AQA

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme June 2002

GCE

Physics A

Unit PHA8/W

Unit 8: Turning Points in Physics

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) α (radiation) ✓

(ii) γ (radiation) ✓ (*2*)

(b)(i) the radiation needs to pass through the <u>body</u> (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 <u>long time</u> 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}) ✓
<u>use</u> of $I = \text{k}\frac{I_o}{x^2}$ (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)(i) an electron requires 1.2 eV of energy to escape from the metal (surface) ✓

(ii) (use of $\phi = hf_0$ gives) $f_0\ (= \frac{\phi}{h}) = \frac{1.2 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$ ✓ $(= 2.9 \times 10^{14}$ (Hz))

(use of $c = f_0\lambda_0$ gives) $\lambda_0\ (= \frac{c}{f_0}) = \frac{3.0 \times 10^{8}}{2.9 \times 10^{14}} = 1.0 \times 10^{-6}$ m ✓ (*3*)

(allow C.E. for value of f_0, if f_0 calculated)

(b)(i) energy of a (light) photon = hf ✓
a blue photon has more energy than a red photon ✓
[or has higher frequency if first mark awarded]
an electron (at the metal surface) absorbs a photon ✓
an electron needs a certain amount of energy to escape from the metal ✓
[or frequency > threshold frequency if 1st and 3rd marks awarded)
a blue photon gives an electron enough energy to escape, whereas a red photon does not ✓

(ii) classical wave theory predicted that all wavelengths/colours/frequencies of light should cause electrons to be emitted ✓
classical wave theory was rejected in favour of the photon theory ✓ max(*5*)

(*8*)

3(a)(i) wave-like nature allows an electron (to transfer) ✓
a wave can penetrate thin barriers (or gaps) ✓
(probability of) transfer of an electron (or tunnelling effect) negligible if gap is too wide ✓

(ii) with a p.d., electrons transfer from – to + only ✓
with zero p.d., equal transfer in either direction ✓
[or so a current can flow for ✓ (only)] max(*4*)

(b) (use of $\lambda = \frac{h}{mv}$ gives) $v\ (= \frac{h}{m\lambda}) = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 1.0 \times 10^{-9}}$ ✓
$= 7.3 \times 10^{+5}$ m s^{-1} ✓ (*2*)

(*6*)

4(a)(i) filament heated by an electric current
[or metal heated by nearby hot wire filament] ✓
(conduction) electrons in the metal gain sufficient
kinetic energy to leave the metal/cathode/filament ✓

(ii) temperature of filament depends on the current
[or low current so small heating effect] ✓
kinetic energy of electrons depends on temperature of filament ✓
electrons must do work (or overcome work function) to leave metal ✓
electrons have insufficient (kinetic) energy to leave
metal/cathode/filament (or overcome work function)
if the current is too low ✓ $_{max}$(*4*)

(b)(i) E_k (= eV = $1.6 \times 10^{-19} \times 4200$) = 6.7×10^{-16} (J) ✓

(ii) (use of $E_k = \frac{1}{2}mv^2$ gives) $\frac{1}{2}mv^2 = 6.7 \times 10^{-16}$ (J) ✓
(allow C.E. for value of E_k)

$$v = \left(\frac{2 \times 6.7 \times 10^{-16}}{9.1 \times 10^{-31}}\right)^{1/2}$$ ✓

$= 3.8 \times 10^7$ m s^{-1} ✓ (*4*)

(*8*)

5(a)(i) (use of $v = \frac{d}{t}$ gives) $v = \frac{240}{0.84 \times 10^{-6}} = 2.8(6) \times 10^8$ m s^{-1} ✓

(ii) actual length = 240 m ✓
(use of $l = l_0\left(1 - \frac{v^2}{c^2}\right)^{1/2}$ gives)

length in particle frame, $l = 240\left(1 - \frac{2.86^2}{3^2}\right)^{1/2}$ ✓

(allow C.E. for value of v)
l = (240 × 0.30) = 72(.5) m ✓ (*4*)

(b) time between two events depends on speed of observer
[or $t = t_0\left(1 - \frac{v^2}{c^2}\right)^{-1/2}$ or rocket time depends on speed of traveller] ✓
traveller's journey time is the proper time between start and stop
[or t_0 is the proper time or t is the time on Earth] ✓
journey time measured on Earth > journey time measured by traveller
[or $t > t_0$ or rocket time slower/less than Earth time] ✓
traveller younger than twin on return to Earth ✓ (*4*)

(*8*)

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