AQA

A-level
Physics

PHA5/2A – Astrophysics
Mark scheme

2450
June 2017

Version: 1.0 Final

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.

Further copies of this mark scheme are available from aqa.org.uk

Question	Answers	Additional Comments/Guidance	Mark	ID details
1 (a) (i)	correct diagram showing four parallel co-axial rays, with outer rays brought to focus on the principal axis ✓ at a point closer to mirror than inner rays ✓	If rays do not cross on PA Or if outer rays focused further away 1 max	2	AO1
1 (a) (ii)	(use of) parabolic mirror ✓	Ignore references to 'secondary'	1	AO1
1 (b) (i)	correct diagram showing two mirrors, one concave, one convex ✓		1	AO1
1 (b) (ii)	mirror blocks light so less light hits objective mirror ✓ light diffracted passing secondary mirror affects image ✓		2	AO1
1 (c) (i)	(light collecting power is proportional to area) area of four telescopes of diameter 8.2 m = 4 π $(d/2)^2$ = 211 m^2 ✓ single telescope of this area has a diameter = 2√ (A/ π) = 16.4 m ✓ [**alternatively** light collecting power is proportional to area, area is proportion to $diameter^2$ therefore $diameter^2$ of four telescopes = $diameter^2$ of single telescope $4 \times (8.2)^2 = d^2$ ✓ d = 16.4 m ✓]	Use of 4 π r^2 Or suggestion r = d 1 max	2	AO2
1 (c) (ii)	use of $\theta = \frac{\lambda}{d}$ gives $\theta = \frac{300 \times 10^{-9}}{130}$ = 2.3 × 10^{-9} rad ✓	Condone 1 sf answer	1	**AO2**
1 (c) (iii)	Infrared		1	**AO1**

Total			**10**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
2 (a) (i)	λ_{max} = 0.0029/3750 = 7.7 x 10^{-7} m ✓		1	AO2
2 (a) (ii)	Graph with correct shape ✓ Wavelength axis labelled With peak just below 8 x 10^{-7} m. ✓	Penalise LHS cutting y-axis Condone one value – eg peak Allow ce for 2ai	2	AO1 AO2
2 (b) (i)	Use of m – M = 5 log (d/10) to give 4.08 – (-7.63) = 11.71 = 5 log (d/10) ✓ log (d/10) = 2.34 d/10 = 220 or d = 2200✓ d = 2200 pc = 7.2 x 10^3 lyr ✓	Treat conversion to lyr as skill mark, give credit for any value in pc used.	3	AO2
2 (b) (ii)	use of $P = \sigma AT^4$ and $A = 4\pi r^2$ ✓ $P_g/P_s = \sigma A_g T_g^4 / \sigma A_s T_s^4$ $= r_g^2 T_g^4 / r_s^2 T_s^4$ ✓ =5.3 x 10^5	Penalise use of r^3 Or using T for T^4 With no ecf	2	AO2
Total			**8**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3 (a) (i)	use of $\frac{\Delta\lambda}{\lambda} = -\frac{v}{c}$ to give $v = \frac{(656.35 - 656.28)}{656.28} \times 3 \times 10^8$ ✓ $= 3.2 \times 10^4\ m\ s^{-1}$ ✓	Use of 656.34 = max 1 Use of 656.21 = max 1 Use of 656.35 on bottom of equation = max 1 Allow 656.28-656.21 on top line.	2	AO2
3 (a) (ii)	circumference of orbit: = orbital speed × orbital period $= 3.2 \times 10^4 \times 8 \times 24 \times 3600$ ✓ $= 2.21 \times 10^{10}$ m (allow ce for 30 km s^{-1}) diameter: $= 2.21 \times 10^{10}/3.14 = 7.04 \times 10^9$ m ✓	Use of radius = 1 max Pot error for km to metres = 1 max	2	AO2
3 (b) (i)	8 days marked after one cycle ✓		1	AO2
3 (b) (ii)	lowest value of apparent magnitude (3.3) occurs when both stars can be seen ✓ first (smaller) dip occurs when hotter star is in front of cooler star ✓ second (larger) dip occurs when cooler star is in front of hotter star ✓	Condone brighter/dimmer for hotter/cooler	3	AO1
Total			**8**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4 (a)	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **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. The candidate states that the distance an object is away can be determined if its absolute magnitude is known and its apparent magnitude is measured. The candidate also gives a statement that the absolute magnitudes of some supernovae is known and that evidence shows that the Universe is expanding at a faster rate than when the supernovae were produced. **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not 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. The candidate states that the distance to some supernovae can be determined, but the reasoning is much more limited. There is a statement that there is evidence that suggests that the expansion of the Universe is accelerating and that there is a controversy, but they may not recognise that Hubble's Law shows that the supernovae should be brighter (ie closer). **Low 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. The candidate recognises that there is a controversy about the expansion of the Universe. They may confuse the two methods of determining distance and their explanation of why there is evidence for an accelerating Universe may be vague.		Max 6	AO1

	The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. • the absolute magnitude of (some) supernovae is known, this allows supernovae to be used as standard candles • using the inverse square law (or from values of absolute magnitudes) allows the distance to be calculated • supernovae are very bright – so they can be seen in very distant galaxies • it has taken billions of years for the light from the most distant galaxies to reach Earth; these supernovae were therefore produced when the Universe was young • measurement of red shift (to measure velocity) and use of Hubble's Law shows that these supernovae are fainter than expected • this indicates that the Universe is expanding faster now than when the supernovae exploded as the light has had to travel further to reach us than expected by a constant rate of expansion			
4 (b) (i)	use of $z = v/c$ to give $z = 1100 \times 10^3/3 \times 10^8$ $= 3(.67) \times 10^{-3}$ ✓		1	AO2
4 (b) (ii)	use of $v = Hd$ to give $d = v/H$ $= 1100/65$ ✓ $= 17$ (Mpc) ✓		2	AO2
Total			**9**	