



General Certificate of Education (A-level)
June 2013

Physics A

PHA5A

(Specification 2450)

Unit 5A: Nuclear and Thermal Physics

Astrophysics

Final

Mark Scheme

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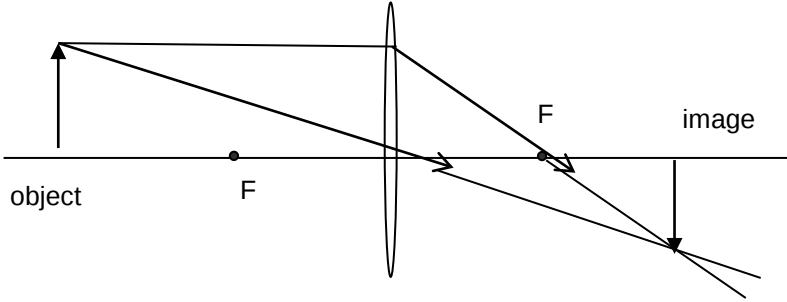
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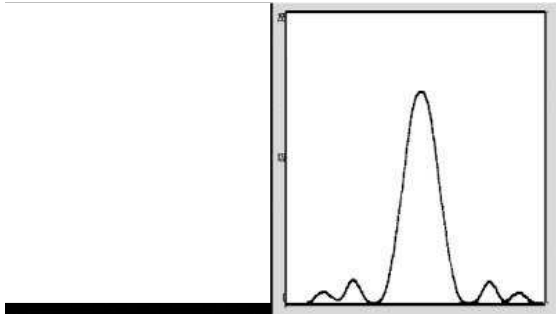
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Section B – Astrophysics

Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	a		 One construction ray correct ✓ Other construction ray to form diminished image ✓ (The parallel construction ray must pass through a labelled F) Object, image labelled correctly. ✓	3	Arrows are not essential Condone only one focus if it is the one used for the construction ray. Construction ray must have focus labelled to get the mark. Lose the second mark if the image is same size or magnified Image line is needed for second mark.
1	b		$u = 128 \text{ cm}$ $v = 200 - 128 = 72 \text{ cm}$ ✓ Use of $1/f = 1/u + 1/v$ To give $1/f = 1/128 + 1/72$ $f = 46 \text{ cm}$ ✓	2	Allow c.e. for incorrect v Condone u and v the wrong way round.
1	c		Objective. As $M = f_o/f_e$, for magnification $f_o > f_e$ ✓ As telescope length = $f_o + f_e$, lens must be objective (so that telescope not too long.) ✓	2	No credit for unsupported answer.

2	a	i	central maximum at least twice the height of adjacent maxima ✓ Subsequent narrower maxima. ✓ 	2	Allow graph to be above angle axis Any further maxima should not get bigger.
2	a	ii	Two sources will be (just) resolved if the central maximum of the diffraction pattern of one coincides ✓ with the first minimum of the other. ✓	2	Central max and first min may be labelled on diagram in 2ai If they use the term 1st maximum it must be clear that it is the central maximum Second mark is for correct part of the second diffraction pattern. Clearly labelled diagram can get both marks.
2	b		Use of $10^8)^2$ ✓ $R_s = 2GM/c^2$ $R_s = 2 \times 6.67 \times 10^{-11} \times 4.1 \times 10^6 \times 2 \times 10^{30} / (3 \times 10^8)^2$ $= 1.2 \times 10^{10} \text{ m}$ ✓ 2sf ✓	3	Allow ce for one from: missing out million; missing out mass of Sun; square in equation, but no square of speed of light in calculation Sf mark stands alone but must be a number (not just stated 2 sf)

2	c	i	use of to give $\theta = \lambda/D$ $\theta = (3 \times 10^8 / 230 \times 10^9) \checkmark / 5000 \times 10^3$ $= 2.6 \times 10^{-10} \text{ (rad)} \checkmark$	2	The first mark is for calculating the wavelength The second mark is for the use of the equation to give the final answer Allow c.e. for an a.e. in the first mark. If frequency used treat as p.e. – no marks
2	c	ii	use of to give $s = r\theta$ $\theta = 5 \times 1.2 \times 10^{10} / (25\,000 \times 9.46 \times 10^{15}) \checkmark$ $= 2.5 \times 10^{-10} \text{ (rad)} \checkmark$ which is (approximately) the answer to 2ci	2	First mark is for the angle subtended (5.12×10^{-11}) Second mark is for showing that this is 5 x answer to c(i). Alternatives: Calculate size of object that could just be resolved at this distance, and showing that this is 5 x radius of black hole.
3			The marking scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC). There are no discrete marks for the assessment of written communication but the quality of written communication will be one of the criteria used to assign the answer to one of three levels. 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.	6	There are three areas: Structure: silicon chip into pixels Function: photon incident, electron excited, electron trapped in potential well, one electron per photon, no of electrons (and therefore charge) proportional to number of incident photons, after sufficient exposure charge on each pixel measured and image produced Advantage: most will say the QE>70%
			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.		A 6 mark answer need not be "perfect" but should be substantially complete, correct and free from major errors. One of the above points may be missing. Eg charge integration

			The candidate provides a comprehensive and logical description of the structure of the CCD. The answer includes a clear description of how the light causes a release of charge and why the charge is stored. The answer also includes an explanation of what is meant by quantum efficiency and a correct value for the q.e. of a CCD. Confusion with the photoelectric effect would reduce a 6 mark answer to 5.		5 marks may have 2 missing eg silicon chip and charge integration
			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 provides a comprehensive and logical description of the CCD. The answer demonstrates some understanding of how the light is used to generate charge. The answer also includes some reference the efficiency of the CCD or other advantage		4 probably has more than 2 missing or no correct advantage
			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 demonstrates an understanding that an image is formed on the CCD and that this image is transferred to a computer.		
			Zero: Incorrect, inappropriate or no response.		
			Points that can be used to support the explanation: • The CCD is a silicon chip • The chip is divided into picture elements • Each picture element is associated with a potential well in the silicon • Incident photons are focused on the CCD • The photons cause the release of electrons within the semiconductor • The number of electrons liberated is proportional to the intensity of the light. • Electrons are trapped in the potential wells • An electron pattern is built up which is identical to the image formed on the CCD. • When exposure is complete the charge is processed to form an image.		

			Advantages: High quantum efficiency > 70% Light integration – using long exposure times to capture faint images. Device can be directly linked to computer for capture and analysis.		
4	a	i	Similarity both would appear the same <u>brightness</u> As the apparent magnitudes are the same ✓ Difference Kocab would appear orange/red, Polaris yellow/white Due to their spectral classes/ different temperatures ✓	2	Description and explanation needed for mark. Any references to same size gets zero for 1 st mark. Allow different colours + ref to spectral class for second mark If colour named, should be correct.
4	a	ii	Polaris is further from Earth: Both stars same size and Polaris is hotter ✓ As $P = \sigma AT^4$ Same A, would mean that Polaris has greater power output. ✓ Polaris must be further from Earth to appear same brightness as Kocab. ✓	3	Alternative: Polaris hotter and same size Hence, Polaris has brighter absolute magnitude/ is intrinsically brighter Same apparent brightness, therefore Polaris is further away.
4	b	i	$v = Hd$ $v = 0.025 \times 3 \times 10^5 = 7.5 \times 10^3 \text{ km s}^{-1}$ ✓ $d = 340 \times 10^6 \text{ l yr} = 340 / 3.26 \text{ Mpc} = 104 \text{ Mpc}$ ✓ $H = 7.5 \times 10^3 / 104 = 72 \text{ kms}^{-1} \text{ Mpc}^{-1}$ ✓	3	1 st mark is for calculating v 2 nd mark is for working out d in Mpc 3 rd mark is for calculating H in the correct unit.
4	b	ii	Age of Universe = $1/H$ $= 0.014 \times 10^6 \times 3.26 \times 9.5 \times 10^{15} / 1000$ $= 4.3 \times 10^{17} \text{ seconds}$ (= 13.6 billion years) Unit consistent with calculation.	3	1 st mark is for the equation 2 nd is for the answer with working 3 rd is for a time unit consistent with their answer/working