AQA

A-LEVEL
Physics

PHYA5/2AR – Astrophysics
Mark scheme

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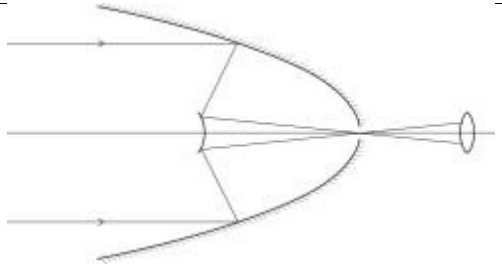
Version 1: Final mark scheme

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Answers	Additional Comments/Guidance	Mark	ID details
1 (a) (i)	largest distance = 2.57 + 1 = 3. 57 AU✓ 3.57 AU = 3.57 x 1.5 x 10^{11} m = 5.36 x 10^{11}(m) ✓	The first mark is for the correct distance in AU The second mark is for the correct conversion to metres. Allow c.e.	2	
1(a) (ii)	angle = s /r = 5.4 x 10^{5} / 1.73 x 10^{11} ✓ = 3.12 x 10^{-6} (rad) ✓	Working needs to be shown for the first mark. At least two sf needed for final mark.	2	
1 (b) (i)	mirrors correct ✓ primary concave, secondary convex. No shading needed. Primary mirror should be continuous i.e. not two mirrors If no hole, evidence can be given by rays passing through rays correct ✓ rays must cross after the secondary mirror	 The lens does not need to be included	2	

1 (b) (ii)	angular resolution = λ / D D = 1 x 10^{-6}/3.3 x 10^{-7} ✓ D = 3.0 m 2 sf needed✓	Allow use of factor of 1.22 Allow 1 sf if justified by discussion of approximate nature of calculation.	2	
1 (c)	Minimum angular resolution is better/smaller than the size of the asteroid. ✓ Details of about 1/10 the angular size of Vesta/ 50km can be seen. ✓	The first mark is for qualitative comparison, the second for the quantitative analysis.	2	
Total			10	

Question				ID details
2 (a)	Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 4 and apply a 'best-fit' approach to the marking. The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidates answer should be assessed holistically. The answer will be assigned to one of 3 levels according to the following criteria:			
0 marks	**Level 1 (1-2 marks)**	**Level 2 (3-4 marks)**	**Level 3 (5-6) marks**	
	Lower level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. Calculations: No relevant calculations. At 1 mark the time period may be quoted as 2 days rather than four. Discussion Only one graph discussed (or both very poorly).	Intermediate level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and no fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Calculations: Some attempt to use Doppler equation. At four marks there may be only a couple of minor errors. Discussion: Correctly links at least one graph to the	High level (good to excellent): 5 or 6 marks. The information conveyed by the answer is clearly organised, logical and coherent using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Calculations: Doppler equation applied correctly. (perhaps a minor error at 5 marks) At the highest level, the use of 4 days and velocity to give the radius may be seen. Discussion:	

	At 1 mark there may some attempt to discuss eclipsing or going towards/away. At 2 marks one discussion will be more correct.	movement of the two stars in terms of eclipsing or movement relative to each other and the Earth.	2 graphs discussed. Mostly correct. At 5 marks there may be some minor incorrect statements – eg referring to red shift rather than Doppler shift.	
	Examples of the points made in the response The explanations expected in a good answer should include most of the following physics ideas The time period , T, is the time from the first dip in the light curve to the third dip. (I) This is approximately 4 days (L) This is one full cycle for the wavelength graph.(I) One full cycle is approximately 4 days.(I) When one star passes in front of the other the amount of light received changes. (L) The brightest (lowest value of) apparent magnitude occurs when both stars can be seen. (I) The dips occur when one star is in front of the other. (I) The similarity in the dips suggests that both stars have similar temperatures/sizes (H) The variation in wavelength is due to the Doppler effect. (I) The peaks and troughs occur when the stars are moving at their greatest velocity away from / towards us.(H) The biggest change in wavelength is 656.52 nm - 656.28 nm = 0.24 nm (I)		**extra information** The letter next to each statement suggests the minimum level of answer the statement may be seen in.	

	The orbital speed,v, is therefore $\Delta\lambda$ x c /λ (I) = 0.24 x 3 x 108/656.28 = 1.1 x 10^5 ms-1(H) The orbital radius is therefore v/(2π/T) = 6.1 x 10^9 m (H)			
2(b)	The temperature (9200K) indicates that the star is in spectral class A. ✓ Hydrogen Balmer lines are strongest in A class stars and therefore would be more easily measured. ✓	Reference to class A not essential if it is clear that stars contain hydrogen in n=2 state.	2	
2 (c)	m – M = 5 log (d/10) d (in parsec) = 7.7 x 10^{17} /3.08 x 10^{16} = 25 pc ✓ dimmest m = 1.981 ✓ dimmest M = 1.981 – 5 log(25/10) = -0.009 ✓	Allow range 1.980 to 1.982 for m Allow c.e. for either d or m. If both incorrect, no marks are awarded.	3	
Total			11	

Question	**Answers**	**Additional Comments/Guidance**	**Mark**	**ID details**
3 (a) (i)	λ_{max} T = 0.0029 λ_{max} = 180 x 10^{-9} m ✓	Allow range for wavelength 170nm to 190nm correct 150nm to 200nm incorrect but treat as a.e. Anything else treat as PE –first two marks not	3	

	T = 0.0029/180 x 10^{-9} = 1.6 x 10^{4} ✓ K ✓	awarded. Allow kelvin for unit. But not degrees kelvin.		
3(a) (ii)	P = σAT^4 A = P/σT^4= 4.2 x 10^{24} /(5.67 x 10^{-8} x (1.6 x 10^4)^4)✓ = 1.1 x 10^{15} m^2 r = $\sqrt{}$(A/4π) = 9.5 x 10^6 m ✓	Allow c.e. for T from ai If formula wrong treat as PE – no marks awarded. Note: this is true if the incorrect equation for A is used within the power equation.	2	
3(b) (i)	dwarf ticked		1	
3(b) (ii)	It has a high temperature ✓ But is relatively small, so it will have a low absolute magnitude ✓ (This puts it into the bottom left region of the HR diagram)	Allow low power output for small. Allow high power output for large Marks can be awarded for ruling out other two. If white dwarf not ticked in bi :- Giant stars – cool and big Main sequence – either cool and small or hot and big for 2 marks Or 'middling temperature and size' for 1 mark	2	
Total			8	

Question	**Answers**	**Additional Comments/Guidance**	**Mark**	**ID details**
4 (a)	An object with an escape velocity greater than the speed of light ✓	Ignore references to singularity and density etc. Allow gravity so strong light cannot escape	1	
4 (b)	Mass of black hole = 1 x 10^{10} x 1.99 x 10^{30} = 2 x 10^{40} kg ✓	M correct for the first mark	2	

	Use of R = $2GM/c^2$ = $2 \times 6.67 \times 10^{-11} \times 2 \times 10^{40} / (3.00 \times 10^8)^2$ = 3×10^{13} m ✓ allow 2.9 or 2.95 etc	Final answer correct for the second mark. Allow ce for the mass No sf penalty		
4 (c)	V= Hd v (in kms^{-1}) = 6300 D (in MPc) = $3.3 \times 10^8 / 3.26 \times 10^6$ = 101 ✓ H = v/d = 6300 / 101 = 62 kms^{-1} Mpc^{-1} ✓ Age of Universe = 1/H = 1/62 = 1.6×10^{-2} Mpc s km^{-1} = $1.6 \times 10^{-2} \times 3.1 \times 10^{16} \times 10^6 / 10^3$ = 5.0×10^{17} s ✓	Alternatively Age of universe = 1/H = D/v = $3.3 \times 10^8 \times 9.47 \times 10^{15}$✓/$6.3 \times 10^6$✓ = 5.0×10^{17} s✓ The first mark is for calculating D, the second for substituting correctly to find H The third is for determining 1/H in seconds. If other value of H used, 1 mark max.	3	
Total			6	