?

..... [1]

(b) The student uses the circuit to take current and potential difference readings.

The student plots a graph of her results.



(i) Look at the graph. What is component **X** in the circuit?

..... [1]

- (ii) The resistance of component **X** varies as the potential difference changes.

Describe how the graph shows this and explain why this happens.

.....
.....
.....
..... [3]

- (c) Component **X** has a resistance of $16\ \Omega$ when a current of 0.25A flows.

- (i) Calculate the potential difference across component **X**.

Use the equation: Potential difference = Current $\times$ Resistance

Answer = ... V [2]

- (ii) Calculate the power of component **X** when a current of 0.25A flows.

Answer = ... W [3]



17 A student investigates the rate of cooling using a cardboard box to model the walls of a building.

She puts a beaker of hot water into the cardboard box. She measures the temperature of the water every two minutes.

She investigates how the rate of cooling changes with the thickness of the walls.

(a) Describe a method she can use to do this investigation.

.....

.....

.....

.....

.....

..... **[3]**

(b) Here are the results of one of her experiments.

Time (minutes)	Temperature of water (°C)
0	90
2	75
4	63
6	54
8	47
10	41
12	37

(i) Plot the results on the grid in **Fig. 17.1**.

Two of the points have been plotted for you.

[2]

(ii) Draw a line of best fit on your graph.

[1]



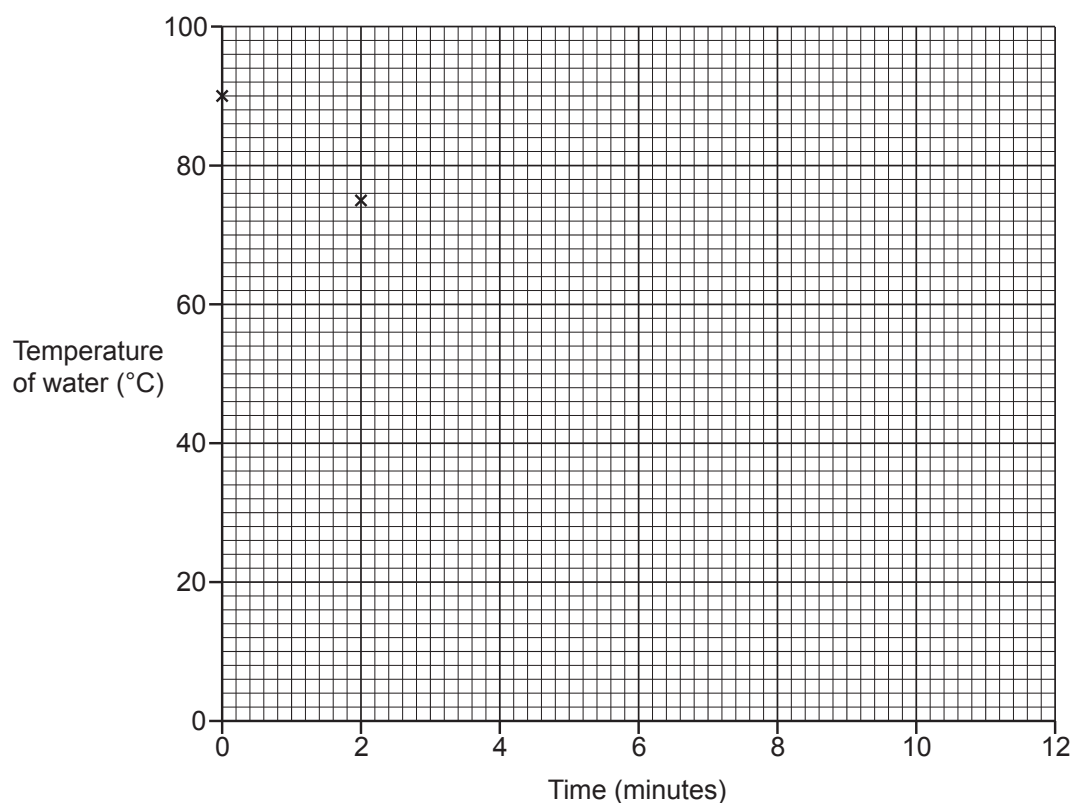


Fig. 17.1

- (iii) Describe how the temperature of the water changes with time.
Use data from the graph **Fig. 17.1** in your answer.

.....

 [2]

- (iv) The thickness of the cardboard box is doubled. Everything else stays the same.

Sketch a line on the graph in **Fig. 17.1** to suggest what these new results may look like.
Label your line **Z**. [1]

- (v) Suggest **one** way to improve the investigation.

.....
 [1]

- (c) Explain why the rate of cooling of a metal box is different to a cardboard box.
Assume the thickness of the walls is the same in both boxes.

.....
 [1]



20 A student uses an electric heater to raise the temperature of water.

Fig. 20.1 shows some of the equipment the student uses.

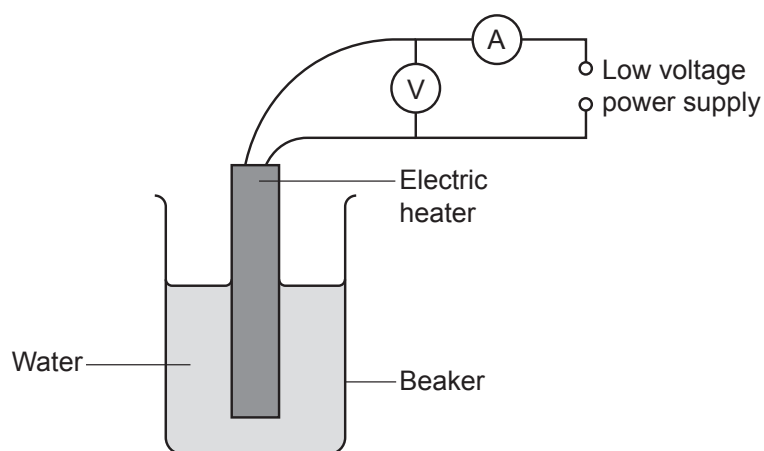


Fig. 20.1

The student obtains the data in **Table 20.1**:

Energy input to the heater	12 000 J
Increase in thermal energy store of the water	8 400 J

Table 20.1

(a) Use the data in **Table 20.1** to calculate the efficiency of the heater.

Efficiency = ... [3]

21 (a) This question is about an electric kettle.

- (i)** An electric kettle is filled with water, connected to the mains and switched on.

The electricity for the kettle is generated in a coal-fired power station.

Describe the energy transfer that occurs when the kettle is switched on.

Include ideas about energy stores in your answer.

.....
.....
..... **[2]**

- (ii)** The mains supply has a potential difference of 230 V.

The kettle has a current of 5.0 A. The kettle is switched on for 2.0 minutes.

Calculate the total energy transferred to the kettle in 2.0 minutes.

Total energy transferred = ... J **[4]**



- (b) (i) **Table 21.1** gives some information about a different kettle.

Energy transferred to the kettle	525 000 J
Mass of water	1.2 kg
Starting temperature of water	25 °C
Final temperature of water	100 °C
Specific heat capacity of water	4200 J/kg °C

Table 21.1

Calculate the efficiency of the kettle described in **Table 21.1**.

Give your answer as a percentage.

Use an equation from the data sheet.

Efficiency = ... % [5]

- (ii) Explain why the efficiency of the kettle is less than 100%.

.....
 [1]

- (c) The water can also be heated using a 12V heater.

A transformer is used to change a 120V supply into 12V.

The current in the secondary coil is 9.0A.

Calculate the current in the primary coil.

Use an equation from the data sheet.

Current = ... A [2]



23 A medical freezer is used to keep vaccines cool.

- (a) (i)** Calculate the energy required by the freezer to cool 0.50 kg of solid vaccines from -5°C to -35°C .

Assume the specific heat capacity of the vaccines is $1900\text{ J/kg}^{\circ}\text{C}$.

Use the Equation Sheet.

Energy = ... J **[2]**

- (ii)** It takes 5 minutes for the freezer to cool the vaccines.

Calculate the power of the freezer.

Use the Equation Sheet.

Power = ... W **[3]**

- (iii)** Suggest **two** reasons why the actual power of the freezer will be greater than that calculated in part **(a)(ii)**.

1

.....

2

.....

[2]



- (b) (i) When the vaccine is used by doctors, it has to be changed back into a liquid. The temperature of the vaccine is first raised to its melting point but it remains as a solid.

Explain **two** reasons why more energy is needed to change the solid vaccine into a liquid at its melting point.

1

.....

2

.....

[2]

- (ii) Calculate the number of 5 mg vaccine doses which can be melted using 6800 J of energy.

Assume the specific latent heat of fusion for the vaccines is 340 000 J/kg.

Use the Equation Sheet.

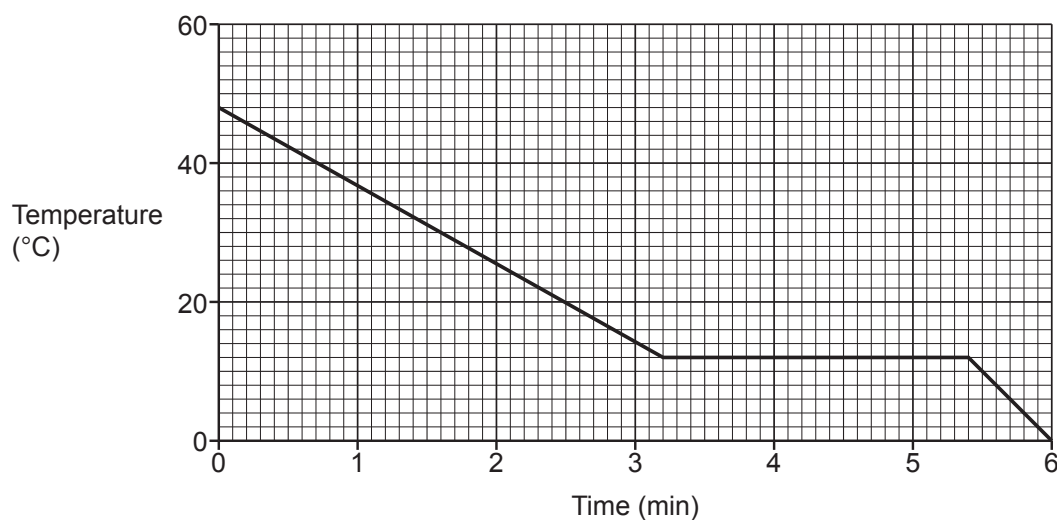
Number of vaccine doses = ... [6]



23 A scientist investigates how liquids cool when they are placed in a freezer.

(a) The scientist places 200 g of liquid **A** in a freezer.

The graph shows how the temperature changes with time as the liquid cools.



(i) What is the initial temperature of liquid **A**?

Initial temperature = ... °C [1]

(ii) What is the freezing point of liquid **A**?

Freezing point = ... °C [1]

(iii) Liquid **A** has a specific heat capacity of 3750 J/kg °C.

Calculate the energy needed to cool the liquid from its initial temperature until it starts to freeze.

Use the Equation Sheet.

Energy = ... J [4]

(b)

(i) Liquid **B** is placed in the freezer.

The freezer needs 54 kJ of energy to cool liquid **B** from its initial temperature to its freezing point. This takes 360 s.

Calculate the minimum power of the freezer needed to cool liquid **B**.

Use the equation: energy transferred = power × time

Minimum power = ... W **[4]**

(ii) Why is the actual power needed to cool liquid **B** larger than your answer to **(b)(i)**?

..... **[1]**

(c) The power of a different portable freezer is 240 W.

The components in the freezer have a total resistance of $0.80\ \Omega$.

Calculate the current in the freezer.

Use the Equation Sheet.

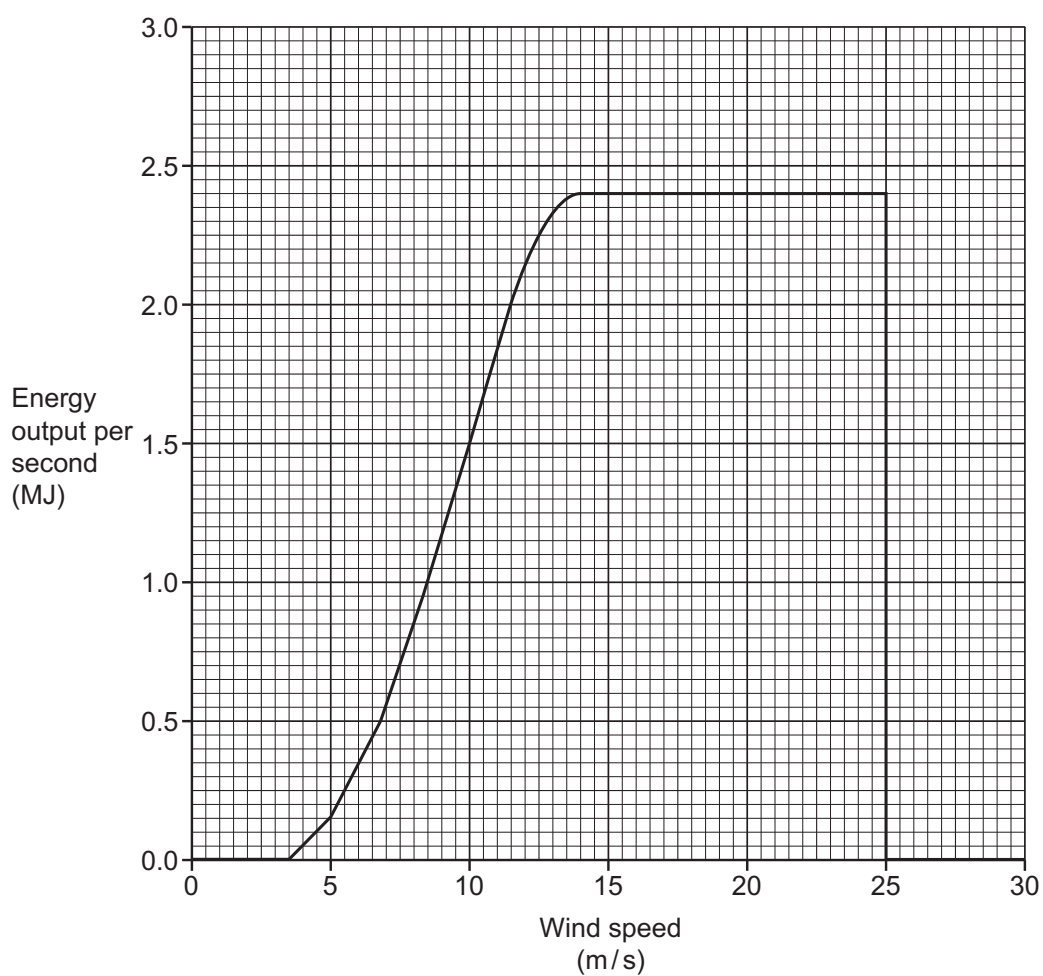
Give your answer to **2** significant figures.

Current = ... A **[4]**



- 21 (a) Fig. 21.1 shows how the energy output per second of a wind turbine depends on the wind speed.

Fig. 21.1



- (i) Suggest a reason why energy output per second is zero when the wind speed is:

1 Less than 3.5 m/s.

.....
.....

2 Greater than 25 m/s.

.....
.....

[2]

- (ii) The wind turbine has an efficiency of 0.35.

Calculate the input energy per second when the wind speed is 10 m/s.

Use **Fig. 21.1** and the Data Sheet.

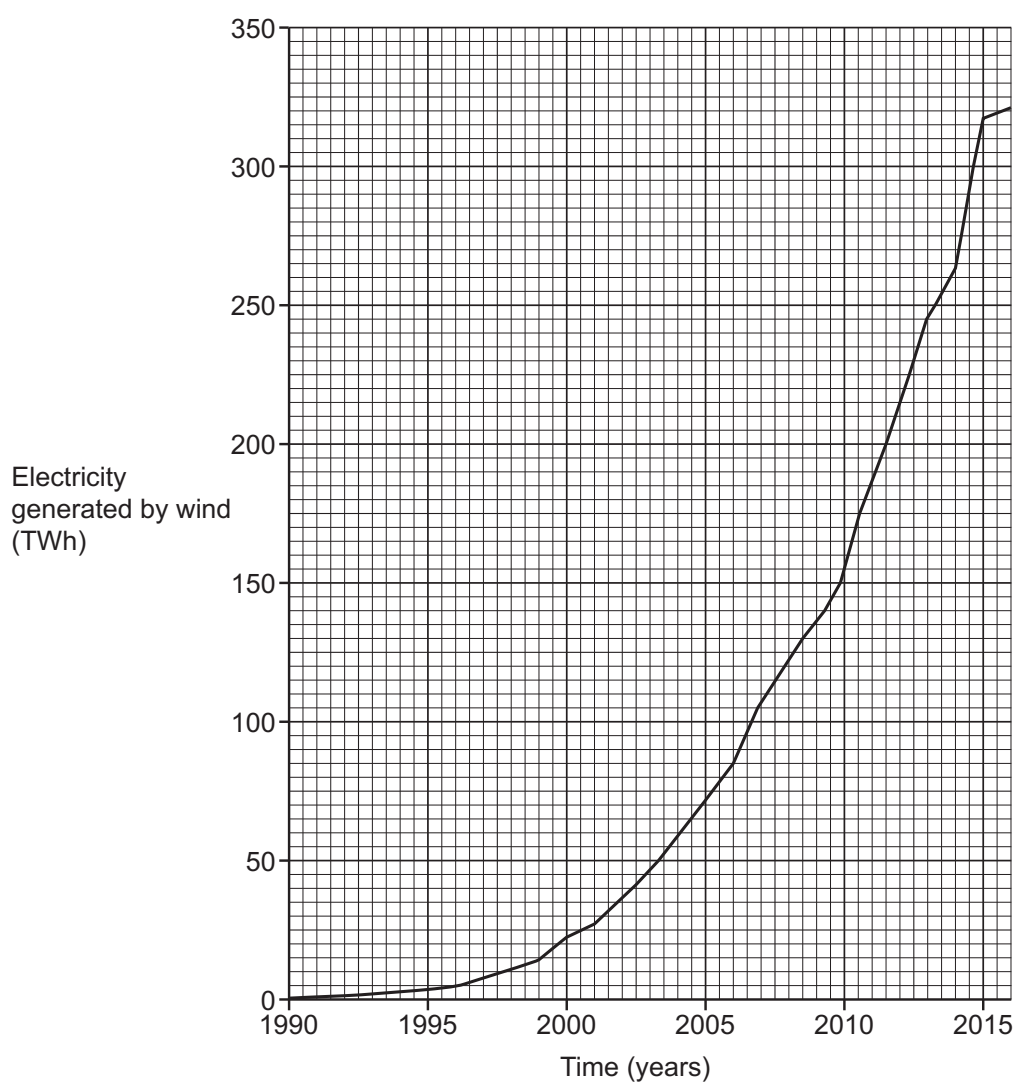
Give your answer to **2** significant figures.

Input energy per second = ... MJ [5]



- (b) Fig. 21.2 shows how the amount of electricity generated by wind in Europe has changed with time.

Fig. 21.2



- (i) State the amount of electricity generated by wind in 2012 in joules.

$$1 \text{ TWh} = 3.6 \times 10^{15} \text{ J}$$

Give your answer in standard form.

Electricity generated = ... J [2]

(ii) Suggest **two** reasons for the change shown in **Fig. 21.2**.

1

.....

2

.....

[2]

(c) The wind turbine generates electricity at 900 V.

The wind turbine is connected to the national grid using a transformer.

- (i) The potential difference across the primary coil is 900 V.
The potential difference across the secondary coil is 36 000 V.
The current in the primary coil is 2800 A.

Calculate the current in the **secondary** coil.

Use the Data Sheet.

Current = ... A [2]

(ii) Explain why the use of the transformer in (c)(i) reduces power loss in the national grid.

.....

.....

.....

.....

.....

..... [3]

(iii) Another transformer has a power input of 864 900 W.

The current in the primary coil is 1860 A.

Calculate the resistance of the primary coil.

Use the equation: $\text{power} = (\text{current})^2 \times \text{resistance}$

Resistance = ... Ω [3]



MARK SCHEMES

official Pearson Edexcel mark schemes



Question			Answer	Marks	AO element	Guidance
6			B ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
11			B ✓	1	2.2	



Question				Answer	Marks	AO element	Guidance
8				C ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
15			B ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
15			A		1	2.1	



Question			Answer	Marks	AO element	Guidance
4			B ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
7			C ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
10				D ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
14			C ✓	1	1.2	



Question	Answer	Marks	AO element	Guidance
3	B ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
10	C	1	1.1	



Question	Answer	Marks	AO element	Guidance
1	C	1	2.1	



Question	Answer	Marks	AO element	Guidance
7	C	1	2.1	



2	D	1	2.1	A: $(500/10) \times 50$ B: 10×500 C: 50×500 D: $500 \times 50 \times 10$
---	---	---	-----	---



Question	Answer	Marks	AO element	Guidance
10	C	1	1.2	



22	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1260 or 1300 (Nm) award 4 marks (Force = $70 \times 10 =$) 700 (N) ✓ (Moment =) force x distance ✓ (Moment =) 700×1.8 ✓ (Moment =) 1260 (Nm) ✓	4	2.1 1.2 2.1 2.1	ALLOW ecf for using mass not weight e.g. 3 marks for an answer of 126 (Nm), 2 marks for 70×1.8 ALLOW ecf for incorrect calculation of force ALLOW ecf for converting 1.8m to 180cm e.g. 3 marks for 126 000 (Nm)
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 8 (m/s) award 4 marks $u = 0$ or $v^2 = (u^2 +) 2as$ ✓ $v^2 = 2 \times 10 \times 3.2$ or $v = \sqrt{2 \times 10 \times 3.2}$ ✓ $v^2 = 64$ ✓ $v = 8$ (m/s) ✓ OR alternative method: $mgh = \frac{1}{2} mv^2$ ✓ $(70 \times) 10 \times 3.2 = \frac{1}{2} (x 70) \times v^2$ ✓ $64 = v^2$ ✓ $v = 8$ (m/s) ✓	4	1.2 2.1 2.1 2.1	$v^2 - u^2 = 2as$ does not score a mark



16	(a)	Any three from: Use a force meter/newton meter to measure (pulling) force ✓ Measure distance (moved) using a ruler/metre rule/measuring tape ✓ Repeat experiment with different masses (on the wooden block) ✓ Use work done = force × distance ✓	3	3 × 3.3a	ALLOW metre stick / metre tape ALLOW different weights (on the wooden block) ALLOW balance/scales to measure mass (on the wooden block) IGNORE ideas about masses on pulleys IGNORE idea of repeating the same experiment (with same mass)
	(b) (i)	4 points correctly plotted to within ½ small square ✓✓ Thin, straight line of best fit drawn ✓	3	3 × 2.2	ALLOW 1 mark for 2 points correctly plotted. DO NOT ALLOW points more than half a square in diameter DO NOT ALLOW all points above or below the line IGNORE line before first plot DO NOT ALLOW first plot joined to last plot ALLOW ECF for lbf drawn for candidate's points
	(ii)	Work done increases as mass increases / ORA ✓	1	3.1a	ALLOW linear relationship IGNORE it is proportional IGNORE positive correlation

Question			Answer	Marks	AO element	Guidance
16	(c)	(i)	Line with positive gradient drawn below the first line of best fit (for all points) ✓	1	3.2b	IGNORE horizontal line / line starting at origin ALLOW curve / missing label L DO NOT ALLOW if the line cuts the x axis from 0.1 kg or more
		(ii)	Any one from: (The lubricant) reduces friction ✓ reduces transfer to thermal energy (store) ✓	1	2.1	ALLOW less friction / prevents friction / less resistance (to motion) ALLOW heat for thermal energy ALLOW less energy transferred to other stores / less energy dissipated / more efficient IGNORE less work done / less energy (needed) / less force

17	(a)	friction / air resistance / drag ✓ (friction) does work on pendulum / energy transferred to thermal (store of surroundings) ✓	2	2 × 2.2	ALLOW force of air ALLOW energy lost to surroundings / energy dissipated (to surroundings/thermal store) IGNORE pendulum loses energy IGNORE KE decreases
	(b) (i)	Any two from: difficult to read the ruler at the right time / while bob is moving/swinging ✓ ruler might not be vertical ✓ reading might not be taken perpendicularly/at eye level to the ruler/scale ✓	2	2 × 3.1b	IGNORE human error unqualified ALLOW difficult to see where the bottom of the bob is / bob is moving too fast / hard to tell exactly when bob is at its highest point ALLOW ruler held at an angle ALLOW there is parallax error when reading scale ALLOW if the ruler is behind the pendulum it is hard to see the values
	(ii)	Any two from: Record the motion on a video and playback in slow motion ✓ (Idea of) mark a point (on piece of card) behind the bob (at end of swing) or use a grid/graph paper behind bob ✓ Clamp the metre ruler/card/graph paper in place ✓ (Idea of) Use a set square/plumb line/spirit level to ensure metre ruler is vertical ✓	2	2 × 3.3b	IGNORE repeat and average ALLOW record/video it (and playback) / take photo(s) at end of swing

Question		Answer	Marks	AO element	Guidance
17	(c)	First check the answer on the answer line If answer = 21 (%) award 3 marks Read value from graph for 6 swings = 4 (cm) ✓ $4 \div 19 \times 100$ ✓ (percentage of initial release height =) 21 (%) ✓	3	3 × 1.2	ALLOW tolerance ± 0.25 (cm) ALLOW ECF for last two marks for incorrect value read from graph

21	(a)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.6 (J) award 3 marks (Energy transferred in stretching =) $\frac{1}{2} \times 40 \times 0.2^2$ ✓ (Energy transferred in stretching =) 0.8 (J) ✓ (Total energy transferred in stretching =) $2 \times 0.8 = 1.6$ (J) ✓	3	1 × 1.2 2 × 2.1	
	(b)		Any two from: Not all of the elastic (potential) energy is converted into kinetic energy ✓ Some energy is converted to gravitational potential energy (store) ✓ Total energy (in a system) must be constant / mention of conservation of energy ✓	2	2 × 2.1	ALLOW Some energy converted to thermal energy store/surroundings for 1 mark. ALLOW Kinetic energy = elastic (potential) energy – gravitational potential energy for 2 marks
	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4.8 (m) award 4 marks (Height =) potential energy ÷ (mass × gravitational field strength) OR EPE = GPE ✓ g = 10 N/kg ✓ (Height =) $2.4 / (0.05 \times 10)$ ✓ (Height =) 4.8 (m) ✓	4	2 × 1.2 2 × 2.1	ALLOW Use of 9.8 N/kg and 9.81 N/kg for g Use of 9.8 or 9.81 gives 4.9 (m) (to 2SF) ALLOW POT (power of ten) error for incorrect conversion of mass for 3 marks
	(d)		Ensure springs extended by the same length each time / use the same springs / same spring constant ✓	1	3.3a	ALLOW constant diameter of the ball IGNORE Use the same equipment.

19	(a)		Increases height/going further away from the Earth ✓	1	1.1	ALLOW it is going (higher) up DO NOT ALLOW gravitational force increases
	(b)		Increases temperature ✓	1	1.1	ALLOW gets hotter/heats up
	(c)	(i)	Energy is (always) conserved OR <u>total</u> energy in is equal to <u>total</u> energy out ✓	1	1.1	ALLOW energy cannot be created or destroyed / total energy cannot change / law of conservation of energy IGNORE ideas about conservation of mass
		(ii)	First check the answer on the answer line If answer = 0.37 award 3 marks (useful energy =) 190 (MJ) ✓ substitution: (efficiency =) $190(\text{MJ}) \div 510(\text{MJ})$ ✓ evaluation: (efficiency =) 0.37 ✓	3	3 × 2.1	ALLOW 37 % for 3 marks ALLOW 0.372549 or 37.2549 % to at least 2 significant figures correctly rounded or truncated ALLOW 190 seen anywhere for this mark ALLOW ECF for substitution of incorrectly calculated useful energy for 1 mark ALLOW ECF for correct evaluation of incorrectly calculated useful energy for 2 marks ALLOW 0.37 to any other power of ten for 2 marks

Question			Answer	Marks	AO element	Guidance
19	(d)	(i)	First check the answer on the answer line If answer = 184 award 4 marks (total KE gained =) $1.2 \times 10^8 \times 12$ OR 1.44×10^9 (J) ✓ substitution : $1.44 \times 10^9 = 0.5 \times 8.5 \times 10^4 \times v^2$ ✓ rearrangement: (speed =) $\sqrt{\frac{(2 \times 1.44 \times 10^9)}{8.5 \times 10^4}}$ ✓ Evaluation: (speed =) 184 m/s ✓	4	4 × 2.1	ALLOW 184.071597 to at least 2 significant figures correctly rounded or truncated for 4 marks ALLOW 53.13689 to at least 2 significant figures correctly rounded or truncated for 3 marks (did not multiply KE by 12) ALLOW 33882.3529 to at least 5 significant figures correctly rounded or truncated for 3 marks (did not take square root) ALLOW the substitution mark for substitution of candidate's incorrect KE ALLOW rearrangement mark with use of incorrect KE ALLOW rearrangement mark in symbols or words ALLOW substitution and rearrangement in either order
		(ii)	Rocket mass/weight decreases (as fuel burns) ✓ (Idea that) for <u>same KE</u> (gained), speed will increase more (if mass is less) ✓	2	2 × 2.2	DO NOT ALLOW weight will be lower due to lower gravitational force IGNORE less air resistance due to thinner atmosphere ALLOW for the same accelerating force, there will be a greater acceleration, so a greater speed



22	(a)		Bar for kinetic energy higher than zero ✓ Bar for thermal energy higher than previous bar ✓ Sum of the heights of the bars = 5 ✓	3	3 × 2.2	DO NOT ALLOW this mark if candidate has drawn a kinetic energy bar which is higher in Fig. 22.2
	(b)	(i)	Any one from: Insulate the tube ✓ Repeat (the experiment) and take an average (temperature rise) ✓	1	3.3b	ALLOW use a tube made of a more insulating material
		(ii)	So pellets do not rub against side of tube / to reduce friction / to reduce thermal energy transfer (to tube)	1	2.2	ALLOW pellets to fall (more) vertically / to reduce the cooling of the pellets
		(iii)	First check the answer on answer line If answer = 0.45 (J) award 2 marks (GPE ⇒) $0.03 \times 10 \times 1.5$ ✓ (GPE ⇒) 0.45 (J) ✓	2		ALLOW 0.44 (J) 2.1 ALLOW use of 9.8(1) N / kg 2.1 ALLOW 0.44 (J)

Question			Answer	Marks	AO element	Guidance
22	(b)	(iv)	First check the answer on answer line If answer = 140 J / kg °C award 4 marks Rearrange to give: $c = E / (m \times \Delta\theta)$ ✓ (c ⇒) $21 / (0.03 \times 5)$ ✓ (c ⇒) 140 ✓ J / kg °C ✓	4		ALLOW 0.14 J / g °C for 4 marks ALLOW K for °C 2.1 2.1 ALLOW 1 mark for correct substitution into unarranged equation, e.g., $21 = 0.03 \times c \times 5$ 2.1 1.1 Unit mark is independent ALLOW J / kg / °C
		(v)	Any three from: Student A: A higher SHC would lead to a lower temperature rise/change ✓ (small) temperature rise/change is more difficult to measure ✓ Student B: More turns mean more energy dissipated as thermal energy (in the tube or surroundings) ✓ a larger SHC value is obtained ✓	3	3 × 3.1b	



20	a		F ✓	1	3.3a	
	b		E ✓ FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 0.6 (s) award 2 marks 5 ÷ 8 ✓ =0.6 (s) ✓	3	3.1a 1.2 2.2	ALLOW 0.625 or 0.63 (s)
	c		Any two from: A, C or D ✓ Thinking distance / reaction time is proportional to speed / AW ✓	2	3.2b 3.2b	ALLOW as speed doubles, thinking distance doubles / ratio of speed:distance or distance:speed is the same / both have reaction time of 0.75 (s)
	d	i	recall of correct equation, $KE = \frac{1}{2}mv^2$ ✓ $\frac{1}{2} \times 1200 \times 32 \times 32 = 614\,000$ ✓	2	1 x 2.1 1 x 1.2	
		ii	KE transferred to thermal energy / heat in brakes / surroundings / AW ✓ ✓ OR (KE of car) is reduced / transferred ✓ Brakes gain / absorb thermal energy / heat ✓	2	1.1 1.2	ALLOW surroundings gain thermal energy / heat dissipated to surroundings IGNORE just brakes get hot

Question			Answer	Marks	AO element	Guidance
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 6396N then ✓✓✓ force = work done ÷ distance or force = work done / distance ✓ = 614000/96 or 614400/96 ✓ If answer is incorrect or incomplete, then 6395 or 6395.8333333 etc. ✓✓ If answer is incorrect or incomplete then or 614 000 ÷ 96 ✓	3	2 x 2.1 1.2	
	e		(The thinking distance will) stay the same (The braking distance will) decrease (The stopping distance will) decrease All three correct ✓✓ Two correct ✓	2	3.2a 3.2a	

18	(a)	Angle of incidence not equal to angle of reflection (at mirror B/second reflection) / AW ✓ Normal line is not at 90° (to surface of mirror B) / AW ✓	2	2 × 1.1	IGNORE not at correct angle If no other marks scored: ALLOW (second) reflected ray should be parallel to original ray for 1 mark
	(b)	dust on it/retroreflector ✓	1	3.2a	ALLOW it is dirty/dull/scratched/not smooth
	(c)	First check the answer on the answer line If answer = 61.6 (J) award 3 marks Select: (gravitational potential energy =) mass × gravitational field strength × height / (E =) mgh ✓ (E =) $77 \times 0.5 \times 1.6$ ✓ (E =) 61.6 (J) ✓	3	1.2 2 × 2.1	ALLOW 62 (J) ALLOW equation in any form

	(d)	First check the answer on the answer line If answer = 5.6×10^{14} (Hz) award 4 marks Select and rearrange: (frequency =) wave speed ÷ wavelength / $f = v \div \lambda$ ✓ (f =) $3 \times 10^8 \div 5.32 \times 10^{-7}$ ✓ (f =) $5.639... \times 10^{14}$ ✓ (f =) 5.6×10^{14} (Hz) (2 s.f.) ✓	4	1.2 2.1 2.1 1.2	 ALLOW correct substitution into unrearranged equation for 1 mark ALLOW $5.639... \times 10^n$ for 2 marks ALLOW 5.6×10^n for 3 marks ALLOW this mark for clear evidence of an incorrect answer (correctly rounded) to two significant figures (not a bald answer to 2 s.f.)
	(e)	Eyes can only detect a limited range of (electromagnetic) waves / wavelength is too large (to be seen) / frequency is too small (to be seen) ✓	1	1.1	ALLOW (frequency/wavelength of) IR is outside of the range of EM waves that is detectable to the eye / eye is not able to see that frequency/wavelength of wave ALLOW eyes can <u>only</u> detect (visible) light BUT IGNORE IR is not visible to the eye / eyes cannot see/detect IR
	(f) (i)	Visible light has a larger frequency (than infrared) / ORA ✓ Visible light has shorter wavelength (than infrared) / ORA ✓	2	2 × 1.1	IGNORE longer/shorter frequency

	(ii)	Any two from: Count number of waves (passing a point) ✓ Measure time (for these waves with a stopwatch) ✓ Divide number of waves (passing a point) by the time (for these waves) ✓ Alternative method (idea of) measure time period / time for 1 wave ✓ Use frequency = $1 \div$ time period ✓	2	2 × 2.2	ALLOW count how many times an object e.g. cork bobs up and down IGNORE time it takes waves to travel a certain distance ALLOW count number of waves in a certain time for 2 marks If no other marks scored: (idea that) frequency is the number of waves per second for 1 mark
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21	(a)		Mistake 1: Unit for acceleration is missing ✓ Correction 1: Unit should be m/s/s or m/s² or ms⁻² ✓ Mistake 2: Acceleration at 3.0 N is only recorded to 1 significant figure ✓ Correction 2: Acceleration should be recorded to 2 significant figures /4.0 (m/s²) ✓	4		ALLOW sig. fig. for d.p. throughout ALLOW answers in any order 3.2a 3.3b ALLOW include units for acceleration 3.2a 3.3b ALLOW not recorded to 1 decimal place (like the others) ALLOW should be recorded to 1 d.p./same number of d.p.
	(b)	(i)	Point correctly plotted at (5.7 m/s ² , 4N) within ½ a small square ✓	1	2.2	
		(ii)	Force is (directly) proportional to acceleration ✓✓ OR Maximum of one mark from: Linear relationship (through the origin)✓ As force increases, acceleration increases / OR A ✓	2	2x3.1a	ALLOW (directly) proportional to each other / they are (directly) proportional ALLOW $y = mx + c$, $c = 0$ so $y = mx$ IGNORE positive correlation
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.7, 0.71 or 0.72 (kg) award 2 marks Change in y / change in x or $5(.0)/7(.0)$ ✓ (mass =) $0.7(0) / 0.71 / 0.72$ (kg) ✓	2		2.2 ALLOW eg 4.3/6.0, 4.0/5.6 etc. to within +/- ½ small square 2.2

Question	Answer	Marks	AO element	Guidance
				ALLOW other answers between 0.65 and 0.75 only if workings shown using correct values read from the graph to within +/- ½ small square ✓✓
	(iv) Any two from: Not all of the energy is transferred to the trolley / energy is transferred/lost to other stores It assumes all of the force on the trolley is equal to the weight added on the string ✓ Friction on the pulley / between the wheels and the surface ✓ Mass of the string/card is ignored ✓ The card on the trolley was not measured properly✓ The card on the trolley did not pass through the light gates vertically/at 90° ✓	2	2x3.2a	ALLOW energy is transferred/lost to the surroundings/due to friction/air resistance ✓ ALLOW table is not smooth / friction in the wheels

Question			Answer	Marks	AO element	Guidance
		(v)	Any two from: Compensate for/reduce friction, e.g. by raising the ramp / use a linear air-track / oil/grease pulley ✓ Repeat the experiment and calculate the mean ✓ Measure the acceleration between two points which are further apart ✓ Use different equipment (to check if it produces similar results) ✓ Use equipment with higher resolution/precision ✓ Use string/card with less mass/weight ✓	2	2x3.3b	ALLOW repeat to remove/identify anomalies ALLOW use lighter string/card / subtract mass of card/string (from measurements) ALLOW use a pulley with less mass to reduce energy wasted when turning pulley / AW
	(c)	(i)	Gravitational (potential energy store) to kinetic (energy store) ✓	1	2.1	ALLOW kinetic (energy store) to thermal (energy store) / gravitational (potential energy) to thermal (energy) ALLOW KE for kinetic energy / GPE for gravitational (potential) energy / heat for thermal IGNORE just potential energy / PE
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.6 (J) award 4 marks 86cm = 0.86 m ✓ (Work done =) $3(.0) \times 0.86$ ✓ (Work done =) 2.58 (J) ✓ (Work done =) 2.6 (J) ✓	4	1.2 2.1 2.1 1.2	ALLOW ecf for missing or incorrect unit conversion e.g. 260 (J) for 3 marks, 258 (J) for 2 marks

21	(a)	(i)	Both points correctly plotted ✓ Smooth curve correctly drawn ✓	2	1.2	ALLOW within ½ small square for plotting DO NOT ALLOW straight lines between data points IGNORE any line drawn for <10°
		(ii)	Increase in angle of ramp increases speed (at bottom ramp) OR ✓ Increase is not linear/doubling angle does not double final speed / AW ✓ Reference to quantitative data for two calculations, for example, increase from 10° to 20° the speed increases by 0.76 whilst 20° to 30° the speed increases by 0.54 ✓	3	3.1a 3.1a 3.1b	IGNORE correlation ALLOW Not directly proportional / Not constant increase NOTE comparison of two increases required NOTE Speed increase from 0° to 10° is 1.81 and speed increase from 30° to 40° is 0.40
		(iii)	(Increase in angle) increases potential energy of the trolley/more work is done raising trolley to that point on the ramp ✓ This increases the / more kinetic energy at the bottom of the ramp ✓	2	1.1x2	ALLOW more PE is transferred to KE
		(iv)	Attempt 1 at 30° (is only recorded to 1 decimal place)/ 3.1 ✓ Student should record data to a consistent number of decimal places or 2 dp / the reading should be recorded as 3.10 / AW ✓	2	3.3a 3.3b	ALLOW only recorded to 2 significant figures ALLOW should be recorded to 3 significant figures NOT same accuracy

Question	Answer	Marks	AO element	Guidance
(v)	Any two from: Reproducible means that the results can be reproduced by someone else ✓ Only one student has collected this data ✓ The experiment is repeatable (as the repeated readings are close together) ✓	2	2.2x2	NOT experiment can be repeated
(b) (i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 6.16 (m/s²) award 5 marks $v^2 - u^2 = 2as$ (no mark – on formula sheet) $u = 0$ ✓ $a = v^2 \div 2s$ ✓ $a = 3.51^2 \div (2 \times 1.0)$ ✓ $a = 6.16005$ (m/s ²) ✓ $a = 6.16$ (m/s ²) (2 decimal places) ✓	5	2.1 1.2 2.1 2.1 1.2	 NOTE must be rearranged ALLOW Any number which rounds to 6.16 ALLOW one mark for any calculated answer to 2dp
(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 9 (J) award 3 marks kinetic energy (J) = 0.5 x mass (kg) x (speed (m/s)) ² / KE = ½ mv ² / KE = 0.5mv ² ✓ KE = 0.5 x 2.0 x 3.0 ² ✓ KE = 9 (J) ✓	3	1.2 2.1 2.1	



Question				Answer	Marks	AO element	Guidance
10				D ✓	1	2.2	



Question			Answer	Marks	AO element	Guidance
14			D ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
2				B	1	2.1	



Question				Answer	Marks	AO element	Guidance
13			A		1	1.1	



Question			Answer	Marks	AO element	Guidance
5			A ✓	1	1.1	



Question			Answer	Marks	AO element	Guidance
1			B ✓	1	2.2	



Question				Answer	Marks	AO element	Guidance
3				B ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
13				C ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
12	D	1	2.1	ALLOW 1250 (MJ)



Question	Answer	Marks	AO element	Guidance
13	C	1	2.1	



16	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.8 (kWh) award 3 marks Recall (Energy transferred =) power x time ✓ 0.2×4 ✓ (Energy =) 0.8 (kWh) ✓	3	1.2 ALLOW correct equation in any form ALLOW 200×4 or $200 \times 4 \times 60 \times 60$ or 200×14400 or $200 \times 4 \times 60$ or $0.2 \times 4 \times 60 \times 60$ or 0.2×14400 or $0.2 \times 4 \times 60$ for one mark 2.1 ALLOW 800 or 2 880 000 or 2880 or 48 000 or 48 for two marks 2.1
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 38.28 (W) award 3 marks Recall (Power =) potential difference x current ✓ 12×3.19 ✓ (P =) 38.28 (W) ✓	3	1.2 ALLOW correct equation in any form 2.1 2.1 ALLOW 38.3 (W) or 38 (W)

22	(a)	<u>direction</u> / <u>displacement</u> is changing / AW ✓	1	1.1	
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 50 (W) award 3 marks Power = energy / time ✓ 3000 / 60 ✓ 50 (W) ✓	3	1.2 2.1 2.1	
	(c)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 10 (s) award 3 marks (Rearrangement) $t = \text{change in velocity} / a$ ✓ $t = (1-5) / (-0.4)$ ✓ $t = 10 \text{ (s)}$ ✓	3	1.2 2.1 2.1	IGNORE negative signs

17	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.28 (A) award 4 marks Rearrange equation current = power ÷ potential difference/ $I = P \div V$ ✓ $I = 65 \div 230$ ✓ $I = 0.2826086$ ✓ $I = 0.28 \text{ (A)}$ ✓	4	1.2 2.1 2.1 1.2	 NOTE If answer not to 2 sig figs max 3 marks ALLOW one mark for any calculated answer to 2sf
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 117000 (or 116000) (J) award 4 marks $E = P \times t$ ✓ Unit conversion 30 minutes = 1800 seconds ✓ $E = 65 \times 1800$ ✓ $E = 117000 \text{ (J)}$ ✓		 1.2 1.2 2.1 2.1	ALLOW ECF from (a) $E = Q \times V$ or $I \times t \times V$ $E = 0.28 \times 1800 \times 230$ ALLOW ECF for incorrect time conversion ALLOW three marks for 1950 (J) $E = 116000 \text{ (J)}$ ✓

20	(a)	A.C. (transmitted in power lines) / (electrical/electron/particle) oscillations / AW ✓ BUT Alternating currents/(electrical/electron/particle) oscillations produce (radio) waves/electromagnetic radiation ✓✓	2	2×1.1	
	(b)	(High voltage means) lower current ✓ Less heating/heat loss/power loss/energy wasted or more useful energy transmitted / ORA ✓	2	2×1.1	IGNORE no energy losses / prevent energy loss / AW ALLOW more efficient / (wires at) lower temperature
	(c)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 20 (A) award 5 marks Recall $I^2 = P / R$ ✓ 6.156 kW = 6156 W ✓ ($I^2 =$) 6156 / 15.39 OR ($I^2 =$) 400 ✓ ($I =$) $\sqrt{400}$ ✓ ($I =$) 20 (A) ✓	5	1.2 2.1 2.1 2.1 2.1	ALLOW correct equation in any form DO NOT ALLOW marks to be awarded from incorrect equation e.g. $I = P / R$ Award marks if 6.156kW has not been correctly converted to W E.g. ($I^2 =$) 0.4 or 6.156/15.39 ✓✓ ($I =$) $\sqrt{0.4}$ ✓✓✓ $I = 0.63$ ✓✓✓✓

16	(a)	(i)	variable resistor ✓	1	1.2	ALLOW rheostat IGNORE potentiometer
		(ii)	Control / change / vary / increase / decrease / AW the resistance / current in the circuit ✓	1	1.2	DO NOT ALLOW merely 'changes the voltage or changes p.d.' BUT ALLOW: changes the potential difference or voltage across (component) X
	(b)	(i)	(filament) bulb / lamp ✓	1	3.2a	
		(ii)	gradient / slope (of graph) changes (as potential difference / voltage changes) ✓ idea of increasing resistance (with more p.d.) / ORA ✓ idea of increasing temperature / AW ✓	3	3.1a 1.2 2.2	ALLOW 'graph / line / slope levels off' / non-linear Resistance increases with greater temperature ✓✓
	(c)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4 (V) award 2 marks 0.25 x 16 ✓ 4 (V) ✓	2	2.1 2.1	
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1 (W) award 3 marks P = IV ✓ P = 0.25 x 4 ✓ P = 1 (W) ✓ OR P = I ² R ✓ P = 0.25 ² x 16 ✓ P = 1 (W) ✓	3	1.2 2.1 2.1 1.2 2.1 2.1	ALLOW e.c.f. from part ci

17	(a)	Change the thickness of the cardboard (and repeat) ✓ Any 2 from: (Control variable) Same volume of water / same starting temperature of water ✓ Measure temperature with thermometer / time with stopwatch ✓ Calculate the rate using change in temperature / time ✓ Repeat results (and calculate the mean) ✓	3	3 × 3.3a	ALLOW use different boxes with different thicknesses / line the box with an insulator ALLOW same beaker / both beakers (don't) have a lid / same room temperature ALLOW a specified amount of water in the beaker / a specified starting temperature
	(b) (i)	5 or 4 points correctly plotted to within ½ small square ✓✓	2	2 × 2.2	3 or 2 correctly plotted points gains 1 mark IGNORE 'blobs' more than ½ square diameter
	(ii)	Smooth curved line of best fit through most points ✓	1	1.2	DO NOT ALLOW a straight line of best fit
	(iii)	Temperature decreases (with time) ✓ At a decreasing rate / by a smaller change in temperature for each increase in time ✓	2	2 × 3.1a	IGNORE non-linear relationship / positive/negative correlation ALLOW inverse proportion for this mark only ALLOW gradient decreases / temperature decreases more quickly at the start (than at the end) ALLOW use of data from the graph to show decreasing rate

Question	Answer	Marks	AO element	Guidance
(iv)	Line starts at 90°C and decreases but remains <u>above</u> their LOBF ✓	1	3.2b	IGNORE shape of the line but no mark for a horizontal line ALLOW 90 +/- 2 °C
(v)	Any one from: Repeat (and find a mean) / check reproducibility/repeatability ✓ Use smaller time intervals ✓ Use more precise timer/thermometer ✓	1	3.3b	ALLOW any sensible suggestion IGNORE a longer time / use more thicknesses ALLOW use equipment with higher resolution / data logger IGNORE better equipment unless qualified
(c)	Thermal conductivity of metal is higher (so rate of cooling is greater) / ORA ✓	1	3.2a	ALLOW metal is a (better thermal) conductor / ORA

20	(a)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.7 OR 70% award 3 marks (Efficiency =) useful energy output ÷ energy input ✓ (Efficiency =) $8400 \div 12000$ or 70 ✓ (Efficiency =) 0.7 ✓	3	1×1.2 2×2.1	ALLOW equation in any form ALLOW 70 (without % sign) for 2 marks ALLOW 0.7% for 2 marks
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 40 (W) award 3 marks (Power =) energy transferred ÷ time ✓ (Power =) $12000 \div 300$ ✓ (Power =) 40 (W) ✓	3	1×1.2 2×2.1	ALLOW 2400 (W) for 2 marks (no unit conversion) ALLOW equation in any form

Question	Answer	Marks	AO element	Guidance
20 (c)*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed explanation of how equipment is used to take appropriate measurements AND Detailed explanation of how the quantities are calculated. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Detailed explanation of how equipment is used to take appropriate measurements OR Detailed explanation of how the quantities are calculated OR Explanation of how equipment is used to take appropriate measurements AND explanation of how the quantities are calculated. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Simple explanation of how equipment is used to take appropriate measurements OR Simple explanation of how the quantities are calculated. OR correct equation stated.	6	2×1.2 $4 \times 3.3a$	AO3 – Analyses information to develop a method to calculate energy input and energy output - p.d./voltage measured with voltmeter - Current measured with ammeter - Mass of water measured with top-pan balance (allow weighing scales) or volume of water measured using measuring cylinder and density of water used - Temperature change measured using thermometer / temperature probe attached to data-logger - Heater used for a fixed time / AW measured with stopwatch - Keep temperature changes low / fully immerse immersion heater in water / do not touch hot immersion heater / insulate the beaker - Stopwatch used to measure time AO1 – Demonstrates knowledge of scientific ideas to work out energy input and energy output - Energy input = power (of heater) × time - Power (of heater) = current × p.d. - Energy input = $I \times V \times t$ - Energy increase in water = mass × SHC × temperature rise - Mass of water = density × volume

Question	Answer	Marks	AO element	Guidance
	<i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>			



21	(a)	(i)	(From) <u>Chemical</u> energy (store) ✓ (To) <u>Thermal</u> energy (store of the water in the kettle) ✓	2	2 × 2.1	ALLOW chemical energy store decreases ALLOW thermal energy store increases ALLOW heat / internal energy for thermal IGNORE sound/electrical energy IGNORE intermediate energy transfers/stores and any energy transfers/stores after thermal (store of the water)
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 138 000 (J) award 4 marks (Recall: energy transferred =) power × time ✓ (Power = 5.0 × 230 =) 1150 ✓ (Time = 2 × 60 =) 120 ✓ (Energy transferred =) 1150 × 120 = 138 000 (J) ✓	4	1.2 2.1 2.1 2.1	ALLOW equation in any form ALLOW ecf for incorrect power calculated ALLOW ecf for incorrect/no conversion of time

Question			Answer	Marks	AO element	Guidance
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 72 (%) award 5 marks Select from data sheet: change in thermal energy = mass × specific heat capacity × change in temperature (no mark) (change in thermal energy =) $1.2 \times 4200 \times 75$ ✓ (change in thermal energy =) 378 000 (J) ✓ (Recall: efficiency =) useful output energy transfer / input energy transfer OR (Efficiency =) $378\,000 / 525\,000$ ✓ (Efficiency =) 0.72 ✓ (Efficiency =) 72 (%) ✓	5	1.2 2.1 1.2 2.1 1.2	ALLOW ecf for incorrect thermal energy calculated ALLOW 4 marks for answer of 0.72 (%)
	(b)	(ii)	some energy is transferred to the (thermal energy store of the) kettle/surroundings/air ✓	1	2.1	IGNORE sound
	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.9 (A) award 2 marks (Rearrangement: $I_p = I_s \times V_s / V_p$) ✓ OR ($I_p =$) $12 \times 9.0 / 120$ ✓ ($I_p =$) 0.9 (A) ✓	2	1.2 2.1	

23	(a)	(i)	First check the answer on answer line If answer = 28 500 (J) award 2 marks ($E = mc\theta$) $E = 0.50 \times 1900 \times 30$ ✓ $E = 28\,500$ (J) ✓	2	2.1 2.1	ALLOW 29 000 J (rounded to 2 significant figures) ALLOW 28.5 kJ
		(ii)	First check the answer on answer line If answer = 95 (W) award 3 marks $P = E \div t$ ✓ $P = 28\,500 \div (5 \times 60)$ ✓ $P = 95$ (W) ✓	3	1.2 2.1 2.1	ALLOW 23(a)(i) divided by 5 for 2 marks ALLOW 23(a)(i) divided by 300 for 3 marks ALLOW ECF from 23(a)(i) ALLOW 5700 (W) for 2 marks (no unit conversion)
		(iii)	Containers of vaccines / other contents of the freezer need to be cooled ✓ Energy / heat dissipated / transferred to surroundings / environment or energy heat dissipated in motor / compressor ✓	2	2 x 3.2a	IGNORE not 100% efficient
	(b)	(i)	Any two from: Energy is needed to change the state of a material ✓ Energy is needed to break / weaken the bonds (between molecules / particles) or overcome attractive forces (between solid (vaccine) molecules) ✓ Some heat transfer with the surroundings / container ✓	2	2 x 1.2	ALLOW ideas about energy needed to increase separation of molecules
		(ii)	First check the answer on answer line If answer = 4000 (doses) award 6 marks $m = E \div L$ ✓ $m = 6800 \div 340000$ ✓ $m = 0.02$ kg ✓ 0.02 kg = 20 000 mg ✓ (number of doses =) $0.02 \div 5 \times 10^{-6}$ OR $20\,000 \div 5$ ✓ (number of doses =) 4000 ✓ Or 5 mg = 5×10^{-6} kg ✓ energy of one dose 5 (mg) $\times 340000$ ✓✓ energy of one does = 1.7 J ✓ (number of doses =) $6800 \div 1.7$ ✓ (number of doses =) 4000 ✓	6	1.2 2.1 2.1 1.2 2.1 3.1b	Rearrangement of the equation ALLOW $0.02 \div 5 \times 10^n$ (missing or incorrect conversion from mg to kg) for 4 marks ALLOW 4×10^n doses for 5 marks ALLOW $5 \times 10^n \times 340000$ for 2 marks ALLOW 1.7×10^n (power of ten error) for 3 marks ALLOW 4×10^n doses for 5 marks

23	(a)	(i)	48°C	1	3.2a	
		(ii)	12°C	1	3.2a	
		(iii)	First check the answer on the answer line If answer = 27,000 (J) award 4 marks $(E = mc\theta)$ 200 g = 0.2(00) kg ✓ $\theta = 48 - 12 = 36^\circ\text{C}$ ✓ $E = 0.2 \times 3750 \times (48 - 12)$ ✓ $E = 27,000 / 2.7 \times 10^4$ ✓	4	1.2 1.2 2.2 2.2	ALLOW 27 kJ for full marks ALLOW ECF from (a)(i) and (a)(ii) IGNORE -ve sign ALLOW 3 marks for $E = 2.7 \times 10^7$ J (did not convert g to kg)
	(b)	(i)	First check the answer on the answer line If answer = 150 (W) award 4 marks $(E = Pt)$ $P = E / t$ ✓ $E = 54 \times 1000 = 54000$ J ✓ $P = 54000 / 360$ ✓ $P = 150$ (W) ✓	4	1.2 1.2 2.1 2.1	 ALLOW 1.5 x 10 ⁿ for 3 marks (no or incorrect conversion of kJ)
		(ii)	Any one from: Not 100% efficient / AW ✓ Energy is <u>gained</u> from the surroundings ✓ There is not enough insulation of the fridge ✓	1	3.2a	IGNORE energy is lost to surroundings (unless clearly related to the efficiency of the motor) ALLOW cooling fridge / other contents

Question			Answer	Marks	AO element	Guidance
	(c)		First check the answer on the answer line If answer = 17 (Ω) award 4 marks $P = I^2 R$ ✓ $(I =) \sqrt{(240 / 0.80)}$ ✓ $I = 17.32 \text{ (A)}$ ✓ $I = 17 \text{ (A)}$ ✓ (2 sig fig)	4		1.2 ALLOW equation in any form 2.1 ALLOW substitution into unrearranged equation for this mark 2.1 ALLOW any number of significant figures for this mark 1.2 ALLOW an incorrectly <u>calculated</u> value to 2 sig figs if working shown IGNORE unqualified 2 sig fig ALLOW 300 (A) for 2 marks (check correct equation used)



21	(a)	(i)	1 Not enough wind/force/energy/speed to turn the turbine ✓ 2 (Speed too high so) could damage the turbine / turbine is shut down to stop damage/for safety reasons ✓	2	2 × 3.2a	ALLOW turbine does not turn ALLOW idea of (the turbine/it) being damaged/broken
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4.3 (MJ) award 5 marks (Useful output energy transfer per second =) 1.5 (MJ) ✓ Efficiency = Useful output energy transfer ÷ Input energy transfer ✓ (Input energy transfer =) $1.5 \div 0.35$ ✓ (Input energy transfer =) 4.2857... ✓ (Input energy transfer =) 4.3 (MJ) ✓	5	2.2 1.2 2 × 2.1 1.2	ALLOW equation in any form ALLOW 4.2857... × 10 ⁶ or 4.3 × 10 ⁶ for 4 marks ALLOW an incorrect answer rounded to 2 sig. fig. for this mark
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 7.7×10^{17} (J) award 2 marks 215 (TWh) from graph ✓ ($215 \times 3.6 \times 10^{15}$ =) 7.7×10^{17} (J) ✓	2	2 × 1.2	ALLOW 210 – 220 (TWh) from graph ALLOW 1 mark for any correct conversion into J e.g. $210 \times 3.6 \times 10^{15} = 7.6 \times 10^{17}$ (J) $220 \times 3.6 \times 10^{15} = 7.9 \times 10^{17}$ (J) IGNORE answer not in standard form

Question			Answer	Marks	AO element	Guidance
21	(b)	(ii)	Any two from: More wind turbines have been built ✓ Modern turbines have a better design / are more efficient ✓ (wind turbines) do not produce air pollution/harmful gases/ carbon dioxide/greenhouse gases / do not contribute to global warming/greenhouse effect/climate change ✓ (idea that wind turbines) conserve/reduce use of fossil fuels ✓ (Idea of) renewable energy ✓ (wind turbines) have low fuel/running costs once set up ✓	2	2 × 1.1	IGNORE increased demand ALLOW better technology IGNORE no pollution / better for the environment unless qualified IGNORE sustainable ALLOW reduce use of finite resources / fossil fuels are running out ALLOW high cost of fossil fuels
	(c)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 70 (A) award 2 marks Rearrangement: Current in secondary coil = current in primary coil × potential difference across primary coil ÷ potential difference across secondary coil OR $2800 \times 900 \div 36000$ ✓ (Current in secondary coil =) 70 (A) ✓	2	2 × 2.1	ALLOW rearranged equation in symbols or numbers

Question			Answer	Marks	AO element	Guidance
21	(c)	(ii)	Any three from: It is a <u>step-up</u> transformer / to increase p.d. ✓ Decrease current (in power lines) ✓ less energy wasted/lost / less heat in power lines / less thermal transfer ✓ (idea that) power loss depends on current² ✓	3	3 × 1.1	ALLOW voltage ALLOW ORA for high current IGNORE just ideas about efficiency DO NOT ALLOW so no power wasted / no energy wasted (as heat in power lines) / no thermal transfer IGNORE less power loss
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.25 (Ω) award 3 marks Rearrangement: resistance = power ÷ (current)² ✓ (Resistance =) 864 900 ÷ 1860² or 864 900 ÷ 3 459 600 ✓ (Resistance =) 0.25 (Ω) ✓	3	1 × 1.2 2 × 2.1	Allow ¼ (Ω)