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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6451

Specification A

PHA5/W Astrophysics

Mark Scheme

2009 examination - June series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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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Instructions to Examiners

1 Give due credit to alternative treatments which are correct. Give marks for what is correct; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the script to the Awards meeting if poor presentation forbids a proper assessment. In each paper candidates may be awarded up to two marks for the Quality of Written Communication in cases of required explanation or description. Use the following criteria to award marks:

2 marks: Candidates write legibly with accurate spelling, grammar and punctuation; the answer containing information that bears some relevance to the question and being organised clearly and coherently. The vocabulary should be appropriate to the topic being examined.

1 mark: Candidates write with reasonably accurate spelling, grammar and punctuation; the answer containing some information that bears some relevance to the question and being reasonably well organised. Some of the vocabulary should be appropriate to the topic being examined.

0 marks: Candidates who fail to reach the threshold for the award of one mark.

3 An arithmetical error in an answer should be marked AE thus causing the candidate to lose one mark. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks (indicated by ticks). These subsequent ticks should be marked CE (consequential error).

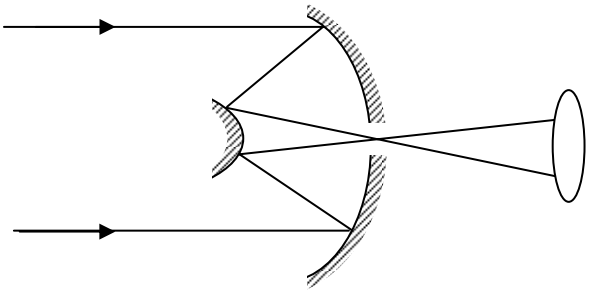
4 With regard to incorrect use of significant figures, normally two, three or four significant figures will be acceptable. Exceptions to this rule occur if the data in the question is given to, for example, five significant figures as in values of wavelength or frequency in questions dealing with the Doppler effect, or in atomic data. In these cases up to two further significant figures will be acceptable. The maximum penalty for an error in significant figures is **one mark per paper**. When the penalty is imposed, indicate the error in the script by SF and, in addition, write SF opposite the mark for that question on the front cover of the paper to obviate imposing the penalty more than once per paper.

5 No penalties should be imposed for incorrect or omitted units at intermediate stages in a calculation or which are contained in brackets in the marking scheme. Penalties for unit errors (incorrect or omitted units) are imposed only at the stage when the final answer to a calculation is considered. The maximum penalty is **one mark per question**.

6 All other procedures, including the entering of marks, transferring marks to the front cover and referrals of scripts (other than those mentioned above) will be clarified at the standardising meeting of examiners.

GCE Physics, Specification A, PHA5/W, Astrophysics

Question 1		
(a) (i)	2.12 MeV ✓	6
(ii)	(0.58 – 0.44) = 0.14 MeV ✓	
(iii)	(if reference is made to electrons/atoms changing energy levels penalise once and give a maximum mark of 2 – if a nucleus is subsequently referred to the max will not apply) • (following beta decay) nucleus/xenon/daughter may be in an excited state ✓ • excited states of the nucleus/xenon/daughter have fixed/discrete/definite/particular energies ✓ • gamma rays are given off when (the xenon nucleus) drops down energy levels/de-excites/relaxes/goes to the ground state ✓ • the gamma (photon) has a fixed/discrete/definite/particular energy ✓ • reference to $\Delta E = hf$ ✓ (give mark for any link between energy and frequency – it can be very general – no need for a formula) • many routes for de-excitation leads to many frequencies **any four points** ✓✓✓✓	
(b)	electrons are not subject to the strong nuclear force (so it is easy to interpret the scattering data) electrons are easy to obtain/accelerate electrons (can be made to) have **wavelengths** comparable to the **size** of nuclei any **two** lines ✓✓	2
(c)	(using $R = r_o A^{1/3}$ or $R_{Pb} / R_{Sn} = (A_{Pb} / A_{Sn})^{1/3}$) $R_{Pb} = 5.99 \times 10^{-15} \times (208 / 120)^{1/3}$ or $r_o = 5.99 \times 10^{-15}/120^{1/3}$ ✓ $7.1 \rightarrow 7.1 \times 10^{-15}$ m ✓ (some working with correct numbers must be seen for both marks)	2
	Total	10

Question 2			
(a)	(i)	concave primary mirror ✓ convex secondary ✓ two correct rays and eyepiece ✓ 	3
(b)	(i)	use of $\theta = \frac{\lambda}{d}$ gives $\theta = \frac{570\times10^{-9}}{0.356}$ = 1.6 × 10^{-6} rad ✓	3
	(ii)	the size of the pixels ✓	
	(iii)	ratio of the number of photons falling on a device that produce a signal to the total number of photons falling on the device ✓	
		Total	**6**

Question 3			
(a)	(i)	Megrez, highest value of apparent magnitude ✓	2
	(ii)	Alkaid, as it is in spectral class B ✓	
(b)	(i)	inherent brightness or brightness seen from 10 pc ✓	2
	(ii)	Dubhe: it appears the brightest from Earth and it is the furthest away (therefore it must have the greatest inherent brightness) ✓	
(c)	(i)	the distance from which 1AU subtends an angle of 1 second of arc	5
	(ii)	101/3.26 = 31 (parsecs) ✓	
	(iii)	use of m – M = 5 log d/10 ✓ to give M = 1.9 – 5 log (31/10) ✓ = – 0.56 ✓	
		Total	**9**

Question 4		
(a) (i)	use of $\frac{\Delta\lambda}{\lambda} = -\frac{v}{c}$ to give $v = \frac{(656.35 - 656.28)}{656.28} \times 3 \times 10^8$ ✓ $= 3.2 \times 10^4\,\text{m s}^{-1}$ ✓	**4**
(ii)	circumference of orbit = orbital speed × orbital period $= 3.2 \times 10^4 \times 8 \times 24 \times 3600$ ✓ $= 2.21 \times 10^{10}\,\text{m}$ (allow ce for $30\,\text{k m s}^{-1}$) diameter = $2.21 \times 10^{10}/3.14 = 7.04 \times 10^9\,\text{m}$ ✓	
(b) (i)	8 days marked after one cycle ✓	**4**
(ii)	lowest value of apparent magnitude (3.3) occurs when both stars can be seen ✓ first (smaller) dip occurs when brighter star is in front of dimmer star ✓ second (larger) dip occurs when dimmer star is in front of brighter star ✓	
	Total	**8**

Question 5		
(a)	Neutron star: any **two** from: extremely dense small (typically 10 km diameter) dim (spinning) radio source ✓✓ Black hole: object which has an escape velocity greater than/equal to speed of light ✓	**max 3**
(b)	use of $R_s = 2GM/c^2$ $= 2(6.67 \times 10^{-11})(40 \times 2 \times 10^{30})/(3 \times 10^8)^2$ ✓ $= 1.19 \times 10^5\,\text{m}$ ✓	**2**
	Total	**5**

Quality of Written Communication Q1 (a) and/or Q4 (b) (ii)	**2**