Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 3

Concepts in Physics

HIGHER TIER

SAMPLE PAPER

(1 hour 45 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**8**	
3.	**9**	
4.	**9**	
5.	**7**	
6.	**10**	
7.	**11**	
8.	**9**	
9.	**4**	
10.	**11**	
11.	**6**	
Total	**90**	

ADDITIONAL MATERIALS
In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer all questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **11**.

EQUATION LIST

final velocity = initial velocity + acceleration × time	$v = u + at$
distance = ½ (initial velocity + final velocity) × time	$x = \frac{1}{2}(u + v)t$
(final velocity)^2 = (initial velocity)^2 + 2 × acceleration × distance	$v^2 = u^2 + 2ax$
distance = initial velocity × time + ½ × acceleration × time^2	$x = ut + \frac{1}{2}at^2$
change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta Q = mc\Delta\theta$
thermal energy for a change of state = mass × specific latent heat	$Q = mL$
energy transferred in stretching = 0.5 × spring constant × (extension)^2	$E = \frac{1}{2}kx^2$
force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength × current × length	$F = BIl$
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in second coil	$V_1I_1 = V_2I_2$

Answer **all** *questions*.

1. (a) The time it takes to accelerate from 0 to 60 mph (i.e. 0 to 27 m/s) is a commonly used performance measure for cars. A car is advertised to accelerate from stationary (0 m/s) to a velocity of 27 m/s in 6.5 seconds.

Select a suitable equation from page 2 and use it to calculate its acceleration in that time. [4]

acceleration …………………… m/s^2

(b) Explain in terms of kinetic energy why reducing the speed limit on roads makes the risk of accidents less. [2]

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2. Four competitors in a weightlifting competition have to lift a weight above their heads.

Their best lifts are displayed in the table below.

Weightlifter	Mass lifted (kg)	Force needed (N)	Distance lifted (m)	Work done (J)
A	68	680	2.4	1 632
B	72	……	2.3	1 656
C	74	740	2.4	……….
D	80	800	2.0	1 600

(a) **Complete** the table. [2]

(b) (i) Weightlifter **D** is the winner of the competition as he lifted the largest mass.
Using information from the table explain why he does the least amount of work. [2]

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(ii) Weightlifter **D** lifts the weight in a time of 5 seconds.
Calculate the mean power for his lift. [2]

mean power = ... W

(iii) All four weightlifters lift their maximum weight in 5 seconds.
State and explain which weightlifter uses the least amount of energy per second. [2]

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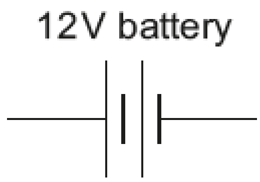
8

3. Students are given this information to set up a circuit in their physics lesson.
A 2 Ω resistor, a 4 Ω resistor and an ammeter are connected in series with a 12 V battery.

(a) Using the correct symbols complete the circuit diagram. [3]



(b) (i) Calculate the **total resistance** in the circuit. [1]

total resistance = ... Ω

(ii) Calculate the reading on the ammeter. [3]

ammeter reading .... A

(iii) Both of the resistors get hot. Power depends both on the current and resistance. Explain which of the two resistors in this circuit will get hotter. [2]

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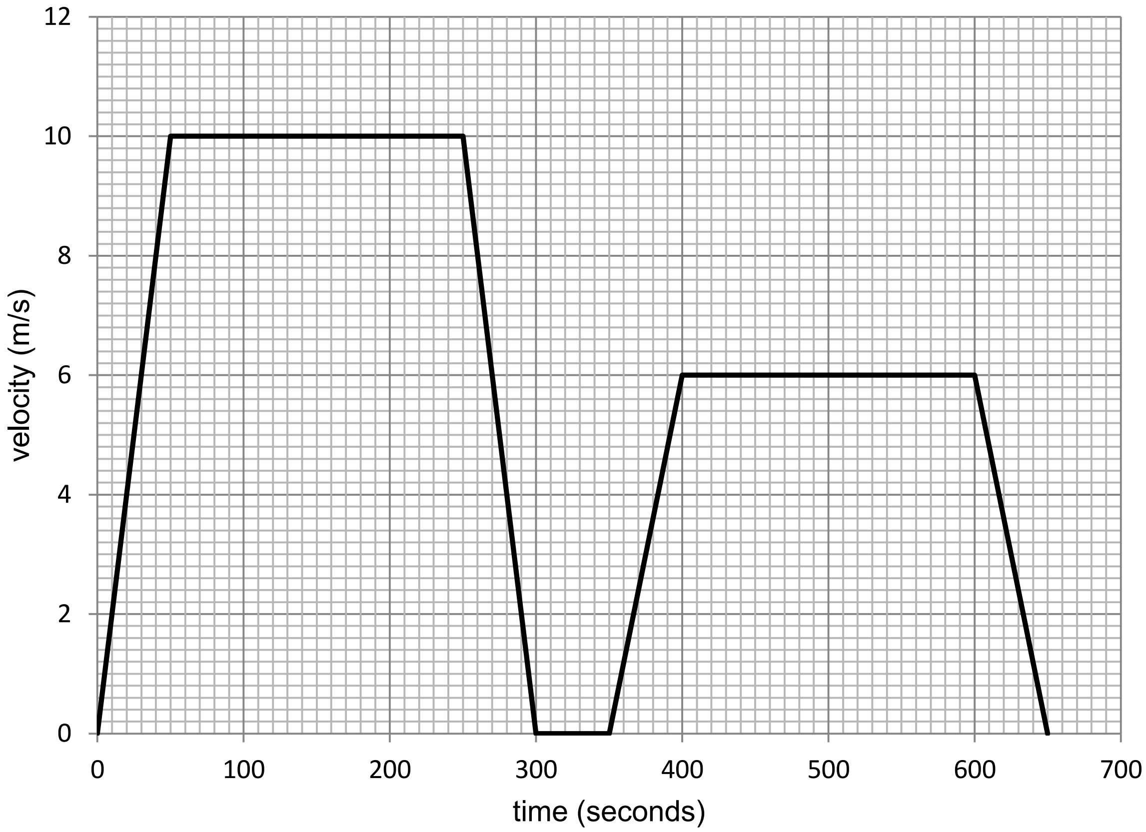
4. A student cycles from school to her home. The graph represents her whole journey. She has to stop during her journey at a pedestrian crossing.



(a) (i) Calculate the change in velocity as she approaches and stops at the pedestrian crossing. [1]

change in velocity .... m/s

(ii) Calculate the student's deceleration when she is approaching the crossing. [3]

deceleration = ... m/s^2

(b) The student and her bike have a total mass of 55 kg. Calculate the resultant force acting on the student and her bike as she decelerates to the crossing. [3]

resultant force = ... N

(c) Explain how the graph shows that the cyclist's mean velocity for the part of her journey before stopping at the pedestrian crossing is greater than for the part of her journey after stopping. [2]

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5. The game of squash uses a small hollow rubber ball. One measure of the bounciness of a squash ball is the coefficient of restitution, *e*.

$$e = \frac{\text{velocity after bounce}}{\text{velocity before bounce}}$$

For a ball dropped on to a surface, the coefficient of restitution can also be calculated using:

$$e = \frac{\sqrt{(\text{height from which the ball is dropped})}}{\sqrt{(\text{height to which the ball bounces})}}$$

Jacob is a keen squash player. He used the procedure below to measure the coefficient of restitution of a squash ball.

Procedure

1. Place a squash ball into the water bath set to 15°C so it is completely submerged and leave for 5 minutes.
2. Set up the metre ruler so one end is on the floor using the clamp and stand to support it.
3. Use the tongs to remove the squash ball.
4. Drop the ball from level with the top of the metre ruler and watch carefully to record the height to which it bounces.
5. Increase the temperature of the water bath by 10° and repeat steps 1 to 4 .

(a) Suggest **two** ways in which Jacob could change the procedure to improve the reliability of his results. [2]

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(b) Jacob's results are shown below.

Temperature of ball (°C)	Height dropped from (m)	Height ball bounced to (m)	Coefficient of restitution
15	1.00	0.15	0.38729
25	1.00	0.20	0.4472
35	1.00	0.30	0.5477
45	1.00	0.35	0.5916

Comment on the number of significant figures he used to record the coefficient of restitution. [1]

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(c) Jacob knows from experience that the ball gets faster as a game progresses and he uses this to his advantage when playing less experienced players. Use the data from the experiment to help explain his observation. [4]

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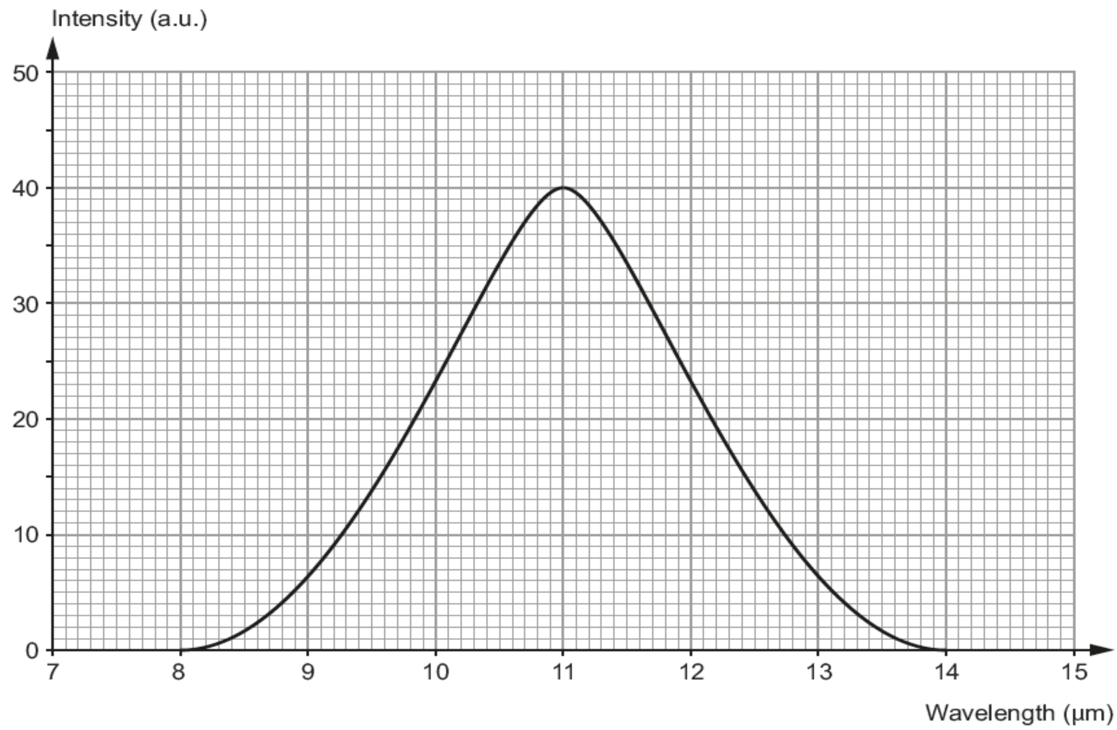
6. Explosions on the surface of the Sun happen frequently. After an explosion a pulse of electromagnetic waves (em waves) immediately followed by a stream of charged particles is radiated out into space.

(a) The em pulse takes 500 seconds to travel from the Sun to the surface of the Earth. The stream of charged particles travels at a speed of 3.2×10^6 m/s. Calculate how long it take for the charged particles to arrive at Earth. (speed of light, $c = 3 \times 10^8$ m/s) [4]

time = ……………….. s

(b) The pulse of em waves emitted from the Sun is shown on the graph below.



The wavelength range of different parts of the electromagnetic spectrum is shown below.

Electromagnetic radiation	**Wavelength (nm)**
gamma radiation	$<10^{-3}$
X-rays	1 - 0.001
ultraviolet	400 - 1
visible	750 - 400
infra-red	2 500 - 750
microwave	10^{6} – 2 500
radio waves	$>10^{6}$

1×10^{6} μm = 1 m
1×10^{9} nm = 1 m

(i) State from which part of the electromagnetic spectrum the wavelength of the most intense part of the pulse is found. [1]

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(ii) An em wave sensor based on Earth is used as an early warning system. It can only detect em waves in the frequency range 1.2×10^{7} Hz to 6.0×10^{9} Hz.
Determine if the most intense part of the em pulse would be detected by the sensor. [3]
Speed of light, $c = 3 \times 10^{8}$ m/s

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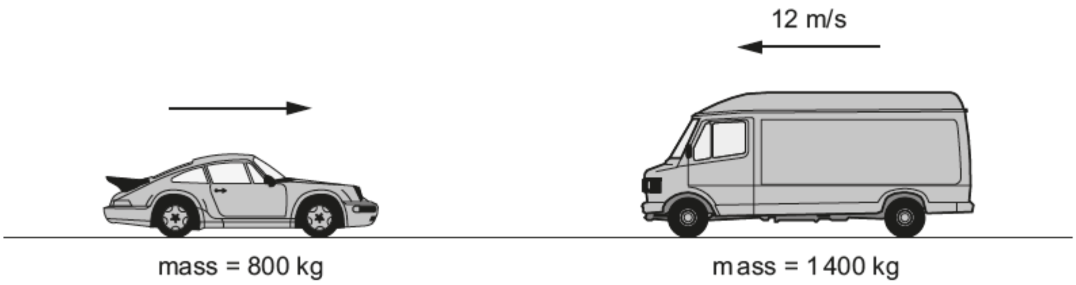
(c) A series of nuclear reactions occur in the Sun leading to the formation of new elements. One step involves helium-7 ($^{7}_{2}\mathrm{He}$) which decays emitting both gamma radiation and beta particles.
Complete the following equation to show the decay of the helium-7 nucleus. [2]

$$^{7}_{2}\mathrm{He} \rightarrow \,^{\cdots}_{\cdots}\beta + \,^{\cdots}_{\cdots}\mathrm{Li}$$

10

7. (a) CCTV (closed-circuit television) recorded a head-on crash between a car and van. The film showed that the vehicles came to an immediate stop when they collided. The tachometer (onboard computer) of the van reads a speed of 12 m/s at the point of impact.



(a) (i) Calculate the momentum of the van before the collision. [2]

momentum = ... kg m/s

(ii) State the principle of conservation of momentum. [2]

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(iii) Use the principle of conservation of momentum to find the speed of the car just before the collision. [2]

speed = ……………… m/s

(iv) The speed limit on the road is 30 miles per hour (30 mph). The car driver claims to have been driving below the speed limit.
Explain whether the statement made by the driver is consistent with the evidence from the CCTV.
2 mph is equivalent to 0.90 m/s. [2]

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(b) The front of the car is designed to crumple in a head-on collision. Using the concept of momentum, explain why a crumple zone should reduce passenger injury in this type of crash. [3]

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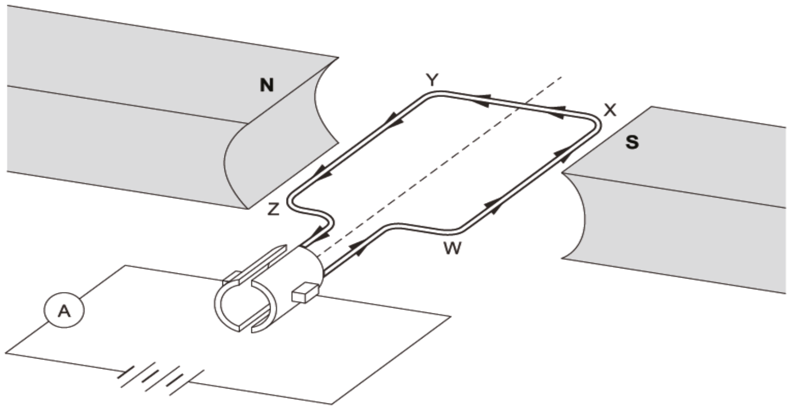
8. The diagram represents a simple electric motor that a pupil investigates in their lesson.
The current in the coil flows from **W** to **Z**. This is shown on the diagram.
An ammeter is used to measure the current through the coil.



(a) Use the diagram to explain how you can determine the direction in which the coil rotates. [3]

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(b) The pupil would like the motor coil to rotate in the opposite direction. Give **two** different ways that could make this happen. [2]

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(c) The length of **YZ** is 0.12 m and the magnetic field strength is 5 mT. Select an equation from page 2, to calculate the reading on the ammeter if the force is 2.4×10^{-3} N. [2]

ammeter reading .... A

(d) Explain what the effect would be on the coil if the current supplied were doubled and the magnetic field strength halved. [2]

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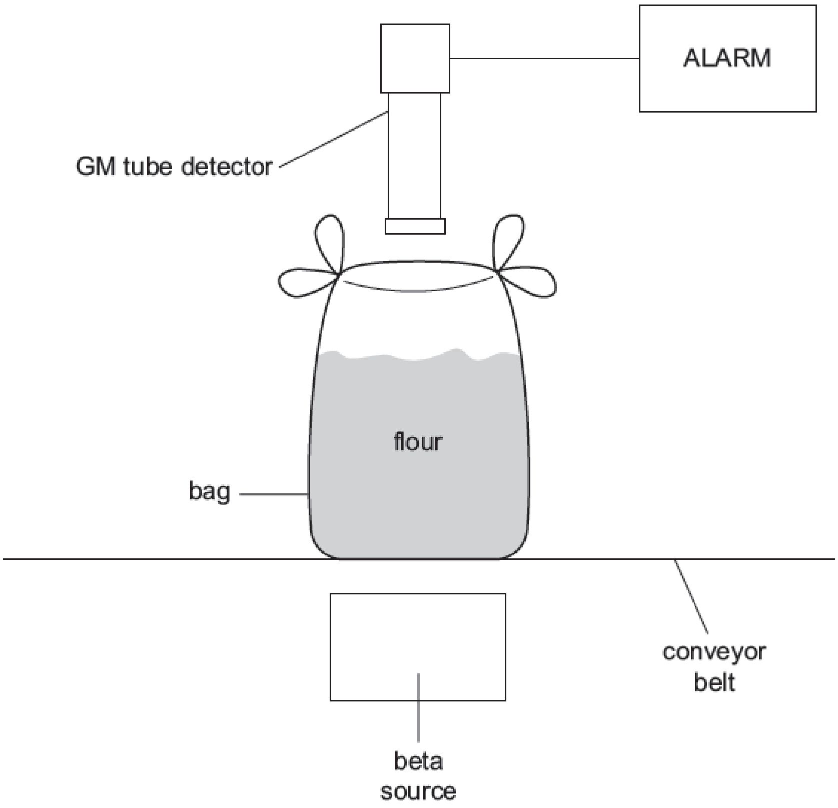
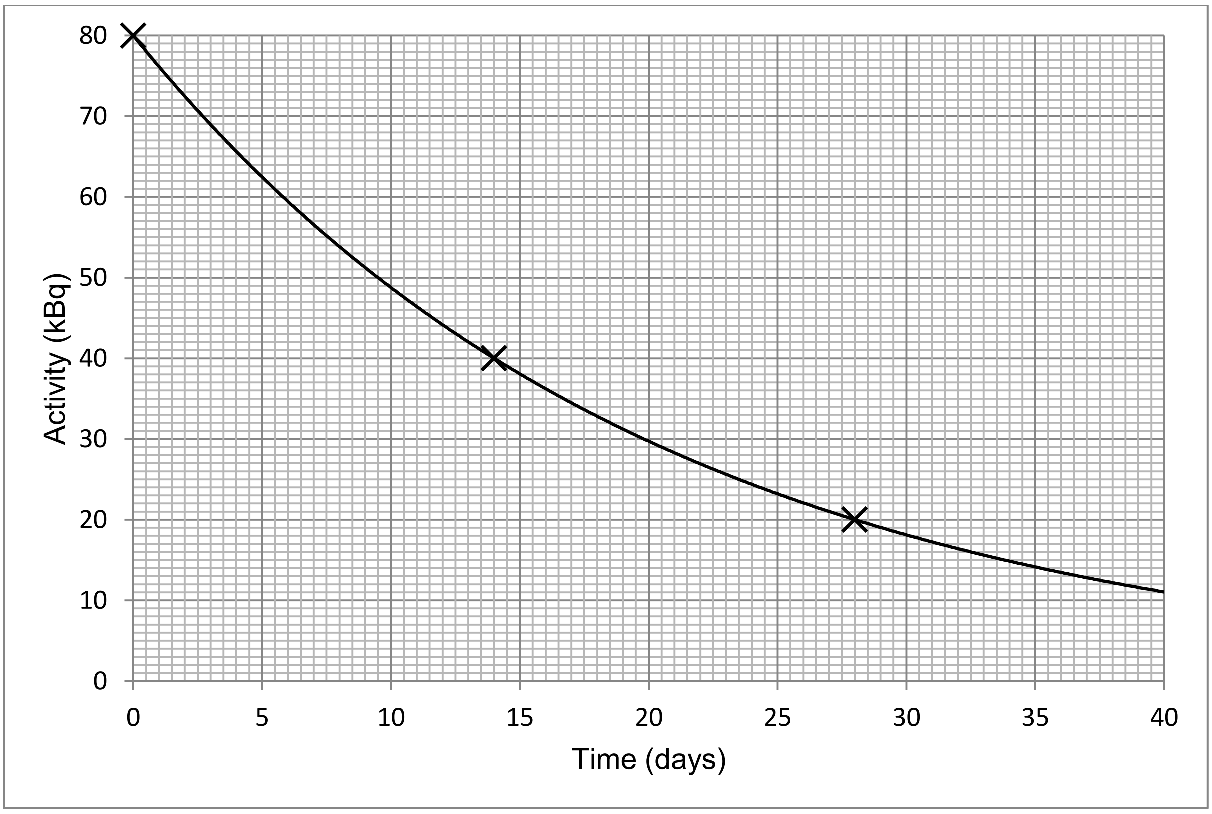
9. Bags of flour move along a conveyor belt in a factory. A radioactive beta (β) source is used to monitor the amount of flour contained. If the count rate from the GM tube drops below a certain level, then the bag is too full and an alarm sounds.



The company who sell the radioactive source to the factory also supply them with a graph of information about the beta (β) radioisotope.



(a) The factory is advised to replace their radioactive source after 6 half-lives. Using data from the graph, calculate the maximum number of days the source can be used before it needs to be replaced. [2]

maximum number of days = ……………….

(b) The source currently being used was bought with an activity of 960 kBq. When tested it was found to have an activity of only 14 kBq. Use this information to explain any action the factory needs to take, if any, to improve testing. [2]

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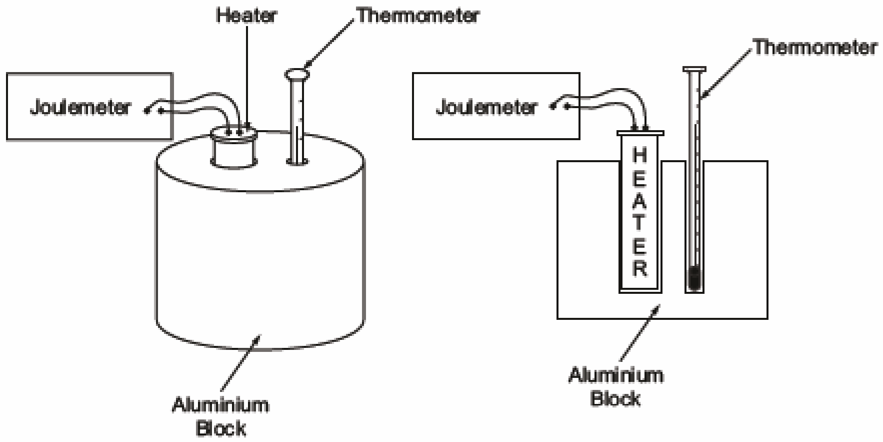
10. This apparatus was used by a pupil to determine the specific heat capacity of an aluminium block.



(a) State why a small amount of oil is placed in the two holes that contain the thermometer and heater. [1]

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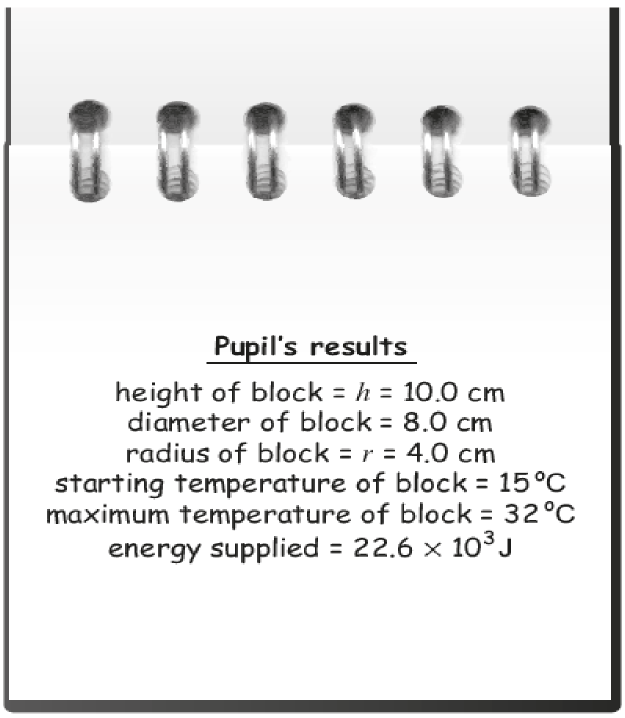
(b) The digital balance is broken so the mass of the block can't be directly measured. A pupil measures the diameter and height of the block with a ruler. Their teacher tells them that the density of aluminium is 2.7 g/cm^3.



(i) Calculate the mass of the block, in kg. [5]
(Use the equation $V = \pi r^2 h$ for the volume)

mass = ... kg

(ii) Using an appropriate equation from page 2 and some of the data from the pupil's results, calculate a value for the specific heat capacity of aluminium. [3]

specific heat capacity = ... J/kg °C

(c) The aluminium block is not wrapped in any insulation. Explain how this affects the value of the specific heat capacity calculated for this experiment. [2]

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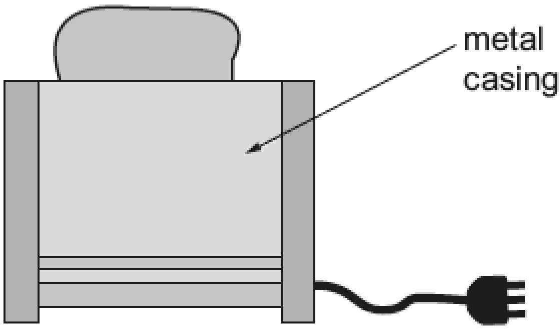
11

11. A **metal cased** toaster has a power rating of 1.6 kW and operates on mains voltage, 230 V a.c. Describe the key electrical safety features in the design of the toaster and explain how they work and why they are necessary.
Use a calculation to support your answer. [6 QER]



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