Mark scheme
January 2004

GCE

Physics A

Unit PHA8/W

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.

Units 5 - 9 : Section A

(this question is common to all Option Modules PHA5/W - PHA9/W)

1

(a) (on grid: first arrow to start from $^{210}_{82}\mathrm{Pb}$; arrows must be consecutive;
last arrow must end on $^{206}_{82}\mathrm{Pb}$)
arrow showing the change for an α emission ✓
arrow showing the change for a β emission ✓
correct α and two β emissions in any order ✓ (*3*)

(b) (positron emission) $^{64}_{29}\mathrm{Cu} \rightarrow ^{64}_{28}\mathrm{Ni} + \beta^{+} + \nu_e$ (+Q) ✓✓

(electron capture) $^{64}_{29}\mathrm{Cu} + ^{0}_{-1}e \rightarrow ^{64}_{28}\mathrm{Ni} + \nu_{(e)}$ (+Q) ✓✓ (*4*)

(c) (the following examples may be included)

α particles ✓
coulomb/electrostatic/electromagnetic repulsion
[or K.E. converted to P.E. (as α particle approaches nucleus)] ✓
information:
any of the following: proton number, nuclear charge,
upper limit to nuclear radius
mass of nucleus is most of the mass of atom ✓

[alternative
(high energy) electron (scattering) ✓
diffraction of de Broglie Waves by nucleus ✓
information:
any of the following: nuclear radius, nuclear density ✓] (*3*)

(*10*)

Unit 8: Section B

2

(a)(i) metal wire emits electrons when heated ✓
conduction electrons in metal gain kinetic energy when wire is heated ✓

(ii) electrons from wire would be absorbed/scattered/stopped by gas atoms
or collide with gas atoms and lose kinetic energy or speed ✓

(iii) electrons carry negative charge so anode needs to be positive (to attract them) ✓ (*4*)

(b)(i) E_k (or $\frac{1}{2}mv^2$) (= work done or eV) = $1.6 \times 10^{-19} \times 2500$ ✓
$= 4.0 \times 10^{-16}$ J ✓

(ii) $$v \left(= \left(\frac{2E_k}{m} \right)^{1/2} \right) = \left(\frac{2 \times 4.0 \times 10^{-16}}{9.11 \times 10^{-31}} \right)^{1/2}$$ ✓

$= 3.0 \times 10^{7}$ m s^{-1} ✓
(allow C.E. for value of E_k from (i)) (*4*)

(*8*)

3

(a) particles of light/corpuscles ✓
attracted towards glass surface (on entry into glass) ✓
velocity/momentum normal to surface increased ✓
velocity/momentum parallel to surface unchanged ✓ $_{max}$(*3*)

(b)(i) Newton predicted $speed_{glass} > speed_{air}$
<u>and</u> Huygens predicted $speed_{glass} < speed_{air}$ ✓

(ii) named experiment ✓
relevance explained ✓
(e.g. Young's double slit ✓ give rise to fringes/interference
which is a wave property ✓
or diffraction of light ✓ which is a wave property ✓) <u>(*3*)</u>
<u>(*6*)</u>

4

(a) electrons can behave as waves
[or electrons can tunnel across gap] ✓
waves can cross narrow gaps
[or non-zero probability of crossing gap] ✓
electron waves would be attenuated too much by large gap
[or probability of transfer negligible if gap too wide]
[or the narrower the gap, the greater the probability] ✓
electron transfer is from – to + ✓ (*4*)

(b) constant height mode: tip height constant ✓
current varies as gap width changes ✓
image built up as tip moves across surface
[or as tip moves across, a decrease (or increase)
of current means the gap widens (or narrows)] ✓
[or constant current mode: tip height altered ✓
to keep current constant ✓
image built up as above
or as tip moves across, the tip height rises
(or falls) if the surface rises or falls ✓] <u>(*3*)</u>
<u>(*7*)</u>

5

(a) Newton's laws obeyed in an inertial frame
[or inertial frames move at constant velocity relative to each other] ✓
suitable example (e.g. object moving at constant velocity) ✓ (*2*)

(b)(i) (use of $t = t_0\left(1-\frac{v^2}{c^2}\right)^{-1/2}$ gives) $t_0 = 18$ (ns) ✓

$t = 18\times10^{-9}\left(1-\frac{(0.995c)^2}{c^2}\right)^{-1/2}$ ✓

$= 1.8 \times 10^{-7}$ s ✓

(ii) time taken $\left(=\frac{\text{distance}}{\text{speed}}\right) = \left(\frac{108}{0.995\times3.0\times10^8}\right) = 3.6\times10^{-7}$ s ✓

time taken = 2 half-lives, which is time to decrease to 25% intensity ✓

[alternative scheme: (use of $l = l_0\left(1-\frac{v^2}{c^2}\right)^{1/2}$ gives) $l_0 = 108$ (m)

$l = 108\left(1-\frac{(0.995c)^2}{c_2}\right)^{1/2} = 10.8$ m ✓

time taken $\left(=\frac{10.8}{0.995c}\right) = 3.6\times10^{-8}$ s

= 2 half-lives, which is time to decrease to 25% intensity ✓] (5)

(7)

Quality of Written Communication (Q1(c) and Q4(a)) ✓✓ (2)

(2)