AQA

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2003

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. 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.

1

(a) 6 (protons) and 6 (electrons) ✓
8 (neutrons) ✓ (*2*)

(b)(i) $(2 \times 1.6 \times 10^{-19}) = 3.2 \times 10^{-19}$ (C) ✓

(b)(ii) 14 ✓

(b)(iii) $m = 14 \times 1.67 \times 10^{-27}$ (kg) ✓

$$\frac{Q}{m} = \left(\frac{3.2 \times 10^{-19}}{14 \times 1.67 \times 10^{-27}}\right) = 1.4 \times 10^{7} \text{ (C kg}^{-1}\text{)} \checkmark \quad (1.37 \times 10^{7} \text{ (C kg}^{-1}\text{))}$$

(allow C.E for values from (i) and (ii)) (*4*)

(6)

2

(a)(i) straight on or deflection of zero degrees ✓

(a)(ii) the atom consists mainly of open space
[or volume of nucleus is (very much) smaller than volume of the atom] ✓ (*2*)

(b) most of the mass of an atom is contained in its nucleus
[or the mass of the nucleus is greater than the mass of the α particle] ✓
the nucleus contains a positive charge ✓
the charge is concentrated at the nucleus ✓ $_{max}$(*2*)

(c)(i) electrostatic (force)
[or electromagnetic or coulomb] ✓

(c)(ii) arrow pointing away from the nucleus ✓
at the closest distance to the nucleus ✓

(c)(iii) path showing less deflection at all times (*4*)

(8)

3

(a) electron diffraction or interference ✓ (*1*)

(b) (use of $\lambda = \frac{h}{mv}$ gives) $\lambda = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times5.0\times10^{5}}$ ✓

$= 1.46\times10^{-9}$ m ✓ (*2*)

(c) $m_\mu = 207\times9.11\times10^{-31}$ (kg) ✓ $(= 1.89\times10^{-28}$ (kg))

(use of $m_e v_e = m_\mu v_\mu$, = when λ is constant, gives)

$v_\mu = \frac{9.11\times10^{-31}\times5.0\times10^{5}}{1.89\times10^{-28}}$ ✓

$= 2.4\times10^{3}$ m s^{-1} ✓ $(2.41\times10^{3}$ m s$^{-1})$ (*3*)

[or recalculate using $v = \frac{h}{m\lambda} = \frac{6.63\times10^{-34}}{1.89\times10^{-28}\times1.46\times10^{-9}}$]

(d) gain in energy or work done on particle is the same for both ✓

wavelength is inversely proportional to momentum ✓

gain in momentum is different for both ✓

the smallest mass has the largest acceleration/gain in speed ✓

[or wavelength proportional to $m^{-½}$ with constant k.e.]

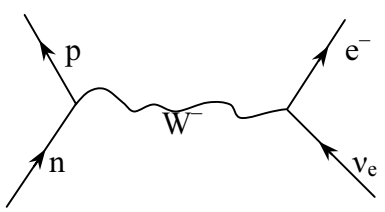
max (*2*)

(*8*)

4

(a)(i) weak interaction ✓

(a)(ii)



e$^-$ ✓

p ✓

(*3*)

(b)(i) obeyed: baryon number, lepton number, charge — any two ✓ ✓

not obeyed: strangeness ✓

(b)(ii) $K^o = \bar{s}\,d$ ✓

$\pi^+ = u\,\bar{d}$ ✓

$\pi^- = \bar{u}\,d$ ✓ (*6*)

(*9*)

5

(a)(i) electrons fall down from orbits or energy levels and emit light/photons ✓
emitted wavelengths/frequencies/photon energies are discrete ✓
[or the transitions are between definite/fixed (energy)levels ✓

(a)(ii) C → B ✓

(a)(iii) between D → C and C → A ✓
the two arrows must point down ✓ $_{max}(4)$

(b)(i) (use of $hf = E_2 - E_1$ gives)
$f = \left(\frac{2.3 \times 10^{-19}}{6.6 \times 10^{-34}}\right) = 3.5 \times 10^{14}$ Hz ✓
$f = 3.2 \times 10^{14}$ (Hz) ✓
$f = 0.3 \times 10^{14}$ (Hz) ✓

(ii) 4.6×10^{-19} (J) ✓
$\left(= \frac{4.6 \times 10^{-19}}{1.6 \times 10^{-19}}\right) = 2.9$ (eV) ✓ (5)

(9)

6

(a)(i) the minimum energy ✓
energy required to eject a (photo)electron (from the metal surface) ✓

(a)(ii) changing the metal/cathode ✓ (3)

(b) conclusion : light below a threshold frequency does not release electrons ✓
explanation: photons carry quanta of energy ✓

[or conclusion: electrons are emitted immediately the light hits the metal surface ✓
explanation : photons carry quanta of energy ✓] (2)

(c)(i) (use of $E = hf = \frac{hc}{\lambda}$ gives) $E = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{4.80 \times 10^{-7}}$ ✓ $= 4.14 \times 10^{-19}$ (J) ✓

(c)(ii) $hf = \phi + E_k$ ✓
$E_k = 4.14 \times 10^{-19} - 1.20 \times 10^{-19}$ ✓
$= 2.94 \times 10^{-19}$ (J) ✓
(allow C.E for value of E from (i)) (5)

(10)

7

(a)(i) θ_c marked ✓

(a)(ii) $\sin \theta_c = \frac{1}{n}$ ✓ $\left(= \frac{1}{1.55}\right)$

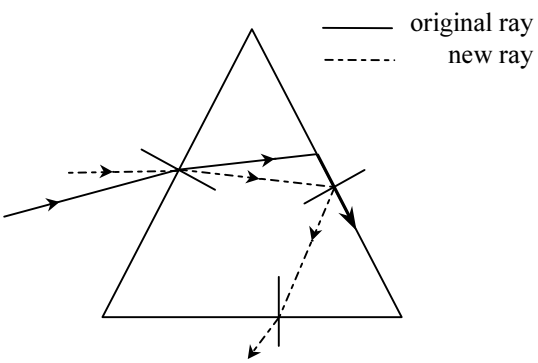
$\theta_c = 40.2^o$ ✓ (*3*)

(b) $n = \frac{\sin\theta_1}{\sin\theta_2}$ ✓

($\theta_2 = 90 - 75.2 = 14.8^o$)

θ_1 ($= \sin^{-1}\{1.55 \sin 14.8\}$) $= 23.3^o$ ✓ (*2*)

(c)



correct refraction at first surface ✓

total internal refraction at second surface ✓

correct refraction at third surface ✓ (*3*)

(*8*)

The Quality of Written Communication marks are to be awarded for the quality of answers to Q5(a) and Q6(b) ✓ ✓ (*2*)

(*2*)