



# Mark Scheme (Results)

Summer 2019

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

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## General Marking Guidance

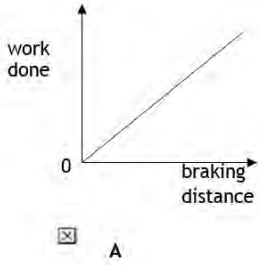
- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should 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

Question Number:	Answer	Mark
1(a)	 <p>The only correct answer is A (showing direct proportionality)  <b>B</b> is not correct – curve (not showing direct proportionality)  <b>C</b> is not correct – constant value shown (not showing direct proportionality)  <b>D</b> is not correct – curve (not showing direct proportionality)</p>	(1)

Question Number	Answer	Additional Guidance	Mark
1(b)	<p><b>one</b> from</p> <p>causes heating of the surroundings (1)</p> <p>transferred to thermal energy of surroundings (1)</p> <p>increases the kinetic energy of molecules in the brake pads (1)</p>	<p>must include destination of final energy</p> <p>increases thermal energy of brake pads / wheels</p>	(1)

Question Number	Answer	Additional guidance	Mark
1(c)	<p>use values from graph (1) e.g. <math>v = 20</math>, <math>d = 31</math></p> <p>rearrangement (1) <math>C = \frac{v^2}{d}</math></p> <p>evaluation (1) (C=) 13</p> <p>unit (1) <math>\text{m/s}^2</math></p>	<p>accepting values to within one square</p> <p>allow numbers from 12.5 to 13.5</p> <p>award 3 marks for the correct numerical answer without working</p> <p>independent mark</p>	(4)

(Total for Question 1 = 6 marks)

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Question Number	Answer	Mark
2(a)	<p>C red</p> <p><b>The only correct answer is C red</b></p> <p>A is not correct because blue has a shorter wavelength than red</p> <p>B is not correct because green has a shorter wavelength than red</p> <p>D is not correct because yellow has a shorter wavelength than red</p>	(1)

Question Number	Answer	Additional guidance	Mark
2(b)	<p>an explanation linking:</p> <p>infrared is absorbed / blocked (by the armchair / objects) / cannot pass through</p> <p><b>OR</b></p> <p>radio waves can go through (the armchair/objects) (1)</p> <p><b>WITH</b></p> <p>(infrared and radio have) different wavelengths / frequencies</p> <p>OR infrared requires 'line-of-sight' (idea)</p> <p>OR radio waves do not require 'line-of-sight' (idea)</p> <p>OR diffraction (idea)</p> <p>(1)</p>	<p>stopped</p> <p>transmitted</p> <p>accept comparison</p>	(2)

Question Number:	Answer	Additional guidance	Mark
2(c)(i)	evidence of use of scale on horizontal distance axis only (1)  12 (cm) (1)	may be seen on the diagram  range 11.5 to 12.5 (cm)  award full marks for the correct answer without working  6 (cm) or 30(cm) scores 1 mark (evidence of use)	(2)

Question Number	Answer	Additional guidance	Mark
2(c)(ii)	a description to include:  moves up and down (1)  at right angles / normal / perpendicular to (direction of) wave / travel (1)	independent marking points  vertical (oscillations)  not in the (direction of) wave / travel  accept 'transverse wave' for 2nd MP	(2)



Question Number	Answer	Additional guidance	Mark
2(d)	recall and substitution (1) (v =) $0.25 \times 1.5$  evaluation (1)  0.38 (m/s)	accept 0.375 or 0.37 (m/s)  accept 37.5, 37 or 38 for 1 mark only  award full marks for the correct answer without working	(2)

(Total for Question 2 = 9 marks)

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Question Number:	Answer	Additional guidance	Mark									
<b>3(a)</b>	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 80px; height: 20px;"></td> <td style="width: 80px; height: 20px;"></td> </tr> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 80px; height: 20px; text-align: center;">7</td> <td style="width: 80px; height: 20px; text-align: center;">6</td> </tr> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 80px; height: 20px; text-align: center;">8</td> <td style="width: 80px; height: 20px; text-align: center;">6</td> </tr> </table> <p style="text-align: center; margin-left: 100px;">(1)      (1)</p>					7	6		8	6	<p>one mark for each column</p> <p>must have both numbers in a column correct to get the mark</p>	<b>(2)</b>
	7	6										
	8	6										

Question Number	Answer	Additional guidance	Mark
<b>3(b)(i)</b>	Geiger (Müller counter) (1)	<p>GM (tube/meter) or other appropriate detector e.g. dosimeter, film badge, scintillation counter</p> <p>accept incorrect spellings such as "giga"</p> <p>ignore radioactive counter</p>	<b>(1)</b>




Question Number	Answer	Additional guidance	Mark
<b>3(c)</b>	processing (1)  <u>125 000</u> 1 000 000  OR $\frac{1}{8}$  OR 3 half-lives or 3 x 5700  evaluation (1)  17100	accept an appropriate attempt using more than one halving           17000  award full marks for the correct answer without working	<b>(2)</b>

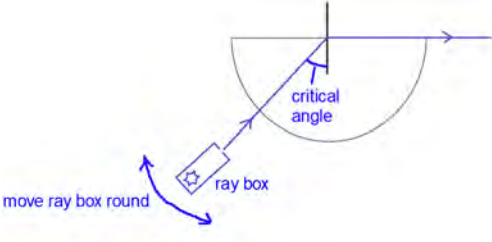
Question Number	Answer	Additional guidance	Mark
3(d)	<p>An explanation linking: neutron (decays) to proton (1)</p> <p>beta emitted (1)</p>	<p>mass number stays the same but atomic number increases by 1</p> <p>accept answers in terms of quarks (dud becomes uud)</p> <p>beta decay / <math>\beta</math> seen</p> <p>NOT <math>\beta^+</math>/beta plus</p> <p>allow (fast) electron emitted</p> <p>allow for 2 marks:</p> <p><math>n \rightarrow p + e</math></p> <p>OR</p> <p><math>{}^{14}_6\text{C} \rightarrow {}^{14}_7\text{N} + {}^0_{-1}\beta^{(-)}</math></p>	(2)

(Total for Question 3 = 8 marks)

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Question Number	Answer	Mark
4(a)(i)	 <p data-bbox="384 891 437 920">□ B</p> <p data-bbox="368 949 794 983"><b>The only correct answer is B</b></p> <p data-bbox="368 1012 1107 1046">A is not correct because it has a smaller power than B</p> <p data-bbox="368 1075 979 1108">C is not correct because it is a diverging lens</p> <p data-bbox="368 1144 979 1178">D is not correct because it is a diverging lens</p>	(1)

Question Number	Answer	Additional guidance	Mark
4(a)(ii)	<p data-bbox="363 1406 858 1440">rearrangement and substitution (1)</p> $\frac{1}{5}$ <p data-bbox="363 1608 836 1641">unit conversion and evaluation (1)</p> <p data-bbox="363 1715 469 1749">20 (cm)</p>	<p data-bbox="880 1704 1117 1861">award full marks for the correct answer without working</p> <p data-bbox="880 1890 1133 1962">accept 0.2 for one mark only</p>	(2)

Question Number	Answer	Additional guidance	Mark
4(b)	<p>a description to include any <b>four</b> from:</p> <p>shine a ray (of light) into the block (1)</p> <p>into block through the curved face along a radius (1)</p> <p>{change angle / move ray(box)} until {the angle of refraction is <math>90^\circ</math> / TIR just occurs} (1)</p> <p><b>measure</b> angle of incidence {when refracted angle is <math>90^\circ</math> / when TIR just occurs} (1)</p> <p>repeat measurement of critical angle (1)</p>	 <p>The diagram shows a semi-circular block with a flat vertical edge on the left and a curved edge on the right. A ray box is positioned to the left of the flat edge, with a ray of light directed towards the center of the flat edge. The ray enters the block and travels along a radius towards the curved edge. At the point where the ray meets the curved edge, it is shown as a horizontal line extending to the right, representing a refracted ray at <math>90^\circ</math>. The angle between the incident ray and the normal (a vertical line from the center of the flat edge) is labeled 'critical angle'. A curved arrow around the ray box is labeled 'move ray box round'. The text 'ray box' is also present near the box.</p> <p>credit marking points in the diagram if they are clear</p> <p>allow 'calculate' for 'measure'</p> <p>plot angle <math>i</math> against angle <math>r</math></p> <p>if light only enters block at straight edge, maximum 1 mark (for MP1)</p>	(4)

Question Number	Answer	Additional guidance	Mark
4(c)(i)	examples: planets have moons (1) the Earth rotates (spins) (1) planets orbit the Sun (1) Pluto is no longer a planet (1) orbits are elliptical (not circular) (1) there are more planets than previously thought (1) ours is not the only solar system (1) Earth is {round/spherical /not flat} (1) planets are not wandering stars (1)	answers must be to do with the solar system	(1)



Question Number	Answer	Additional guidance	Mark
4(c)(ii)	<p>smooth curve drawn on the graph (1)</p> <p>horizontal line drawn from 4.6 Earth years to intercept the drawn line/curve (1)</p> <p>EITHER: their reading from line / curve (1)</p> <p>OR</p> <p>430±30 (million km) (1)</p>	<p>accept curve up to Mars followed by a straight line</p> <p>plot point /draw line at year length = 4.6</p> <p>reading on distance axis ± half small square from their graph</p> <p>award full marks for the correct answer without working</p>	<b>(3)</b>

**Total for Question 4 = 11 marks)**

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Question Number	Answer	Additional guidance	Mark
5(a)	<p>An answer that includes:</p> <p>(measure) mass of the trolley (1)</p> <p>(measure) (vertical) height / h (1)</p> <p>repeat for a range of masses (1)</p> <p>plus <b>any one</b> from:</p> <p>method of identifying / measuring h (1)</p> <p>OR</p> <p>repeat firing with same mass (1)</p>	<p>weigh the trolley</p> <p>NOT measure height of ramp</p> <p>e.g. use of reference mark</p> <p>accept "use ruler to measure height/h" for 2 marks</p> <p>NOT "use ruler to measure height of ramp"</p>	(4)

Question Number	Answer	Additional guidance	Mark
5(b)	<p>reference to <math>\Delta PE = mg(\Delta)h</math> (1)</p> <p>relevant values from graph and one calculation to find energy (1)</p> <p>repeated with 2<sup>nd</sup> set of values (1)</p>	<p>can be seen in calculations</p> <p>e.g. <math>0.6 \times 10 \times 0.230 \approx 1.4</math> (J)</p> <p>e.g. <math>1.0 \times (10) \times 0.138 \approx 1.4</math> (J)</p> <p>must see calculations for mp2 and 3</p> <p>1 mark for 2 calculations of <math>mh</math> with 'g' omitted (MP3)</p>	(3)
Question Number	Answer	Additional guidance	Mark
5(c)	<p>A description including:</p> <p>measure appropriate distance (1)</p> <p>measure appropriate time (1)</p> <p>use</p> <p>(average) speed = <math>\frac{\text{distance}}{\text{time}}</math> (1)</p>	<p>e.g. distance along runway from max height to P</p> <p>e.g. start the watch when trolley stops stop the watch when trolley hits spring</p> <p>accept <math>s = \frac{d}{t}</math></p>	(3)

(Total for Question 5 = 9 marks)

Question Number	Answer	Additional guidance	Mark
6(a)	<p><b>An explanation linking:</b></p> <p>make the distance between students larger (1)</p> <p>OR</p> <p>viable alternative method such as use microphones / sound sensors / datalogger (to start and stop timer) (1)</p> <p><b>with:</b></p> <p>to give a more measurable time (1)</p> <p>OR</p> <p>to remove (variable) reaction times (at start and end) / to reduce effect of reaction times / improve accuracy of timing (1)</p>	<p>50 m is too short (a distance to produce a measurable time)</p> <p>gives a longer time – more accurate measurement</p> <p>do not accept 'more accurate' without qualification for either method</p>	(2)

Question Number	Answer	Additional guidance	Mark
6(b)	<p>A description including <u>particles</u> (at end) vibrate (more) (about fixed positions) (1)</p> <p>cause neighbouring particles to vibrate (more) (1)</p>	<p>allow atoms / ions / molecules for particles</p> <p>vibrations passed along</p> <p>OR</p> <p>reference to longitudinal waves / compressions and rarefactions</p>	(2)

Question Number	Answer	Additional guidance	Mark
6(c)	<p>single straight line in upper right quadrant (1)</p> <p>direction change <b>towards</b> the normal (1)</p>	<p>ignore arrow direction</p> <p>conditional on first mark point</p>	(2)

Question Number	Answer	Additional guidance	Mark
6(d)	using cold row: evaluate $(K=)376$ (1)  using warm row: substitute K and $\rho$ $\frac{376}{\sqrt{1.16}}$ OR 349.10... (1)  349 (m/s) to 3 sig figs (1)	$\frac{\text{other K from earlier calculation}}{\sqrt{1.16}}$ any answer to 3 sig figs  349.10... scores MP1 and MP2  award full marks for the correct answer without working	(3)

(Total for Question 6 = 9 marks)

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Question Number	Answer	Additional guidance	Mark
7(a)	<p><input type="checkbox"/> B centripetal force</p> <p><b>The only correct answer is B (correct term for circular motion)</b></p> <p><b>A</b> is not correct – incorrect term</p> <p><b>C</b> is not correct – incorrect term</p> <p><b>D</b> is not correct – incorrect term</p>		(1)

Question Number	Answer	Additional guidance	Mark
7(b)(i)	single arrow towards centre of the circle applied to the object (1)	judge by eye	(1)

Question Number:	Answer	Additional Guidance	Mark
7(b)(ii)	<p>an explanation including</p> <p>velocity is a vector (1)</p> <p>(because) direction changes (1)</p>	velocity has (magnitude and) direction / velocity is speed in a (certain) direction	(2)

Question Number:	Answer	Additional guidance	Mark
7(c)(i)	substitution in $v^2 - u^2 = 2ax$ (1) $24^2 - 7.6^2 = 2 \times 3 \times x$  rearrangement (1) $(x =) \frac{24^2 - 7.6^2}{6}$  evaluation (1) 86 (m)	accept rearrangement and substitution in either order     allow numbers that round to 86 (m)  award full marks for the correct answer without working	(3)



Question Number	Answer	Additional guidance	Mark
7(c)(ii)	<p>recall and substitution (1)  <math display="block">a = \frac{v - u}{t} \quad 3.0 = \frac{24 - 7.6}{t}</math></p> <p>rearrangement (1)  <math display="block">t = \frac{v - u}{a}</math></p> <p>OR</p> $t = \frac{24 - 7.6}{3.0}$ <p>evaluation (1)            5.5 (s)</p>	<p>Allow alternative method:            average speed = distance / time i.e <math>15.8 = 86(.37) / \text{time}</math></p> <p><math>(t = ) 86(.37) / 15.8</math></p> <p>allow numbers that round to 5.5 (s)            OR            numbers that round to 5.4 if using alternative method and distance = 86</p> <p>award full marks for the correct answer without working</p> <p>no marks for  <math>t = d / (v - u) = 86(.37) / (24 - 7.6)</math>            giving 5.3 s as an answer</p>	(3)

**(Total for Question 7 = 10 marks)**

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Question Number	Answer	Additional guidance	Mark
8(a)(i)	<p>an explanation including:</p> <p>(fluorine-18 has) a short half-life (1)</p> <p>(so) it must be <b>used</b> as soon as possible after making (1)</p>	<p>decays too quickly related to transport / proximity</p> <p>ignore arguments about harm to person / the environment</p>	(2)

Question Number	Answer	Additional guidance	Mark
8(a)(ii)	<p>an explanation including:</p> <p><b>alpha</b> short range/low penetration (1)</p> <p>(so) needs to be close to the tumour (1)</p> <p><b>gamma</b> long range/high penetration (1)</p> <p>(so) can get into the body from outside (1)</p>	<p>accept highly ionising</p> <p>accept weakly ionising</p> <p>pass through the skin</p> <p>'alpha more ionising than gamma' 1 mark by itself</p>	(4)

Question Number:	Answer	Mark
8(b)(i)	<p><input type="checkbox"/> C a neutron</p> <p><b>The only correct answer is C (neutron causes U-235 fission)</b></p> <p>A is not correct – incorrect particle</p> <p>B is not correct – incorrect particle</p> <p>D is not correct – incorrect particle</p>	(1)

Question Number	Answer	Additional guidance	Mark
8(b)(ii)	<p>recall and substitution (1)</p> $1.2 \times 10^{-11} = \frac{1}{2} \times 1.4 \times 10^{-25} \times v^2$ <p>rearrangement (1)</p> $v^2 = \frac{2 \times 1.2 \times 10^{-11}}{1.4 \times 10^{-25}}$ <p>evaluation (1)</p> <p>(v=) <math>1.3 \times 10^7</math> (m/s)</p>	<p>accept rearrangement and substitution in either order</p> <p>ignore POT until evaluation</p> $v^2 = 1.71 \times 10^{14}$ <p>allow numbers that round to <math>1.3 \times 10^7</math> (m/s)</p> <p>1.3 to any other power of ten scores 2 marks</p> <p>award full marks for the correct answer without working</p>	(3)

**(Total for Question 8 = 10 marks)**

Question Number	Answer	Additional guidance	Mark
9(a)	suggestion to include <b>one</b> from (ultraviolet/UV) is (the most) harmful to the eyes (1)  protects eyes from damage/harm (from UV rays) (1)	(UV) can damage eyes  protects against cataracts/cancer  accept makes it more comfortable in bright sunlight	(1)

SSQ NO:	Answer	Additional guidance	Mark
9(b)	(Jupiter is) 5 times (further away) (1)  radio waves and light waves travel at the same speed (in space) (1)	All electromagnetic (EM) waves travel at the same speed  accept attempt to use consistent speed (of light) to calculate two distances	(2)

Question Number:	Answer	Additional guidance	Mark									
9(c)	<p>a description including:</p> <p>UVA <b>mostly</b> transmitted OR <b>some</b> absorbed (1)</p> <p>UVB <b>some</b> transmitted OR <b>mostly</b> absorbed (1)</p> <p>UVC <b>not</b> transmitted OR <b>mostly</b> absorbed OR <b>some</b> reflected (1)</p> <p>correct relationship of absorption/ transmission to wavelength / <math>\lambda</math> (1)</p>	<p>UVA <b>mostly</b> travels through</p> <p>accept <b>less</b> transmitted than UVA</p> <p><b>more</b> absorbed than UVA or UVB</p> <p>wavelength decreasing (with) absorption increasing OR longer wavelengths transmit more</p> <table border="1" data-bbox="874 1182 1153 1303"> <tr> <td><math>\lambda</math></td> <td>abs</td> <td>trans</td> </tr> <tr> <td>inc</td> <td>dec</td> <td>inc</td> </tr> <tr> <td>dec</td> <td>inc</td> <td>dec</td> </tr> </table>	$\lambda$	abs	trans	inc	dec	inc	dec	inc	dec	(4)
$\lambda$	abs	trans										
inc	dec	inc										
dec	inc	dec										

Question Number	Answer	Mark
9(d)*	<p>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.</p> <p>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.</p> <p style="text-align: center;"><b>AO1 strand 1 (6 marks)</b></p> <ul style="list-style-type: none"> <li>• radio waves are (often) produced intentionally (by humans)</li> <li>• gamma rays are (often) produced spontaneously / randomly</li> <li>• radio waves are produced by (free) electrons</li> <li>• radio waves are produced by oscillating (free) electrons / alternating current (ac)</li> <li>• radio waves are produced in electrical circuits / aerials</li> <li>• gamma rays may result from radioactive decay</li> <li>• gamma rays produced in the nucleus</li> <li>• gamma rays produced by energy changes / rearrangement in the nucleus</li> <li>• gamma rays produced to stabilise the nucleus</li> <li>• gamma rays produced in annihilations (PET scanning etc)</li> <li>• gamma rays may be produced as a result of (nuclear) fission or fusion</li> </ul>	(6)

Level	Mark	Descriptor
	0	<ul style="list-style-type: none"> <li>No rewardable material.</li> </ul>
Level 1	1-2	<ul style="list-style-type: none"> <li>Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1)</li> <li>Presents an explanation with some structure and coherence. (AO1)</li> </ul>
Level 2	3-4	<ul style="list-style-type: none"> <li>Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1)</li> <li>Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)</li> </ul>
Level 3	5-6	<ul style="list-style-type: none"> <li>Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1)</li> <li>Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)</li> </ul>

### Summary for guidance

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 fact(s) about one radiation	<u>Possible candidate responses</u> gamma rays are (often) produced spontaneously / randomly
Level 2	3-4	<u>Additional guidance</u> Some understanding shown i.e. a limited comparison made including some facts about the production of each radiation  OR more detailed facts given about the production of one of them	<u>Possible candidate responses</u> radio waves produced in wires and gamma produced in nucleus  radio waves produced by AC in wires
Level 3	5-6	<u>Additional guidance</u> Understanding is detailed and fully developed.  detailed comparison made with linked facts about the production of each  (one radiation may have significantly more detail than the other but both should feature for level 3)	<u>Possible candidate responses</u> radio waves produced by electrons oscillating in wires; gamma produced by annihilation of electrons interacting with positrons

**(Total for Question 9 = 13 marks)**



Question Number	Answer	Additional guidance	Mark
10(a)(i)	a description to include: nebula collapses (1)  under <b>gravity</b> (1) plus any one from: GPE converted into KE (1) OR (very) <b>high</b> temperatures/pressures reached (1)	allow gas/dust for nebula  allow condensing/coming together for collapses  allow gravitational force  producing (large) increase in <b>KE</b> of particles / more (frequent) collisions  Ignore references to hot / heat	<b>(3)</b>

Question Number	Answer	Additional guidance	Mark
10(a)(ii)	rearrangement <b>and</b> substitution (1)  $(m =) \frac{3.86 \times 10^{26}}{(3.00 \times 10^8)^2}$  evaluation (1)  $(m =) 4.29 \times 10^9 \text{ (kg)}$	ignore Power Of Ten (POT) error until evaluation  allow numbers that round to $4.3 \times 10^9$ (kg)  award full marks for the correct answer without working  4.3 to any other power of ten scores 1 mark	(2)

Question Number	Answer	Mark
10(b)*	<p>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.</p> <p>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.</p> <p style="text-align: center;"><b>AO1 strand 1 (6 marks)</b></p> <p><b>evidence for expansion</b></p> <ul style="list-style-type: none"> <li>• red shift</li> <li>• light from distant galaxies/stars</li> <li>• shifted to red side of em spectrum</li> <li>• (observed) wavelength of light is longer</li> <li>• showing source moving away</li> <li>• (nearly) all galaxies show this</li> <li>• Doppler effect</li> <li>• (expanding at an increasing rate / dark energy)</li> </ul> <p><b>evidence for beginning at a point</b></p> <ul style="list-style-type: none"> <li>• CMBR</li> <li>• microwave radiation left over from beginning</li> <li>• the increase of recessional velocities with distance - (extrapolating)</li> <li>• microwaves because of cooling</li> <li>• detected from all over the sky</li> </ul>	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	<ul style="list-style-type: none"><li>• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1)</li><li>• Presents an explanation with some structure and coherence. (AO1)</li></ul>
Level 2	3-4	<ul style="list-style-type: none"><li>• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1)</li><li>• Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)</li></ul>
Level 3	5-6	<ul style="list-style-type: none"><li>• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1)</li><li>• Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)</li></ul>

## Summary for guidance

Level	Mark	Additional Guidance	General additional guidance – the decision within levels
	0	No rewardable material.	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.
Level 1	1-2	<u>Additional guidance</u> some element of physics about the expansion / single point origin	<u>Possible candidate responses</u> red shift shows expansion or CMBR connected with beginning
Level 2	3-4	<u>Additional guidance</u> more detail about one piece of evidence or basic detail about two pieces of evidence	<u>Possible candidate responses</u> red shift connected with galaxies moving away (from earth observer)  CMBR to do with release of radiation at the beginning
Level 3	5-6	<u>Additional guidance</u> Understanding is detailed and fully developed. includes detail about both pieces of evidence  (one may be stronger than the other but both should feature for level 3)	<u>Possible candidate responses</u> red shift connected with galaxies moving away (from earth observer) with the further they are away the faster they are moving away  CMBR to do with release of (leftover) radiation at the beginning □ microwaves because of cooling – detected from all over the sky

Question Number:	Answer	Additional guidance	Mark
<b>10(c)</b>	rearrangement (1) $R^3 = \frac{3M}{4 \times \pi \times D}$  evaluation (1) (R =) $1.17 \times 10^4$ m	may be seen as substituted values or as the cube-root form or $R^3 = 1.59 \times 10^{12}$  allow numbers that round to $1.2 \times 10^4$ (m)  award full marks for the correct answer without working	<b>(2)</b>

**(Total for Question 10 = 13 marks)**

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