

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel Level 1/Level 2 GCSE (9–1)

Thursday 25 May 2023

Morning (Time: 1 hour 45 minutes)

Paper reference **1PH0/1H**

Physics

PAPER 1

Higher Tier

You must have:
Calculator, ruler, Equation Booklet (enclosed)

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- A list of equations is included at the end of this exam paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

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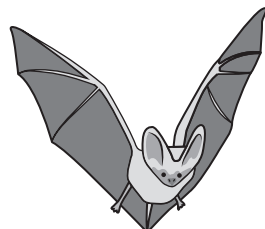
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Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

- 1 Figure 1 shows a bat and its prey.



bat



prey

not to scale

Figure 1

The bat emits a high frequency sound pulse to locate its prey.

The speed of sound in air is 330 m/s.

- (a) The wavelength of the sound is 11 mm.

Calculate the frequency of the sound.

(2)

Use the equation

$$v = f \times \lambda$$

frequency = Hz

- (b) The pulse returns to the bat after a time of 18 ms.

Calculate the distance from the bat to its prey.

(4)

distance = m

(Total for Question 1 = 6 marks)



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2 (a) Which of these is a scalar quantity?

(1)

- ☐ **A** acceleration
- ☐ **B** distance
- ☐ **C** force
- ☐ **D** weight

(b) A student has some cupcake cases.

One cupcake case is shown in Figure 2.



(Source: © Anton Starikov/Shutterstock)

Figure 2

The student drops a stack of cupcake cases with the base facing downwards, as shown in Figure 3.



(Source: © Elena Schweitzer/Shutterstock)

Figure 3

The speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

- (i) The student also has a stop clock and a metre rule.

Describe an investigation to show how the speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

(4)

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- (ii) A stack of cupcake cases has a mass of 0.005 kg.

Calculate the weight, in newtons, of the stack of cupcake cases.

Gravitational field strength = 10 N/kg

(2)

Use the equation

$$W = mg$$

weight = N



Figure 4 shows a cupcake case that is falling at a constant velocity.

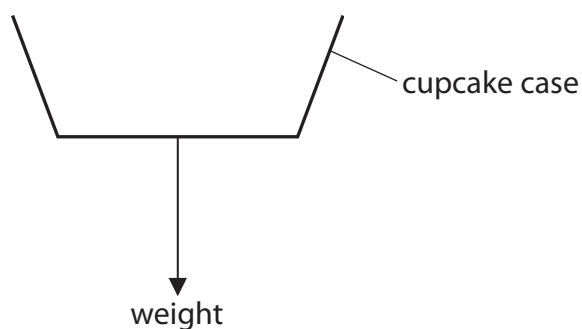


Figure 4

- (iii) Draw an arrow on Figure 4 to show the force due to air resistance on the cupcake case. (1)
- (iv) State the value of the acceleration of the cupcake case when it is falling at a constant velocity. (1)

(Total for Question 2 = 9 marks)

- 3 (a) Figure 5 shows a football kicked against a wall.

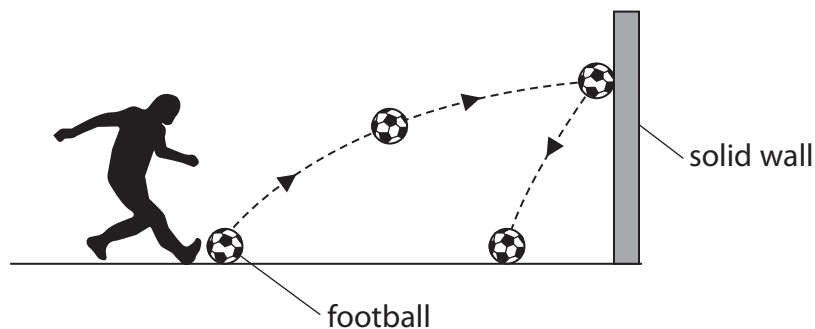


Figure 5

The football has a mass of 0.42 kg.

- (i) The football gains 11 J of gravitational potential energy as it moves from the ground to the wall.

Calculate the height at which the ball hits the wall.

(3)

Gravitational field strength = 10 N/kg

Use the equation

$$\Delta GPE = m \times g \times \Delta h$$

height = m

- (ii) Calculate the kinetic energy of the football when it is moving at a velocity of 12 m/s.

(2)

Use the equation

$$KE = \frac{1}{2} \times m \times v^2$$

kinetic energy = J

(iii) Describe the energy transfers that happen when the ball hits the wall.

(2)

(b) A stone is held at rest above the ground.

The stone is released and falls until its velocity is 17 m/s .

Calculate the distance the stone has fallen when its velocity has reached 17 m/s .

(2)

distance = m

(Total for Question 3 = 9 marks)



- 4 (a) Figure 6 shows two objects, **E** and **D**.

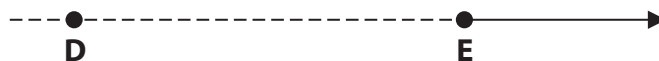


Figure 6

E emits a sound.

D detects the sound.

E is moving in the direction shown by the arrow, but **D** is not moving.

E emits a sound of wavelength 1.86 m.

D measures the wavelength of this sound as 1.98 m.

- (i) Calculate the difference between the wavelength that **E** emits and the wavelength that **D** detects.

(1)

difference in wavelength = m

- (ii) The velocity of sound is 330 m/s.

Calculate the velocity of **E**.

(2)

Use the equation

$$\text{velocity of } \mathbf{E} = \frac{\text{velocity of sound} \times \text{difference in wavelength}}{\text{wavelength } \mathbf{E} \text{ emits}}$$

velocity of **E** = m/s



- (b) The wavelength of light emitted from distant galaxies is different when the light is detected on Earth.

Explain how this difference in wavelength shows that the Universe is expanding.

(2)

- (c) CMB radiation provides evidence that the Universe had a definite beginning.

Use the table in Figure 7 to give a typical value for the wavelength of CMB radiation.

type of radiation	typical wavelength
gamma rays	$1.0 \times 10^{-12} \text{ m}$
X-rays	$3.0 \times 10^{-11} \text{ m}$
ultraviolet	200 nm
visible	600 nm
infrared	$4.0 \mu\text{m}$
microwaves	1.0 mm
radio waves	50 m

Figure 7

(2)

wavelength =

- (d) During the evolution of a star, the nebula collapses and becomes a main sequence star.

(i) State what causes the nebula to collapse.

(1)



(ii) Explain why the nebula stops collapsing as it becomes a main sequence star.

(3)

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(Total for Question 4 = 11 marks)



5 Figure 8 is a velocity/time graph for a lift moving upwards in a tall building.

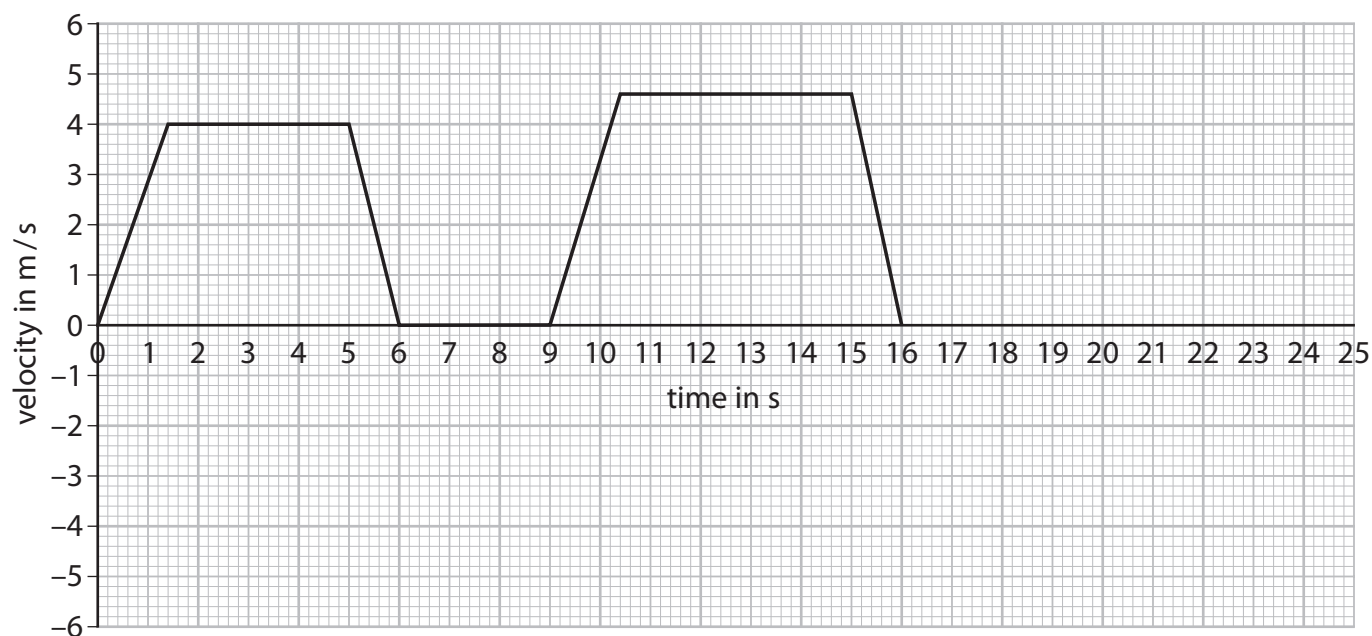


Figure 8

(a) For what length of time is the lift at rest during the first 16 s?

(1)

- ☐ **A** 1.4 s
- ☐ **B** 3.0 s
- ☐ **C** 3.6 s
- ☐ **D** 4.0 s

(b) Use the graph in Figure 8 to determine the maximum velocity of the lift during the first 16 s.

(1)

maximum velocity = m/s

(c) Use the graph in Figure 8 to determine the acceleration of the lift during the first 1.4 s.

(3)

acceleration = m/s²



- (d) Use the graph in Figure 8 to determine the distance that the lift travelled during the first 6.0 s.

(3)

distance = m

- (e) At 18 s, the lift starts to move downwards.

Sketch a line on the graph in Figure 8 to show the lift moving downwards after 18 s.

(1)

(Total for Question 5 = 9 marks)



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- 6 (a) Figure 9 shows two technicians, L and M, measuring the speed of sound in air.

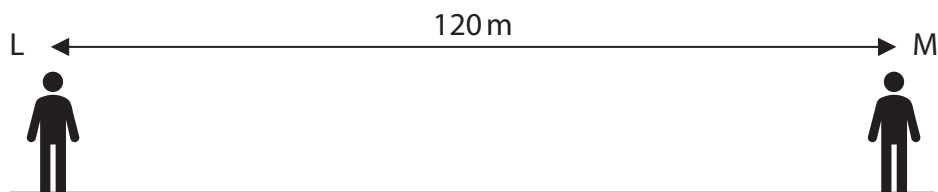


Figure 9

L fires a starting pistol.

M starts a stopwatch when first seeing the smoke from the starting pistol.

M stops the stopwatch when hearing the bang made by the starting pistol.

The distance between L and M is 120 m.

M's reaction time is 0.23 s.

The speed of sound in air is 330 m/s.

- (i) Calculate M's reaction time as a percentage of the time sound takes to travel from L to M.

(3)

.....%

- (ii) Which of these would improve the technicians' measurement of the speed of sound?

(1)

- ☐ A Use a firework 'banger' instead of the starting pistol.
- ☐ B Use a stop clock that measures time in minutes.
- ☐ C Increase the distance between L and M.
- ☐ D Decrease the distance between L and M.

- (b) Figure 10 shows the difference in refraction of sound waves and light waves when these waves travel from air into water.

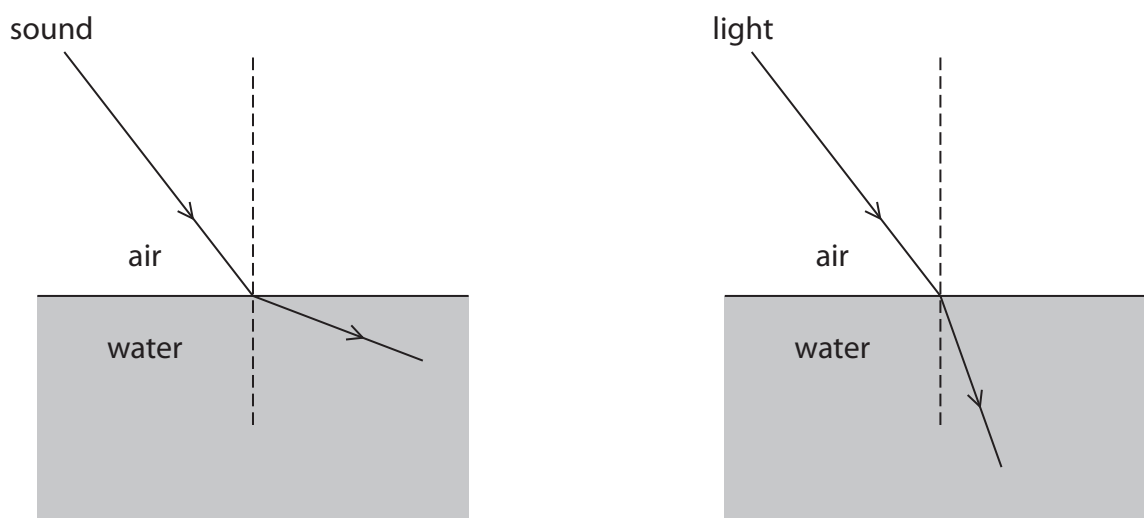


Figure 10

Explain why the refraction of the sound wave is different from the refraction of the light wave in Figure 10.

(3)

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(c) Light is one example of an electromagnetic wave.

Light can transfer energy from a lamp to the leaf of a plant, causing chemical reactions in the leaf.

Describe examples of **two** other electromagnetic waves transferring energy.

(4)

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(Total for Question 6 = 11 marks)

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- 7 (a) Figure 11 is the symbol for a nucleus of americium-241.



Figure 11

Americium-241 is a radioactive isotope of americium.

Americium-241 decays by emitting alpha (α) particles.

- (i) Which of these is the symbol for another radioactive isotope of americium?

(1)

☐ **A** ${}_{97}^{241}\text{Am}$

☐ **B** ${}_{96}^{243}\text{Am}$

☐ **C** ${}_{95}^{245}\text{Am}$

☐ **D** ${}_{94}^{247}\text{Am}$

- (ii) Which of these is the approximate maximum distance that alpha particles can travel in air at normal atmospheric pressure?

(1)

☐ **A** 5 mm

☐ **B** 5 cm

☐ **C** 5 m

☐ **D** 5 km

- (iii) Complete the equation in Figure 12 for americium-241 decaying into neptunium (Np).

(3)



Figure 12



(b) The activity of a radioactive source is measured as 128 Bq.

This is shown as a point on the graph in Figure 13.

(3)

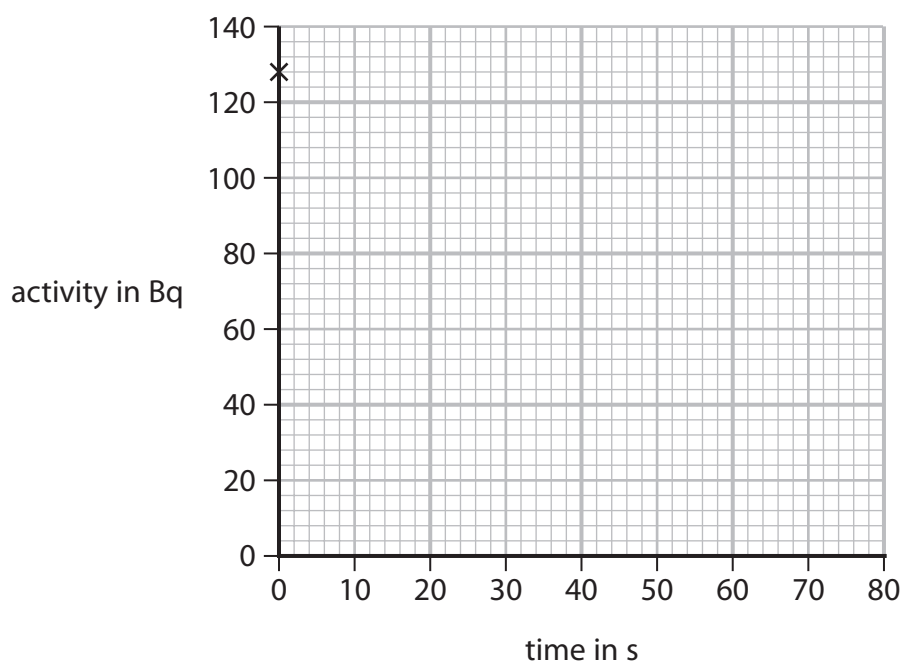


Figure 13

The half-life of this radioactive source is 17 s.

Use this information to plot three more points on the graph grid in Figure 13 to show how the activity of the source changes with time.

(c) Describe what happens in the nucleus of an atom when a positron is emitted.

(2)

(Total for Question 7 = 10 marks)

- 8 (a) A student does an experiment to determine the critical angle for glass.

The student shines a ray of light into a semicircular glass block and measures the angles i and r , as shown in Figure 14.

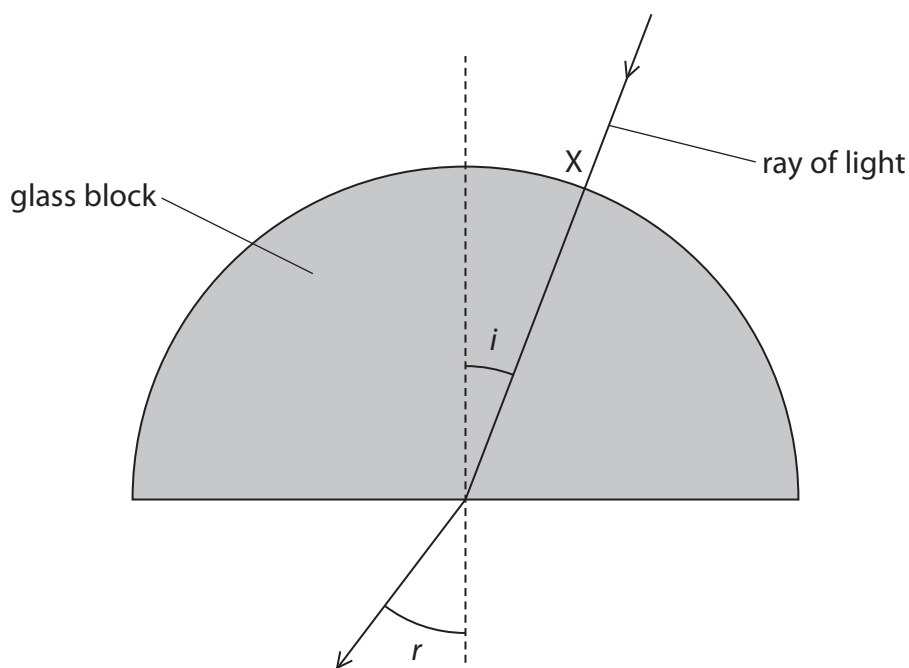


Figure 14

- (i) The ray of light does not change direction when it enters the glass block at point X.

Which of these **explains** why the ray of light does not change direction when it enters the glass block at point X.

(1)

- ☐ A The ray enters along a normal to the edge of the block.
- ☐ B The ray enters at right angles to a normal to the edge of the block.
- ☐ C The ray speeds up as it enters the glass.
- ☐ D The ray slows down as it enters the glass.

(ii) The student repeats the procedure for different values of angle i .

Figure 15 is a graph of the student's results.

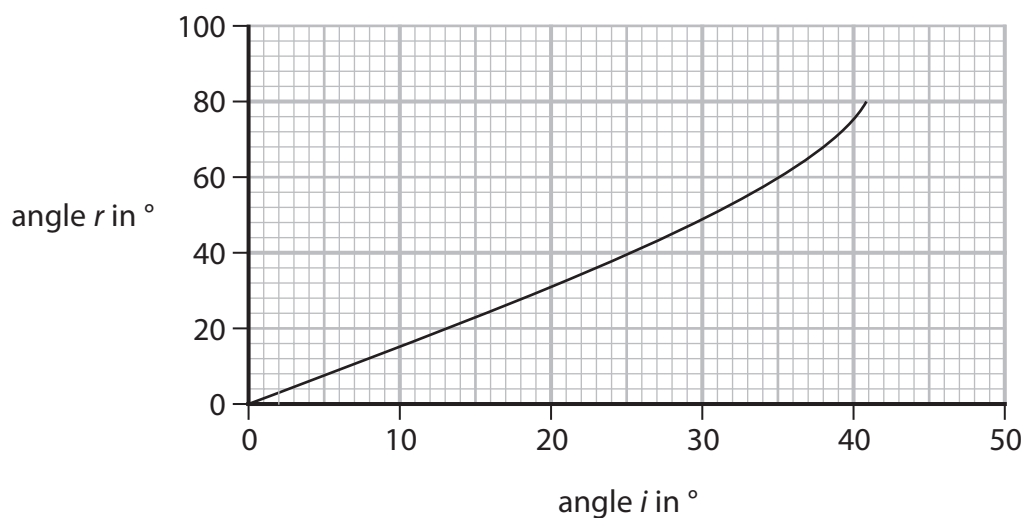


Figure 15

Describe how the student should use the graph in Figure 15 to determine the critical angle for glass.

(3)

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- (b) Figure 16 shows two iron spheres, **P** and **Q**, near to a radiant heater. **P** is painted black and **Q** is painted white.

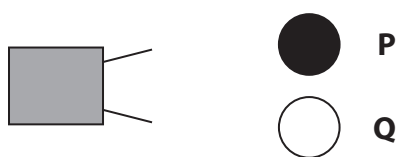


Figure 16

Each sphere is the same distance away from the heater.

The spheres have the same radius.

The heater is switched on and the spheres heat up.

The temperature of each sphere is monitored.

- (i) Explain why the temperature of sphere **P** increases at a faster rate than the temperature of sphere **Q**.

(2)

- (ii) The heater remains switched on.

Figure 17 shows how the temperature of sphere **P** changes with time.

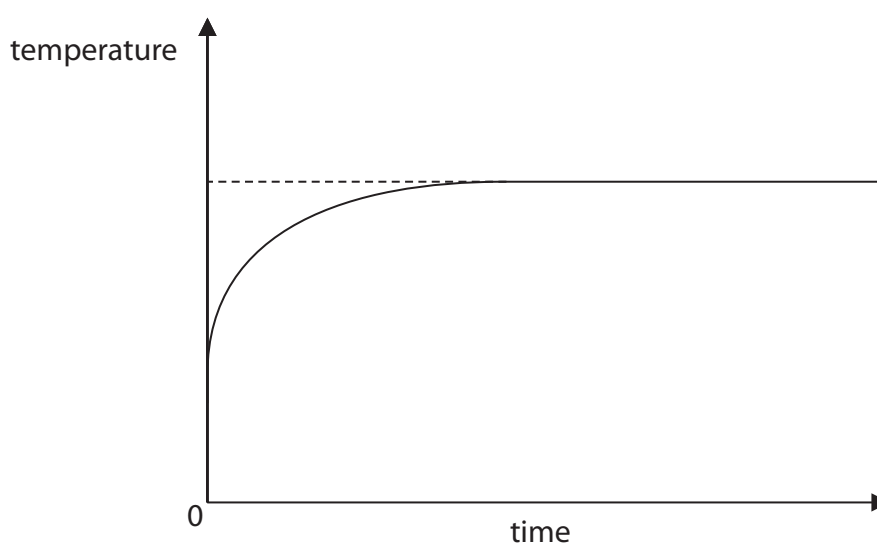


Figure 17



Explain why the temperature of **P** reaches a constant value, even though the heater remains switched on.

(4)

(Total for Question 8 = 10 marks)

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- 9 (a) An atom of mass 6.6×10^{-26} kg is moving with a velocity of 480 m/s.

Calculate the momentum of the atom.

(3)

momentum = kg m/s

- (b) Figure 18 shows a ball before and after it collides with a wall.

The arrows show the direction of movement of the ball.

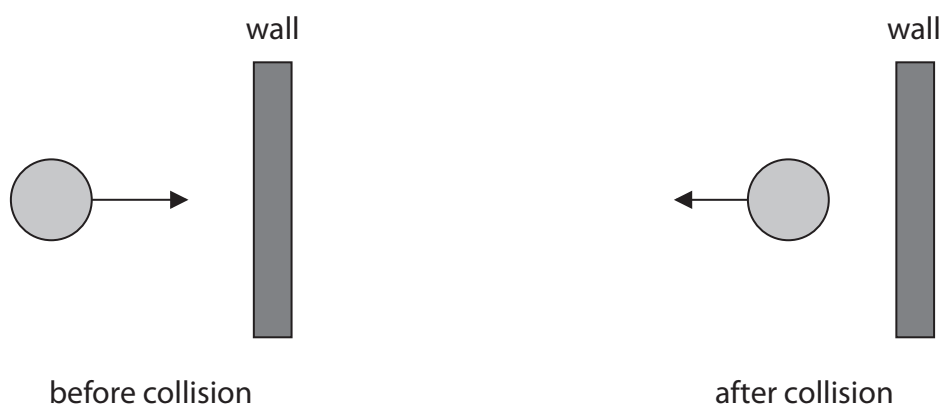


Figure 18

Before the collision, the momentum of the ball is 0.80 kg m/s.

After the collision, the momentum of the ball is 0.60 kg m/s in the opposite direction.

The ball is in contact with the wall for a time of 70 ms during the collision.

Calculate the force exerted on the ball by the wall.

(3)

Use an equation selected from the list of equations at the end of the paper.

force = N



*(c) Newton's second law can be stated as

$$\text{force} = \text{mass} \times \text{acceleration}$$

A student is provided with a trolley and a runway on a bench, as shown in Figure 19, and access to other equipment.

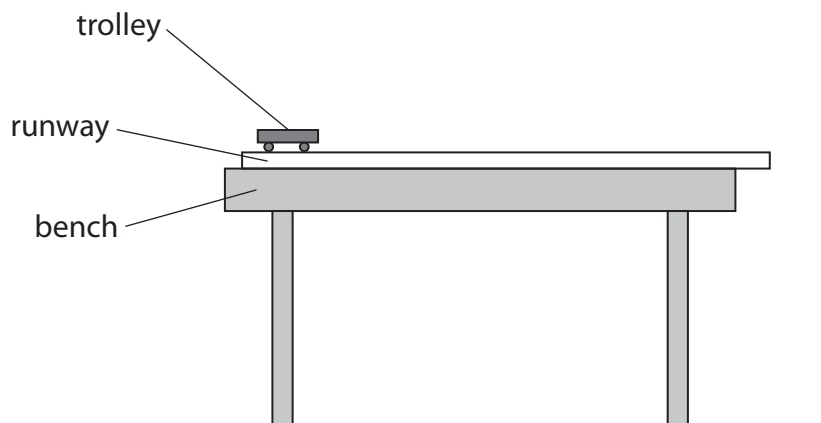


Figure 19

Describe a procedure the student could use to investigate how the acceleration of the trolley depends on the force applied to the trolley.

You may add to the diagram in Figure 19 to help your answer.

(6)

(Total for Question 9 = 12 marks)

- 10 (a) Figure 20 shows a Mars rover, a vehicle used for exploring the surface of the planet Mars.



(Source: © BEST-BACKGROUNDS/Shutterstock)

Figure 20

The power supply in a Mars rover is called an RTG.

The RTG contains a radioactive isotope that releases thermal energy as it decays.

The RTG uses the thermal energy released in the decay to provide electrical power for the rover.

- (i) An RTG has an efficiency rating of only 7%.

Calculate the useful energy transferred by the RTG when 1300 J of thermal energy is released in the decay.

(2)

Use the equation

$$\text{efficiency} = \frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})} \times 100\%$$

useful energy transferred = J

- (ii) Suggest, with a reason, **one** property the isotope must have to be suitable for use in the RTG.

(2)

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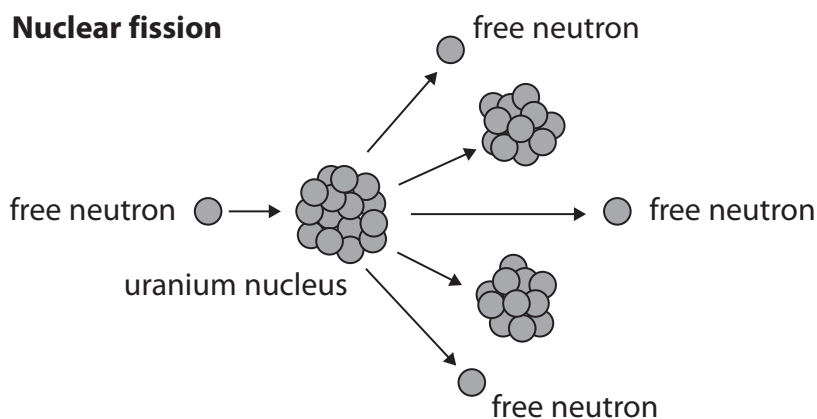
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(b) Figure 21 shows the fission of a uranium nucleus.



(Source: adapted from © 1501926062/Shutterstock)

Figure 21

The total mass of all the particles after the reaction is less than the total mass of the particles before the reaction.

The energy released in the reaction comes from the change in mass.

This is shown in the equation

$$\text{energy released} = (\text{change in mass}) \times (\text{speed of light})^2$$

The energy released in one fission reaction = $1.49 \times 10^{-10} \text{ J}$.

The speed of light = $3.00 \times 10^8 \text{ m/s}$.

Calculate the change in mass.

(3)

change in mass = kg

*(c) The energy released in a single uranium fission is very small.

In a nuclear power station, the fission of uranium in the reactor releases large amounts of energy.

The energy released is enough to generate electricity for thousands of homes.

The demand for electricity varies.

Explain

- how large amounts of energy can be released in the reactor
- how the rate of energy release is controlled as the demand for electricity varies.

(6)

(Total for Question 10 = 13 marks)

TOTAL FOR PAPER = 100 MARKS



Equations

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

$$v^2 - u^2 = 2 \times a \times x$$

$$\text{force} = \text{change in momentum} \div \text{time}$$

$$F = \frac{(mv - mu)}{t}$$

$$\text{energy transferred} = \text{current} \times \text{potential difference} \times \text{time}$$

$$E = I \times V \times t$$

$$\text{force on a conductor at right angles to a magnetic field carrying a current} = \text{magnetic flux density} \times \text{current} \times \text{length}$$

$$F = B \times I \times l$$

$$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\text{potential difference across primary coil} \times \text{current in primary coil} = \text{potential difference across secondary coil} \times \text{current in secondary coil}$$

$$V_p \times I_p = V_s \times I_s$$

$$\text{change in thermal energy} = \text{mass} \times \text{specific heat capacity} \times \text{change in temperature}$$

$$\Delta Q = m \times c \times \Delta \theta$$

$$\text{thermal energy for a change of state} = \text{mass} \times \text{specific latent heat}$$

$$Q = m \times L$$

$$P_1 V_1 = P_2 V_2$$

$$\text{to calculate pressure or volume for gases of fixed mass at constant temperature}$$

$$\text{energy transferred in stretching} = 0.5 \times \text{spring constant} \times (\text{extension})^2$$

$$E = \frac{1}{2} \times k \times x^2$$

$$\text{pressure due to a column of liquid} = \text{height of column} \times \text{density of liquid} \times \text{gravitational field strength}$$

$$P = h \times \rho \times g$$



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Pearson Edexcel Level 1/Level 2 GCSE (9–1)

May–June 2023 Assessment Window

Paper
reference

1PH0/1H

Physics
PAPER 1



Higher Tier

Equation Booklet

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If you're taking **GCSE (9–1) Combined Science** or **GCSE (9–1) Physics**, you will need these equations:

HT = higher tier

distance travelled = average speed $\times$ time	
acceleration = change in velocity $\div$ time taken	$a = \frac{(v - u)}{t}$
force = mass $\times$ acceleration	$F = m \times a$
weight = mass $\times$ gravitational field strength	$W = m \times g$
HT momentum = mass $\times$ velocity	$p = m \times v$
change in gravitational potential energy = mass $\times$ gravitational field strength $\times$ change in vertical height	$\Delta GPE = m \times g \times \Delta h$
kinetic energy = $\frac{1}{2} \times \text{mass} \times (\text{speed})^2$	$KE = \frac{1}{2} \times m \times v^2$
efficiency = $\frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})}$	
wave speed = frequency $\times$ wavelength	$v = f \times \lambda$
wave speed = distance $\div$ time	$v = \frac{x}{t}$
work done = force $\times$ distance moved in the direction of the force	$E = F \times d$
power = work done $\div$ time taken	$P = \frac{E}{t}$
energy transferred = charge moved $\times$ potential difference	$E = Q \times V$
charge = current $\times$ time	$Q = I \times t$
potential difference = current $\times$ resistance	$V = I \times R$
power = energy transferred $\div$ time taken	$P = \frac{E}{t}$
electrical power = current $\times$ potential difference	$P = I \times V$
electrical power = (current) $^2 \times$ resistance	$P = I^2 \times R$
density = mass $\div$ volume	$\rho = \frac{m}{V}$



	force exerted on a spring = spring constant $\times$ extension	$F = k \times x$
	(final velocity) ² – (initial velocity) ² = 2 $\times$ acceleration $\times$ distance	$v^2 - u^2 = 2 \times a \times x$
HT	force = change in momentum $\div$ time	$F = \frac{(mv - mu)}{t}$
	energy transferred = current $\times$ potential difference $\times$ time	$E = I \times V \times t$
HT	force on a conductor at right angles to a magnetic field carrying a current = magnetic flux density $\times$ current $\times$ length	$F = B \times I \times l$
	For transformers with 100% efficiency, potential difference across primary coil $\times$ current in primary coil = potential difference across secondary coil $\times$ current in secondary coil	$V_p \times I_p = V_s \times I_s$
	change in thermal energy = mass $\times$ specific heat capacity $\times$ change in temperature	$\Delta Q = m \times c \times \Delta\theta$
	thermal energy for a change of state = mass $\times$ specific latent heat	$Q = m \times L$
	energy transferred in stretching = 0.5 $\times$ spring constant $\times$ (extension) ²	$E = \frac{1}{2} \times k \times x^2$

If you're taking **GCSE (9–1) Physics**, you also need these extra equations:

	moment of a force = force $\times$ distance normal to the direction of the force	
	pressure = force normal to surface $\div$ area of surface	$P = \frac{F}{A}$
HT	$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$
	to calculate pressure or volume for gases of fixed mass at constant temperature	$P_1 \times V_1 = P_2 \times V_2$
HT	pressure due to a column of liquid = height of column $\times$ density of liquid $\times$ gravitational field strength	$P = h \times \rho \times g$

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Mark Scheme (Results)

Summer 2023

Pearson Edexcel GCSE
In Physics (1PH0)
Paper 1H

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Summer 2023

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Mark schemes have been developed so that the rubrics of each mark scheme reflects the characteristics of the skills within the AO being targeted and the requirements of the command word. So for example the command word 'Explain' requires an identification of a point and then reasoning/justification of the point.

Explain questions can be asked across all AOs. The distinction comes whether the identification is via a judgment made to reach a conclusion, or, making a point through application of knowledge to reason/justify the point made through application of understanding. It is the combination and linkage of the marking points that is needed to gain full marks.

When marking questions with a 'describe' or 'explain' command word, the detailed marking guidance below should be consulted to ensure consistency of marking.

Assessment Objective		Command Word	
Strand	Element	Describe	Explain
AO1*		An answer that combines the marking points to provide a logical description	An explanation that links identification of a point with reasoning/justification(s) as required
AO2		An answer that combines the marking points to provide a logical description, showing application of knowledge and understanding	An explanation that links identification of a point (by applying knowledge) with reasoning/justification (application of understanding)
AO3	1a and 1b	An answer that combines points of interpretation/evaluation to provide a logical description	
AO3	2a and 2b		An explanation that combines identification via a judgment to reach a conclusion via justification/reasoning
AO3	3a	An answer that combines the marking points to provide a logical description of the plan/method/experiment	
AO3	3b		An explanation that combines identifying an improvement of the experimental procedure with a linked justification/reasoning

*there will be situations where an AO1 question will include elements of recall of knowledge directly from the specification (up to a maximum of 15%). These will be identified by an asterisk in the mark scheme.

	Answer	Additional guidance	Mark
1(a)	substitution and rearrangement (1) $(f =) \frac{330}{11 \times 10^{-3}}$ evaluation (1) 30 000 (Hz)	award full marks for the correct answer without working 30 or 300 or 3000 scores 1 mark	(2) AO2

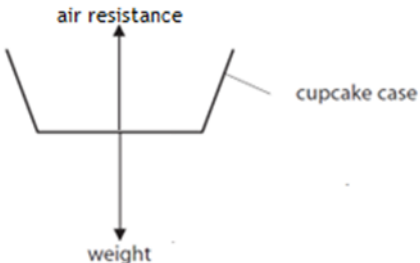
	Answer	Additional guidance	Mark
1(b)	Two possible methods: selection (1) distance = speed x time substitution (1) (total distance =) $330 \times 18 \times 10^{-3}$ evaluation of total distance (1) 5.9(4) (m) evaluation of distance from bat to prey (1) 3.0 (m) OR selection (1) distance = speed x time division of time by 2 (1) 9×10^{-3} substitution (1) (total distance =) $330 \times 9 \times 10^{-3}$ evaluation of distance from bat to prey (1) 3.0 (m)	speed = distance / time $330 = d / 18 \times 10^{-3}$ $330 \times 18 \times 10^{-3}$ scores mp1 and mp2 allow their distance divided by 2 for MP4 allow 2.97 (m) 5.94 scores 3 marks 5.94 to any other power of 10 scores 2 marks 2.97 or 3 to any other power of 10 scores 3 marks speed = distance / time $330 = d / 9 \times 10^{-3}$ $330 \times 9 \times 10^{-3}$ scores mp1 and mp2 and mp3 allow 2.97 (m) 2.97 or 3 to any other power of 10 scores 3 marks award full marks for the correct answer without working	(4) AO2

Total for Question 1 = 6 marks.

Question Number	Answer	Additional guidance	Mark
2 (a)	B distance A, C and D are incorrect as these are vector quantities		(1) AO1

Question number	Answer	Additional guidance	Mark
2 (b)(i)	A description to include any 4 from: measure height (1) measure time of fall (1) use (average) speed=distance ÷ time (1) repeat with different number of cupcake cases in the stack/more cupcake cases (1) repeat and average time (of fall for each stack of cupcake cases) (1) plot a graph (speed of fall against number of cupcake cases dropped) (1)	allow 'keep same height' allow in this context hold against (fixed point on) metre rule allow 'time it' accept cupcakes for cupcake cases	(4) AO1

Question Number	Answer	Additional guidance	Mark
2 (b)(ii)	substitution (1) (W=)0.005 x 10 evaluation (1) 0.05 (N)	5×10^{-2} (N) do not allow power of ten error award full marks for the correct answer with no working give full credit for use of $g=9.8$ or 9.81 N/kg	(2) AO2

Question number	Answer	Additional guidance	Mark
2 (b)(iii)	 air resistance arrow (1)	Judge by eye any vertical upward arrow outside or inside the cupcake case ignore length of arrow arrow need not touch cupcake holder ignore label on arrow	(1) AO2

Question number	Answer	Additional guidance	Mark
2 (b) (iv)	zero / there is none / 0 / it has no acceleration	ignore 'constant' ignore units	(1) AO2

Total for question 2 = 9 marks

Question number	Answer	Additional guidance	Mark
3 (a) (i)	substitution (1) $11 = 0.42 \times 10 \times \Delta h$ rearrangement (1) $(\Delta h =) \frac{11}{0.42 \times 10}$ evaluation (1) 2.6 (m)	accept substitution and rearrangement in either order $(\Delta h =) \frac{\Delta GPE}{m \times g}$ accept any value which rounds to 2.6 (m) award 2 marks for 2.6 to any other power of 10 allow 1 mark for 0.38 allow 1 mark for 46(.2) award full marks for the correct answer with no working give full credit for use of $g=9.8$ or 9.81 N/kg (gives 2.7 (m))	(3) AO2

Question number	Answer	Additional guidance	Mark
3 (a) (ii)	substitution(1) ($KE = \frac{1}{2} \times 0.42 \times 12^2$) evaluation (1) 30 (j)	allow 30.2(4) (j) award 1 mark for 30 240 (j) award 1 mark for 2.52 (j) award 1 mark for 60.5 (j) award full marks for the correct answer with no working	(2) AO2

Question number	Answer	Additional guidance	Mark
3(a)(iii)	A description including: KE/kinetic (energy store) (1) (transfers to) and one of: elastic (potential energy store) (1) OR thermal (energy of ball/wall/surroundings) (1) OR <u>dissipates</u> (to surroundings) (1)	allow mechanically / mechanical transfer ignore reference to gravitational potential energy allow heat for thermal allow sound in this context ignore reference to the ground	(2) AO2

Question number	Answer	Additional guidance	Mark
3 (b)	selection and substitution (1) $17^{(2)} = 2 \times 10 \times \text{distance}$ evaluation (1) 14(.45) (m)	use of either $v^2 - u^2 = 2ax$ or $v^2 = 2gh$ $17^{(2)} = 2 \times a \times \text{distance}$ allow 289 for 17^2 award full marks for the correct answer without working give full credit for use of $g=9.8$ or 9.81 m/s^2 gives 14.7 (m)	(2) AO2

Total for question 3 =9 marks

	Answer	Additional guidance	Mark
4 (a) (i)	$(1.98-1.86) = (+/-) 0.12$		(1) AO2

	Answer	Additional guidance	Mark
4(a)(ii)	(velocity =) $\frac{330 \times 0.12}{1.86}$ (1) (+/-) 21.3 (m/s) (1)	ecf from 4ai accept numbers that round to 21 (m/s) award 1,2 marks for (i) and (ii) for the correct answer for (ii) even without working	(2) AO2

	Answer	Additional guidance	Mark
4 (b)	(there is) an increase in wavelength (of light) (1) shows <u>galaxies</u> are moving away (from Earth) (1)	allow wavelength stretches allow red shift ignore shift to red end of spectrum ignore objects / stars / planets	(2) AO1

	Answer	Additional guidance	Mark
4 (c)	1(.0) (1) mm (1)	Allow values between 1.0 and 1.9 allow <u>1x10⁻³ m</u> or <u>0.001 m</u> for 2 marks if nothing in answer line, credit answer indicated in table	(2) AO3

	Answer	Additional guidance	Mark
4 (d)(i)	gravitational attraction / gravitational force (causing collapse) (1)	allow gravity ignore weight ignore gpe ignore gravitational energy	(1) AO1

	Answer	Additional guidance	Mark
4 (d)(ii)	An explanation linking: (gravity causing) increase in temperature (1) (until hot enough for) fusion (1) (until) balance (between gravity and fusion/thermal) (1)	allow increase in pressure/density hydrogen to form helium allow nuclear reactions ignore fission allow equilibrium / counteracts	(3) AO1

Total for Question 4 = 11 marks.

	Answer Additional guidance	Mark
5(a)	B 3.0 s A, C and D are incorrect as they are the wrong time.	(1) AO3

	Answer	Additional guidance	Mark
5(b)	4.6 (m/s)	allow any value between 4.5 and 4.7 (m/s) inclusive	(1) AO3

	Answer	Additional guidance	Mark
5(c)	correct data point(s) seen (1) (accel =) $\frac{\Delta v}{t}$ (1) evaluation (1) 2.9 (m/s ²)	allow MP1 and MP2 in either order any data point(s) on the line e.g. (1.4,4) allow 'gradient' allow e.g. $\frac{4}{1.4}$ for 2 marks allow values that round to 2.9 (m/s ²) (e.g. 2.857...) award full marks for the correct answer without working	(3) AO3

	Answer	Additional guidance	Mark
5(d)	(distance =) area (under graph) (1) substitution (1) $\frac{1}{2}(1.4 \times 4) + (3.6 \times 4) + \frac{1}{2}(1 \times 4)$ evaluation (1) 19 (m)	may be seen on graph $2.8 + 14.4 + 2.0$ $\frac{1}{2} \times [3.6 + 6] \times 4$ allow values that round to 19 (m) (e.g. 19.2..) award full marks for the correct answer without working if no other marks scored allow $(4 \times 6 =) 24$ (m) for 1 mark	(3) AO3

	Answer	Additional guidance	Mark
5(e)	graph continued below time axis, starting at 18 s	do not accept vertical line do not accept line extending to left of 18 s	(1) AO3

Total for Question 5 = 9 marks.

	Answer	Additional guidance	Mark
6(a)(i)	calculation of time of travel (1) (120/330 =) 0.36(36) (s) substitution (1) $\frac{0.23 \times 100}{0.36(36)}$ evaluation (1) 63 (%)	ecf from MP1 for MP2&3 accept values that round to 64 or 63 accept values that round to 0.64 or 0.63 for 2 marks award full marks for the correct answer without working	(3) AO2

	Answer	Mark
6(a)(ii)	C Increase the distance between L and M. A, B and D are incorrect as these would not improve the technicians' measurement	(1) AO3

	Answer	Additional guidance	Mark
6(b)	an explanation linking: (refraction caused by) change in speed (1) sound speeds up (when entering water) (1) light slows down (when entering water) (1)	allow 3 marks for sound speeds up and light slows down (when entering water) allow 2 marks for sound speeds up (when entering water) OR light slows down (when entering water) if no other marks scored allow 1 mark for description of any speed change (when entering water) if no other marks scored allow 1 mark for wavelength changes ignore references to transverse, longitudinal.	(3) AO1

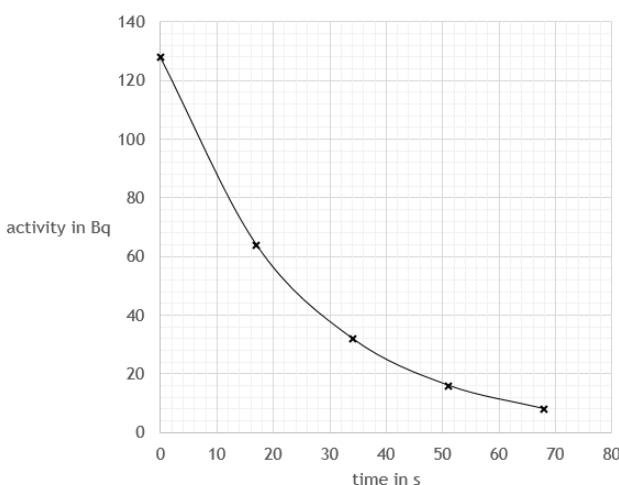
	Answer	Additional guidance	Mark
6(c)	example 1 e-m wave (1) corresponding result of energy transfer (1) example 2 e-m wave (1) corresponding result of energy transfer (1)	e.g. radio waves: communication, oscillations (of electrons) in wires microwaves: cooking, communications and satellite transmissions, internal heating of body cells, increase KE/vibration of water molecules infrared: cooking, thermal imaging, optical fibres, television remote controls, skin burns ultraviolet: security marking, fluorescent lamps, detecting forged bank notes and disinfecting water, damage to surface cells and eyes, skin cancer x-rays: observing the internal structure of objects, airport security scanners and medical x-rays, mutation or damage to cells in the body, cancer gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment, mutation or damage to cells in the body, cancer additional effect for visible light scores 1 mark e.g. : including vision, photography and illumination	(4) AO1

Total for Question 6 = 11 marks.

	Answer	Mark
7(a)(i)	${}_{95}^{245}\text{Am}$ A, B and D are incorrect as these are not isotopes of americium.	(1) AO1

	Answer	Mark
7(a)(ii)	[x] B 5 cm A, C and D are incorrect as these are not the correct range of an alpha particle in air.	(1) AO1

	Answer	Additional guidance	Mark
7(a)(iii)	${}_{2}^{4}\alpha$ (1) ${}_{115}^{237}\text{Nh}$ (1) ${}_{93}^{149}\text{Np}$ (1)	both correct for the mark ecf from mp1 ecf from mp1	(3) AO2

	Answer	Additional guidance	Mark
7(b)	plots at three of: 17,64 (1) 34,32 (1) 51,16 (1) 68,8 (1) tolerance ± 1 s ± 4 Bq	 allow line passing through correct point(s) ignore incorrect curve if no other marks scored allow 1 mark for evidence of halving activity e.g. 128 to 64	(3) AO3

	Answer	Additional guidance	Mark
7(c)	description to include: proton (1) becomes a neutron (1)	award 2 marks for $p \rightarrow n$ award 2 marks for answers in terms of quarks: $u \rightarrow d$ or $up \rightarrow$ down or $uud \rightarrow udd$ if no other mark scored, allow 1 mark for any one of neutron becomes proton $n \rightarrow p$ $d \rightarrow u$ decrease in atomic number <u>by one</u> mass number stays the same gains a neutron reduce charge (of nucleus) <u>by one</u> responses referring to emission of gamma or neutrino	(2) AO1

Total for Question 7 = 10 marks.

	Answer	Mark
8(a)(i)	A The ray enters along a normal to the edge of the block. B, C and D are incorrect as these do not explain why the light ray does not change direction.	(1) AO2

	Answer	Additional guidance	Mark
8(a)(ii)	explanation linking: extrapolate / extend the graph/curve (1) (until it reaches) $r = 90^\circ$ (1) read corresponding value of i (1)	Allow annotation on graph: extension of line on graph to at least $r = 90^\circ$ line down from line to x axis and labelled as critical angle	(3) AO2

	Answer	Additional guidance	Mark
8(b)(i)	explanation linking any 2 of: black / P is good absorber / poor reflector (1) white / Q is good reflector poor absorber (1) different colour of surfaces absorb differently (1)	allow any one statement for 2 marks: - black / P better absorber - black / P worse reflector - white / Q worse absorber - white / Q better reflector - black / P absorbs (radiation) and white / Q reflects (radiation)	(2) AO1

	Answer	Additional guidance	Mark
9(a)	selection (1) $p = m \times v$ substitution (1) $6.6 (\times 10^{-26}) \times 480$ evaluation (1) 3.2×10^{-23} (kgm/s)	allow mom(entum) = mass x velocity allow numbers that round to 3.2×10^{-23} e.g. 3.168×10^{-23} award full marks for the correct answer without working $6.6 (\times 10^{-26}) \times 480$ seen scores MP1 and MP2, 2 marks 3.2 to any other power of ten scores MP1 and MP2, 2 marks	(3) AO2

	Answer	Additional guidance	Mark
9(b)	attempt to find momentum change (Δp) (1) $(\Delta p) = \pm 1.4$ substitution in to $F = \frac{\Delta p}{t}$ (1) $\frac{\pm 1.4}{70 \times 10^{-3}}$ evaluation (1) $(\pm) 20 \text{ (N)}$	$\pm 0.8 \pm 0.6$ allow $(\Delta p) = \pm 0.2$ allow $\frac{\pm 0.2}{70 \times 10^{-3}}$ answers which round to $(\pm) 20$ to any other power of 10 score 2 marks answers which round to $(\pm) 2.9$ scores 2 marks answers which round to $(\pm) 2.9$ to any other power of 10 score 1 mark award full marks for the correct answer without working	(3) AO2

Question number	Indicative content	Mark
9c	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 isolated statements • weights on hanger • weights added to trolley • light gate(s) / ticker(tape) timer / ultrasonic transducer • datalogger • (interrupter) card on trolley • sloping runway • weigh trolley • use newtonmeter • use $a = (v-u)/t$ • measure distance and time • use stopclock and ruler • use (average) speed = distance / time • use $a = (v^2-u^2)/2s$ • plot graph of F against a detail of procedure • suspend weights from weight hanger to produce force • changing weights on hanger • keeping mass constant by moving weights between hanger and trolley • light gates/ticker(tape) timer/ultrasonic transducer used to measure acceleration/velocity/time • runway on slope so no (effect of) friction /so trolley rolls at constant speed (with no weights/force) • increase angle of slope to increase force • interrupter card for time through gate • final speed = 2 x average speed	(6) AO1

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated facts mention at least 2 isolated statements evidence may be seen in the diagram	<u>Possible candidate responses</u> add weights and use light gates
Level 2	3–4	<u>Additional guidance</u> limited procedure 1 detail of procedure and mention 1 other isolated statement evidence may be seen in the diagram	<u>Possible candidate responses</u> use light gates to measure acceleration/velocity/time and add weights
Level 3	5–6	<u>Additional guidance</u> detailed procedure 2 details of procedure and mention 1 other isolated statement evidence may be seen in the diagram	<u>Possible candidate responses</u> use light gates to measure acceleration/velocity/time and suspend weights from weight hanger to produce force and sloping runway

Total for Question 9 = 12 marks

	Answer	Additional guidance	Mark
10(a)(i)	substitution and rearrangement (1) useful energy transferred = $\frac{7(\%) \times 1300}{100}$ evaluation (1) 90 (J)	useful energy transferred = 0.07×1300 allow 91 (J) 0.91 or 0.9 scores 1 mark award full marks for the correct answer without working	(2) AO2

	Answer	Additional guidance	Mark
10(a)(ii)	statement plus reason for example: long half-life (1) with one from: the rover takes a long time (to get to Mars) (1) rover needs to operate for a long time (on Mars) (1) (once on Mars) cannot be replaced (1)	Allow other relevant properties for MP1 with reason for MP2, for example: high melting point ... to maintain RTG integrity not chemically reactive ... to prevent corrosion	(2) AO3

	Answer	Additional guidance	Mark
10(b)	substitution (1) $1.49 \times 10^{-10} = \text{change in mass} \times (3 \times 10^8)^2$ rearrangement (1) (change in mass =) $\frac{1.49 \times 10^{-10}}{9 \times 10^{16}}$ evaluation (1) $1.66 \times 10^{-27} \text{ (kg)}$	$\frac{1.49 \times 10^{-10}}{(3 \times 10^8)^2}$ allow $m = E/c^2$ Accept values that round to 1.7×10^{-27} if no other marks scored 1.66 or 1.7 to any other power of ten scores 1 mark award full marks for the correct answer without working	(3) AO2

Question number	Indicative content	Mark
10c	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 chain reaction • neutrons emitted in one fission go on to hit other U-235 nuclei • neutrons emitted in one fission go on to cause a chain reaction control rods • rods absorb/capture/stop neutrons • limit/control number of fissions • varies rate of (thermal) energy released moderator • slows down neutrons • makes them more likely to cause fission	(6) AO1

Level	Mark	Descriptor
	0	No rewardable material. relevant
Level 1	1-2	- Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	- Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	- Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated statements	<u>Possible candidate responses</u> Mention of 2 of: chain reaction OR control/boron rods OR moderator
Level 2	3–4	<u>Additional guidance</u> limited explanation detail of 1 of chain reaction/ control rods/ moderator and mention at least 1 other	<u>Possible candidate responses</u> neutrons emitted in one fission go on to hit other U-235 nuclei and mention control rods
Level 3	5–6	<u>Additional guidance</u> detailed explanation detail of 2 of chain reaction/ control rods/ moderator and mention the other one	<u>Possible candidate responses</u> neutrons emitted in one fission go on to hit other U-235 nuclei AND control rods absorb neutrons to reduce number of fissions AND mention of moderator