ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme June 2002

GCE

Physics A

Unit PA01

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Unit 1: Particles, Radiation and Quantum Phenomena

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.

1(a) 18 (protons) ✓
(37 – 18 gives) 19 (neutrons ✓ (*2*)

(b) (charge) = 2^+ or 2^- ✓
$Q = 2 \times 1.60 \times 10^{-19} = 3.2 \times 10^{-19}$ (C) ✓ (*2*)

(c)(i) neutron ✓

(ii) electron ✓ (*2*)

(d) (%) = $\dfrac{16 \times 9.11 \times 10^{-31}}{1.67 \times 10^{-27} \times 37}$ ✓ ✓ (for correct nuclear mass and substitution)
$(= 2.36 \times 10^{-4}) = 2.36 \times 10^{-2}$(%) ✓ (*3*)
(*9*)

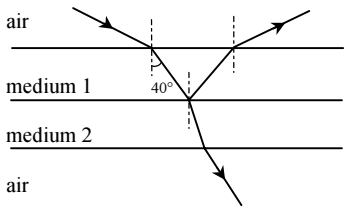
2(a)(i) to prevent absorption/deflection/interaction/collision
of the α particle (by the air) ✓

(ii) (nucleus) has a positive charge
(or same charge sign as an α particle
(nucleus) contains most of the mass (or is very dense) ✓ ✓ (any two)
(nucleus) is small compared to the separation between nuclei

(iii) electromagnetic or electrostatic or Coulomb ✓ (*4*)

(b) (particle 1) path is straighter than path of particle 2 ✓
(particle 3) path is bent more than path of particle 2, with
minimum radius of curvature near the minimum separation
and in front of the nucleus ✓ (*2*)
(*6*)

3(a)



(i) incident angle > 40° ✓
angle of refraction into medium 2 < 40° ✓
emergent ray with correct refraction ✓

(ii) reflection at boundary between media with $i \approx r$ ✓
(hence) emergent ray at approximately same angle as incident ray
and showing correct refraction ✓ max(*4*)

(b)(i) (use of $_1n_2 = \frac{\sin\theta_1}{\sin\theta_2}$ gives) $1.35 = \frac{\sin\theta_1}{\sin 40}$ ✓

$\theta_1 = 60(.2)^\circ$ ✓

(ii) $\left(\text{use of } {}_1n_2 = \frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2} \text{ gives }\right)$ $\frac{1.65}{1.35} = \frac{\sin 40}{\sin\theta_2}$ ✓ ✓

$\theta = 31.7^\circ$ ✓ (*5*)

(c) (total internal reflection) only occurs when light goes
from a higher to a lower refractive index
[or goes from a more dense to a less dense medium/material] ✓ (*1*)

(*10*)

4(a)(i) a (mercury) atom in which an orbiting electron is raised
to a higher (energy) level or orbit ✓

(ii) by electron collision ✓
with an electron accelerated by the high voltage (of the tube) ✓ (*3*)

(b) the powder absorbs light/photons (emitted from the mercury) ✓
powder atoms are excited and emit light/photons ✓
of different wavelengths (to those received) ✓
any other relevant statement such as,
electrons cascade down energy levels, emitting many wavelengths,
or the spectral lines are broadened ✓ max(*2*)

(c)(i) (use of $hf = E_1 - E_2$ gives) $f = \frac{-0.26\times10^{-18} - \left(-0.59\times10^{-18}\right)}{6.63\times10^{-34}}$ ✓

$= 5.0\times10^{14}$ Hz ✓

(ii) line joining level $n = 3$ to level $n = 2$ with arrow pointing down ✓ (*3*)

(*8*)

5(a)(i) anti ✓ baryon ✓ (hadron, one mark only)

(ii) π^o [or η^o] ✓ (*3*)

(b)(i) $u\bar{s}$ ✓ ✓ (✓ for quark + antiquark)

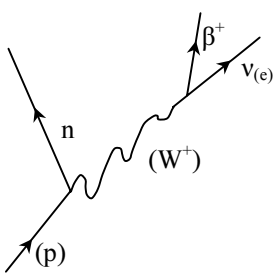
(ii) weak (interaction) ✓

(iii) $K^- \rightarrow \mu^- + \nu_\mu$ ✓

(iv) lepton ✓

(v) mass (or its generation or rest energy or stability) ✓ (*6*)

(c)



✓ ✓ ✓ (one mark for each particle)

(*3*)
(*12*)

6(a)(i) the energy of a photon does not depend on the intensity ✓
so electron gains no extra energy
[or the energy is dependent on the wavelength/frequency] ✓

(ii) the intensity of the light determines the number of photons per second ✓
one photon interacts with one electron
[or hence more interactions with electrons] ✓ max(*3*)

(b)(i) (use of $c = f\lambda$ gives) $f = \dfrac{3.00 \times 10^8}{5.10 \times 10^{-7}}$ ✓
$= 5.88 \times 10^{14}$ (Hz) ✓

(ii) (use of $E = hf$ gives) $E = 6.63 \times 10^{-34} \times 5.88 \times 10^{14}$ ✓
(allow C.E. for value of f from (i))
$= 3.9(0) \times 10^{-19}$ (J) ✓

(iii) (use of $hf = \phi + E_k$ gives) $3.9 \times 10^{-19} = 3.58 \times 10^{-19} + E_k$ ✓
(allow C.E. for value of E from (ii))
$E_k = 3.2 \times 10^{-20}$ (J) ✓

(iv) caesium ✓ (allow C.E. for value of E from (ii)) (*7*)
(*10*)

7(i) speed of electron = $\frac{2.00 \times 3.00 \times 10^{8}}{100}$ ✓ (=6.00×10^{6} (m s^{-1}))

(use of $\lambda = \frac{h}{mv}$ gives) $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 6.00 \times 10^{6}}$ ✓

$= 1.21 \times 10^{-10}$ m ✓

(ii) (use of $c = f\lambda$ gives) $f = \frac{3.00 \times 10^{8}}{1.21 \times 10^{-10}}$ ✓

(allow C.E. for value of λ from (i))

$= 2.48 \times 10^{18}$ Hz ✓ (5)

(5)

The Quality of Written Communication marks are awarded primarily for the quality of answers to Q6(a) and Q4(a)(b).