ASSESSMENT and QUALIFICATIONS ALLIANCE

# Mark scheme June 2002

# GCE

## Physics A

## Unit PHA5/W



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# Unit 5: Astrophysics

**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. However, no candidate may be awarded more than the total mark for the paper. Use the following criteria to award marks:

2 marks: Candidates write with almost faultless accuracy (including grammar, spelling and appropriate punctuation); specialist terms are used confidently, accurately and with precision.

1 mark: Candidates write with reasonable and generally accurate expression (including grammar, spelling and appropriate punctuation); specialist terms are used with reasonable accuracy.

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 A.E. 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 C.E. (consequential error).

**4** With regard to incorrect use of significant figures, normally a penalty is imposed if the number of significant figures used by the candidate is one less, or two more, than the number of significant figures used in the data given in the question. 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 S.F. and, in addition, write S.F. 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.

## Section A

**1**(a)(i) $\alpha$ (radiation) ✓

(ii) $\gamma$ (radiation) ✓ (*2*)

(b)(i) the radiation needs to pass through the body (to be detected) ✓

(ii) (otherwise) the activity of the source becomes too weak (during measurements) ✓

(iii) the decaying source may remain in the body for a long time and could cause damage ✓
[or the activity of the source will be low unless a large quantity is used ($T_{1/2} \propto 1/\lambda$)] (*3*)

(c) corrected count rate at 0.2 m (= 2550 – 50) = 2500 (c min$^{-1}$) ✓
corrected count rate at least distance (= 6000 – 50) = 5950 (c min$^{-1}$) ✓
use of $I = k\frac{I_o}{x^2}$ (or in the form $\frac{I_1}{I_2} = \left(\frac{x_2}{x_1}\right)^2$) ✓
(allow C.E. for using uncorrected count rate)
gives least distance = $0.20 \times \left(\frac{2500}{5950}\right)^{1/2}$ ✓
least distance = 0.13 m ✓ (*5*)
(*10*)

## Section B

**2**(a) diagram to show:
both focal points coinciding and labelled, with $f_o > f_e$ ✓
centre ray straight through objective, rays crossing at focal plane and proceeding to eyepiece ✓
rays refracted at eyepiece and emerge parallel to construction line ✓ (*3*)

(b)(i) ($f_o + f_e = 3.5$, and $f_o/f_e = 100$) estimate $f_o \approx 3.5$ m and $f_e \approx 0.035$ m ✓

(ii) (use of $M = \frac{\alpha'}{\alpha}$ gives) $\alpha = \frac{4.0 \times 10^{-3}}{100} = 4.0 \times 10^{-5}$ (rad) ✓
(use of $\alpha = \frac{D}{r}$ gives) $D = 4.0 \times 10^{-5} \times 1.3 \times 10^{9} = 5.2 \times 10^{4}$ km ✓
(allow C.E. for value of $\alpha$ (*3*)

(c) no chromatic aberration - mirrors do not refract light (✓)
no spherical aberration - use of parabolic mirror (✓)
no distortion - mirror can be supported more strongly (✓)
better resolving power or greater brightness - mirrors can be larger (✓)
more light gets through (image brighter) - lens absorbs more light (✓)
(any two) (*2*)
(*8*)

**3**(a)(i) (use of $\lambda_{max} T = 0.0029$ gives) $\lambda = \frac{0.0029}{6000}$ ✓
$= 4.8 \times 10^{-7}$ m ✓

(ii) values on axis : 0.5 1.0 1.5 2.0 ✓

(iii) similar shaped curve with peak shifted to right ✓ (*4*)

(b)(i) difference in absolute magnitude = 5 ✓
corresponds to × 100 difference in brightness, some reference to absolute scale ✓
Arcturus lower absolute magnitude, therefore brighter ✓

(ii) ( use of $P = \sigma A T^4$ gives) $\frac{P_A}{P_S} = 100 = \frac{A_A T_A^4}{A_S T_S^4}$ ✓

$\frac{A_A}{A_S} = 100 \times \left(\frac{6000}{5000}\right)^4$ ✓ (= 200)

max (*4*)
(*8*)

**4**(a) ratio of the number of photons falling on a device that produce a signal to the total number of photons falling on the device ✓
> 70% (for CCD) ✓ (*2*)

(b) silicon chip ✓
divided into picture elements (pixels) ✓
(light) photons incident ✓
electrons released ✓
charge or number released proportional/related to beam intensity/brightness ✓
image produced identical to electron pattern ✓
when exposure complete, charge processed to give image ✓ max (*5*)
(*7*)

**5**(a)(i) exploding (super)giant star
[or reference to a sudden, very large, short lived increase in luminosity] ✓

(ii) very dense
powerful radio source
spinning (any two) ✓ ✓
faint
strong magnetic field (*3*)

(b)(i) boundary of a black hole, where escape velocity = *c*
or light cannot escape ✓

(ii) $R = \frac{2GM}{c^2}$ ✓

$= \frac{2 \times (6.67 \times 10^{-11}) \times (10^6 \times 2.0 \times 10^{30})}{(3 \times 10^8)^2}$ ✓

$= 3.0 \times 10^9$ m ✓ (*4*)
(*7*)

The Quality of Written Communication marks are awarded primarily for the quality of answers to Q4(b) and Q5(a).