



Mark Scheme (Results)

October 2025

Pearson Edexcel International Advanced
Subsidiary level In Physics
WPH15/01A

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

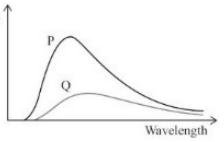
October 2025

Question Paper Log Number P87444A
Publication Code WPH15_01A_2510_MS
All the material in this publication is copyright
© Pearson Education Ltd

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.

Question Number	Answer	Mark				
1	<p>The only correct answer is D (Pushing a swing each time the swing is at its maximum height)</p> <p>A is not the correct answer, because this is a free oscillation B is not the correct answer, because this is a free oscillation C is not the correct answer, because this is a free oscillation</p>	1				
2	<p>The only correct answer is C</p> <table border="1" data-bbox="316 446 848 565"> <tr> <td data-bbox="316 446 585 493">Alpha radiation</td><td data-bbox="585 446 848 493">Gamma radiation</td></tr> <tr> <td data-bbox="316 493 585 565">High ionisation and low penetration</td><td data-bbox="585 493 848 565">Low ionisation and high penetration</td></tr> </table> <p>A is not the correct answer, because α has high ionisation & γ has high penetration B is not the correct answer, because α has high ionisation & γ has low ionisation D is not the correct answer, because γ has low ionisation</p>	Alpha radiation	Gamma radiation	High ionisation and low penetration	Low ionisation and high penetration	1
Alpha radiation	Gamma radiation					
High ionisation and low penetration	Low ionisation and high penetration					
3	<p>The only correct answer is B (It is always in the opposite direction to the velocity)</p> <p>A is not the correct answer, because this would sometimes increase the amplitude C is not the correct answer, because this would sometimes increase the amplitude D is not the correct answer, because this would increase the amplitude</p>	1				
4	<p>The only correct answer is C $\left(\frac{1}{1.37 \times 10^{10} \times 3.15 \times 10^7} \right)$</p> <p>A is not the correct answer, because conversion y to s is incorrect B is not the correct answer, because conversion y to s is incorrect and units not s^{-1} D is not the correct answer, because this does not have units s^{-1}</p>	1				
5	<p>The only correct answer is A (damped)</p> <p>B is not the correct answer, because the oscillation is not forced C is not the correct answer, because the oscillation is not free D is not the correct answer, because this is not resonance</p>	1				

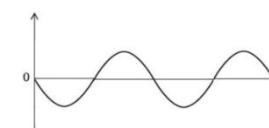
6	<p>The only correct answer is B (The distance of star X is half the distance of star Y from Earth)</p> <p>A is not the correct answer, because $I \propto \frac{1}{d^2}$</p> <p>C is not the correct answer, because $I \propto \frac{1}{d^2}$</p> <p>D is not the correct answer, because $I \propto \frac{1}{d^2}$</p>	1						
7	<p>The only correct answer is C</p>  <p>A is not the correct answer, because intensity is plotted against frequency</p> <p>B is not the correct answer, because intensity is plotted against frequency</p> <p>D is not the correct answer, because the hotter star has a higher peak</p>	1						
8	<p>The only correct answer is A</p> <table border="1" data-bbox="707 659 1290 801"> <thead> <tr> <th data-bbox="707 659 931 770">Distance between Earth and Sun</th><th data-bbox="931 659 1156 770">Gravitational force</th><th data-bbox="1156 659 1290 770">Gravitational potential energy</th></tr> </thead> <tbody> <tr> <td data-bbox="707 770 931 801">least</td><td data-bbox="931 770 1156 801">greatest</td><td data-bbox="1156 770 1290 801">greatest</td></tr> </tbody> </table> <p>B is not the correct answer, because force is greatest when distance is least</p> <p>C is not the correct answer, because magnitude of PE is least when distance is greatest</p> <p>D is not the correct answer, because force is least when distance is greatest</p>	Distance between Earth and Sun	Gravitational force	Gravitational potential energy	least	greatest	greatest	1
Distance between Earth and Sun	Gravitational force	Gravitational potential energy						
least	greatest	greatest						
9	<p>The only correct answer is C ($\sqrt{2}$)</p> <p>A is not the correct answer, because $T \propto \sqrt{m}$</p> <p>B is not the correct answer, because $T \propto \sqrt{m}$</p> <p>D is not the correct answer, because $T \propto \sqrt{m}$</p>	1						
10	<p>The only correct answer is A ($\frac{1}{\sqrt{3}}$)</p> <p>B is not the correct answer, because $\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$ and T is constant</p> <p>C is not the correct answer, because $\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$ and T is constant</p> <p>D is not the correct answer, because $\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$ and T is constant</p>	1						

Question Number	Answer	Additional Guidance	Mark
11	Use of $g = \frac{GM}{r^2}$ $g = 5.8 \text{ N kg}^{-1}$ (1)	(1) allow unit of m s^{-2} <u>Example of calculation</u> $g = \frac{6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \times 7.0 \times 10^{24} \text{ kg}}{(1.4 \times 6.4 \times 10^6 \text{ m})^2}$ $= 5.82 \text{ N kg}^{-1}$	2
	Total for question 11		2

Question Number	Answer	Additional Guidance	Mark
12	<p>Use of $\frac{\Delta f}{f} \approx \frac{v}{c}$ (1)</p> <p>$v = 1.1 \times 10^5 \text{ m s}^{-1}$ (1)</p>	<p>must have $6.9124 (\times 10^{14})$ in the denominator allow use of $z = \frac{\Delta f}{f}$ and $z = \frac{v}{c}$</p> <p><u>Example of calculation</u></p> $\frac{v}{3.0 \times 10^8 \text{ m s}^{-1}} \approx \frac{(6.9149 - 6.9124) \times 10^{14} \text{ Hz}}{6.9124 \times 10^{14} \text{ Hz}}$ $v = \frac{3.0 \times 10^8 \text{ m s}^{-1} \times (6.9149 - 6.9124) \times 10^{14} \text{ Hz}}{6.9124 \times 10^{14} \text{ Hz}}$ $\therefore v = 1.09 \times 10^5 \text{ m s}^{-1}$	2
	Total for question 12		

Question Number	Answer		Additional Guidance	Mark
13(a)	See an expression for gravitational potential energy, $\frac{GMm}{r}$ Equate gravitational potential energy expression to kinetic energy expression with algebra to get required expression	(1) (1)	Do not credit $mg\Delta h$ <u>Example of derivation</u> $\frac{1}{2}mv^2 = \frac{GMm}{R}$ $v^2 = \frac{2GM}{R}$ $v = \sqrt{\frac{2GM}{R}}$	2
13(b)	Use of $v = \sqrt{\frac{2GM}{R}}$ with $v = c$ $R = 1.3 \times 10^{10} \text{ m}$	(1) (1)	 <u>Example of calculation</u> $R = \frac{2 \times 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \times 4.30 \times 10^6 \times 1.99 \times 10^{30} \text{ kg}}{(3.0 \times 10^8 \text{ m s}^{-1})^2}$ $R = 1.27 \times 10^{10} \text{ m}$	2
	Total for question 13			4

Question Number	Answer	Additional Guidance	Mark
14	<p>Substitutes into $V = \frac{4}{3}\pi r^3$ to calculate volume Or Substitutes $V \propto r^3$</p> <p>Conversion of temperature to K</p> <p>Use of $pV = NkT$</p> <p>Temperature = 88°C Or Temperature = 361 K</p> <p>$88\text{ }(\circ\text{C}) < 95\text{ }(\circ\text{C})$, so the temperature of the air in the balloon does not become equal to the temperature of the water Or Comparison of their calculated value with corresponding value for final situation and correct conclusion made</p>	<p>(1) <u>Example of calculation</u> $V = \frac{4}{3}\pi \left(\frac{11.5 \times 10^{-2} \text{ m}}{2} \right)^3 = 7.963 \times 10^{-4} \text{ m}^3$</p> <p>(1) $\frac{p}{Nk} = \frac{T}{V} = \frac{(273 + 22) \text{ K}}{7.963 \times 10^{-4} \text{ m}^3} = 3.705 \times 10^5 \text{ K m}^{-3}$</p> <p>(1) $V = \frac{4}{3}\pi \left(\frac{12.3 \times 10^{-2} \text{ m}}{2} \right)^3 = 9.743 \times 10^{-4} \text{ m}^3$</p> <p>(1) $T = 3.705 \times 10^5 \text{ K m}^{-3} \times 9.743 \times 10^{-4} \text{ m}^3 = 360.9 \text{ K}$ Temperature = $(361 - 273) = 88.0^\circ\text{C}$</p> <p>$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ and $V = \frac{4}{3}\pi r^3$, so $\frac{r_1^3}{T_1} = \frac{r_2^3}{T_2}$</p> <p><u>Alternative method</u> $T_2 = T_1 \times \frac{r_2^3}{r_1^3}$</p> $T_2 = (273 + 22) \text{ K} \times \left(\frac{6.15 \text{ cm}}{5.75 \text{ cm}} \right)^3 = 360.9 \text{ K}$	5
Total for question 14			5

Question Number	Answer	Additional Guidance	Mark
15(a)(i)	<p>x is the displacement from the equilibrium position (1)</p> <p>For equilibrium position accept: undisplaced point / position or fixed point / position or central point / position)</p>		1
15(a)(ii)	The (resultant) force is in the opposite direction to the displacement (1)	Do not accept force is in the direction of the equilibrium position	1
15(a)(iii)	<p>Use of $\omega = \frac{2\pi}{T}$ (1)</p> <p>Use of $v = \omega A \sin \omega t$ with $\sin \omega t = 1$ (1)</p> <p>Use of $E_k = \frac{1}{2}mv^2$ (1)</p> <p>$E_{k,\max} = 1.1 \times 10^{-3} \text{ J}$ (1)</p> <p>Alternative solution:</p> <p>Use of $T = 2\pi \sqrt{\frac{m}{k}}$</p> <p>Use of $F = k\Delta x$ to calculate F</p> <p>Use of $W = \frac{1}{2}F\Delta x$</p> <p>$E_{k,\max} = 1.1 \times 10^{-3} \text{ J}$</p>	<u>Example of calculation</u> $\omega = \frac{2\pi}{0.64 \text{ s}} = 9.82 \text{ rad s}^{-1}$ $v = 9.82 \text{ rad s}^{-1} \times 3.5 \times 10^{-2} \text{ m} \times 1 = 0.344 \text{ m s}^{-1}$ $E_{k,\max} = \frac{1}{2} \times 1.8 \times 10^{-2} \text{ kg} \times (0.344 \text{ m s}^{-1})^2 = 1.07 \times 10^{-3} \text{ J}$	4
15(b)	<p>Minus sine graph drawn (1)</p> <p>Sinusoidal shape with approximately the same period as acceleration graph [amplitude should be approximately constant; the magnitude of the amplitude is not important] (1)</p>	<u>Example of graph</u> 	2
Total for question 15			8

Question Number	Answer	Additional Guidance	Mark	
16(a)	<p>EITHER</p> <p>Use of $\rho = \frac{m}{V}$</p> <p>Use of $\Delta E = mc\Delta\theta$</p> <p>$\Delta E = 42 \text{ kJ}$</p> <p>Time from graph [270 s] and compared with 300 s and consistent conclusion Or Energy from graph for 300 s [46 kJ] and compared with 42 kJ and consistent conclusion.</p> <p>OR</p> <p>Use of $\Delta E = mc\Delta\theta$ with energy from graph for 300 s [46 kJ]</p> <p>Use of $\rho = \frac{m}{V}$</p> <p>Final temperature = 62°C</p> <p>Calculated final temperature compared with 65°C and consistent conclusion</p>	<p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(1)</p>	<p><u>Example of calculation</u></p> $m = 960 \text{ kg m}^{-3} \times 3.0 \times 10^{-4} \text{ m}^3 = 0.288 \text{ kg}$ $\Delta E = 0.288 \text{ kg} \times 4200 \text{ J kg}^{-1} \text{ K}^{-1} \times (100 - 65) \text{ K} = 4.23 \times 10^4 \text{ J}$ <p>$t = 270 \text{ s}$ for 42 kJ $270 \text{ s} < 300 \text{ s}$, so claim is not accurate</p>	4
16(b)	<p>The rate of decrease of temperature would increase Or Less energy transferred (as temperature changes by 35°C)</p> <p>Hence the time taken for the colour to change would decrease [MP2 dependent upon MP1]</p>	<p>(1)</p> <p>(1)</p>	<p>MP1 accept temperature would decrease more quickly Ignore references to graph for MP2</p>	2
	Total for question 16		6	

Question Number	Answer	Additional Guidance	Mark
17(a)	Top line correct Bottom line correct	(1) (1) ${}_{38}^{90}\text{Sr} \rightarrow {}_{39}^{90}\text{Y} + {}_1^0\beta^- + {}_0^0\nu_e$	2
17(b)(i)	Use of $\lambda t_{1/2} = \ln 2$ Use of $A = \lambda N$ $N = 1.2 \times 10^{26}$	(1) (1) (1) $\lambda = \frac{\ln 2}{9.5 \times 10^8 \text{ s}} = 7.30 \times 10^{-10} \text{ s}^{-1}$ $N = \frac{8.5 \times 10^{16} \text{ Bq}}{7.30 \times 10^{-10} \text{ s}^{-1}} = 1.16 \times 10^{26}$	3
17(b)(ii)	Use of $A = A_0 e^{-\lambda t}$ Conversion between seconds and years $t = 100$ years, this is less than 1000 (years), so the suggestion is inaccurate Or After 1000 years, $A = 8.8 \times 10^6 \text{ Bq}$ which is less than $8.0 \times 10^{15} \text{ (Bq)}$ so the suggestion is inaccurate (allow ecf for λ from (i))	(1) (1) (1) $\begin{aligned} \text{Example of calculation} \\ 8.0 \times 10^{15} \text{ Bq} &= 8.5 \times 10^{16} \text{ Bq} \\ &\times e^{-7.30 \times 10^{-10} \text{ s}^{-1} \times t} \\ \ln\left(\frac{8.0 \times 10^{15} \text{ Bq}}{8.5 \times 10^{16} \text{ Bq}}\right) \\ &= -7.30 \times 10^{-10} \text{ s}^{-1} \times t \\ \therefore t &= \frac{2.36}{7.30 \times 10^{-10} \text{ s}^{-1}} = 3.24 \times 10^9 \text{ s} \\ \therefore t &= \frac{3.24 \times 10^9 \text{ s}}{3.15 \times 10^7 \text{ s year}^{-1}} = 103 \text{ years} \end{aligned}$	3
Total for question 17			8

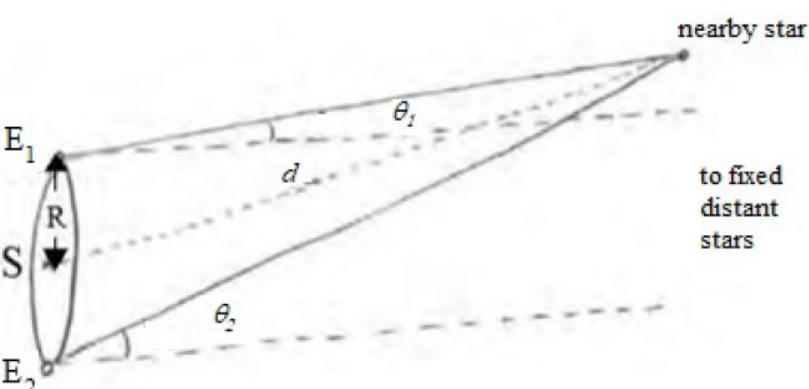
Question Number	Answer	Additional Guidance	Mark
18(a)(i)	Reverse temperature scale on horizontal axis including units Logarithmic scale values	(1) Accept °C and K but not °K (1) Minimum of 3 values Maximum range of values for x -axis is 60 000 K > T > 2 000 K	2
18(a)(ii)	Red giant stars are present top right of diagram Or The upper part of the main sequence is missing White dwarf stars are present bottom left of diagram	(1) Accept “red super giants” but not “super giants” on its own (1) MAX 1 mark There are red giant and white dwarf stars on the diagram)	2
18(b)(i)	Use of $\lambda_{\text{max}}T = 2.898 \times 10^{-3} \text{ m K}$ Calculates surface area (using $A = 4\pi r^2$) Use of $L = \sigma AT^4$ Ratio of star radii = 24 Or $25r_{\text{Sun}} = 1.74 \times 10^{10} \text{ m}$ Or $\frac{r_{\text{Arc}}}{25} = 6.6 \times 10^8 \text{ m}$ Comparison of calculated value with appropriate value and consistent conclusion.	(1) <u>Example of calculation</u> (1) $T = \frac{2.898 \times 10^{-3} \text{ m K}}{6.76 \times 10^{-7} \text{ m}} = 4290 \text{ K}$ (1) $A = \frac{L}{\sigma T^4}$ $= \frac{6.54 \times 10^{28} \text{ W}}{5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4} \times (4290 \text{ K})^4}$ $= 3.41 \times 10^{21} \text{ m}^2$ (1) $r = \sqrt{\frac{3.41 \times 10^{21} \text{ m}^2}{4\pi}} = 1.65 \times 10^{10} \text{ m}$ $\frac{r}{r_{\text{Sun}}} = \frac{1.65 \times 10^{10} \text{ m}}{6.96 \times 10^8 \text{ m}} = 23.7$ 24 ≈ 25, so website claim is accurate Or 24 < 25, so website claim is not accurate	5

18(b)(ii)	Arcturus would be to the right (of the Sun), as it has a lower (surface) temperature than the Sun [Allow position corresponding to temperature of Arcturus calculated in (i)] Arcturus would be higher up (than the Sun) as it has a larger radius / luminosity (than the Sun)	(1) (1)	[Accept above and to the right (of the Sun) Or in the red giant region for MAX 1 mark] Accept higher up and bigger (than the Sun)	2
	Total for question 18			11

Question Number	Answer	Additional Guidance	Mark								
19(a)	<p>(The balloon displaces air so) an upthrust acts on the balloon Or Upward force = $V\rho_A g$ (1)</p> <p>Weight of helium/balloon acts in opposite direction to upthrust Or Downward force = $V\rho_{He}g$ (1)</p> <p>Upthrust > weight (1)</p> <p>Resultant force acts on the balloon (and balloon accelerates upwards) (1)</p>	<p>Allow “downwards” for “opposite direction to upthrust”</p> <p>May be seen as $U > W$</p>	4								
*19(b)	<p>Indicative content</p> <p>IC1 When temperature rises (average) kinetic energy of atoms/molecules increases</p> <p>IC2 (Mean) velocity/moment of atoms/molecules increases</p> <p>IC3 Atoms/molecules make more frequent collisions with balloon</p> <p>IC4 Rate of change of momentum during collisions with balloon increases</p> <p>IC5 Force (on balloon) increases</p> <p>IC6 $p = \frac{F}{A}$ so pressure increases, (and balloon expands)</p>	<table border="1"> <tr> <td>Number of marks awarded for structure of answer and sustained line of reasoning</td> <td></td> </tr> <tr> <td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td> <td>2</td> </tr> <tr> <td>Answer is partially structured with some linkages and lines of reasoning</td> <td>1</td> </tr> <tr> <td>Answer has no linkages between points and is unstructured</td> <td>0</td> </tr> </table>	Number of marks awarded for structure of answer and sustained line of reasoning		Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	6
Number of marks awarded for structure of answer and sustained line of reasoning											
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2										
Answer is partially structured with some linkages and lines of reasoning	1										
Answer has no linkages between points and is unstructured	0										
	Total for question 19		10								

Question Number	Answer	Additional Guidance	Mark
20(a)	<p>When binding energy increases energy is released (1)</p> <p>Binding energy (per nucleon) increases for ^{235}U (undergoing fission) (1)</p> <p>But binding energy (per nucleon) decreases for ^4He (undergoing fission) (1)</p>	MAX 1 if not other mark scored Energy is released when the total mass decreases	3
20(b)(i)	<p>Mass defect calculated (1)</p> <p>Conversion between u and kg (1)</p> <p>Use of $\Delta E = c^2 \Delta m$ (1)</p> <p>Conversion between J and MeV (1)</p> <p>Binding energy per nucleon calculated (1)</p> <p>B.E./nucleon = 8.5 (MeV) [to at least 2 sf] (1)</p>	<p>Allow 1.67×10^{-27} kg in conversion for MP2</p> <p><u>Example of calculation</u></p> <p>Total mass of nucleons = 28×1.00728 u + $(56-28) \times 1.00867$ u = 56.4466 u</p> <p>$\Delta m = 55.93494$ u - 56.4466 u = 0.51166 u</p> <p>Mass defect = 0.51166 u $\times 1.66 \times 10^{-27}$ kg u$^{-1}$ = 8.4936×10^{-28} kg</p> <p>$\Delta E = 8.4936 \times 10^{-28}$ kg $\times (3.0 \times 10^8 \text{ m s}^{-1})^2 = 7.6442 \times 10^{-11}$ J</p> <p>Energy released = $\frac{7.6442 \times 10^{-11} \text{ J}}{1.60 \times 10^{-13} \text{ J MeV}^{-1}}$ = 477.8 MeV</p>	6

		$B.E./\text{nucleon} = \frac{477.8 \text{ MeV}}{56} = 8.53 \text{ MeV}$	
20(b)(ii)	Evidence of working B.E. / nucleon for U in range $(7.2 \rightarrow 8.0) \text{ MeV}$	(1) (1)	2 <u>Example of calculation</u> B.E./nucleon for Fe = 8.6 units B.E./nucleon for U = 7.5 units B.E./nucleon for Fe = $\frac{7.5}{8.6} \times 8.5 \text{ MeV} = 7.4 \text{ MeV}$
	Total for question 20		11

Question Number	Answer	Additional Guidance	Mark	
21(a)	<p>Determine angular displacement of the star against background of distant / fixed stars over a 6 month period</p> <p>(1)</p> <p>Trigonometry is used to calculate the distance to the star</p> <p>(1)</p> <p>The diameter / radius of the Earth's orbit about the Sun must be known / measured</p> <p>(1)</p> <p>Marks may be obtained from a suitably annotated diagram:</p>  <p>Diagram should indicate the Earth in two positions at opposite ends of a diameter, with lines drawn heading towards a point with a relevant angle marked</p>	<p>Accept diameter of the Earth's orbit instead of reference to 6 month period</p> <p>[Do not accept Pythagoras]</p> <p>[Accept the symmetrical diagram seen in many textbooks]</p>	3	
21(b)(i)	<p>ANY TWO FROM:</p> <p>Small radius Or small surface area Very dense</p>	<p>(1)</p> <p>(1)</p>	<p>Accept small volume</p>	2

	Very high (surface) temperature Low luminosity No fusion takes place	(1) (1) (1)	Accept very hot	
21(b)(ii)	Determine intensity of supernova (as observed from Earth) [Allow “flux” for “intensity”] Luminosity of supernova is known Use inverse square law to calculate distance (to galaxy / supernova) [Allow reference to $I = \frac{L}{4\pi d^2}$ if I and L are defined]	(1) (1) (1)	Accept standard candle for supernova for all MP	3
21(c)(i)	EITHER $\frac{GMm}{r^2}$ equated to $m\omega^2 r$ Use of $\omega = \frac{2\pi}{T}$ Required height is total distance – radius of Earth Height = 3.6×10^7 m OR $\frac{GMm}{r^2}$ equated to $\frac{mv^2}{r}$ Use of $v = \frac{2\pi r}{T}$ Required height is total distance – radius of Earth Height = 3.6×10^7 m	(1) (1) (1) (1) (1) (1) (1) (1) (1)	<u>Example of calculation</u> $\omega = \frac{2\pi}{(24 \times 60 \times 60) \text{ s}} = 7.27 \times 10^{-5} \text{ rad s}^{-1}$ $r = \sqrt[3]{\frac{GM}{\omega^2}}$ $= \sqrt[3]{\frac{6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \times 6.0 \times 10^{24} \text{ kg}}{(7.27 \times 10^{-5} \text{ rad s}^{-1})^2}}$ $= 4.23 \times 10^7 \text{ m}$ $h = 4.23 \times 10^7 \text{ m} - 6.4 \times 10^6 \text{ m}$ $= 3.59 \times 10^7 \text{ m}$	4
21(c)(ii)	The lasers will act as sources of known luminosity/power Or the lasers are at a known distance	(1)	[Accept ‘intensity’ for ‘luminosity’] [Accept “standard candle” for “sources of known luminosity”]	1
	Total for question 21			13