ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2002

GCE

Physics A

Unit PA01

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 Awardsmeeting 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 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 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 '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.

Particles, Radiation and Quantum Phenomena

1(a) 27 (protons) and 27 (electrons) ✓
32 (neutrons) ✓ (*2*)

(b) $^{60}_{27}\mathrm{Co}$ ✓ ✓
(correct nucleon number ✓, correct symbol and proton number ✓) (*2*)

(c)(i) $^{3}_{1}\mathrm{H}$ (or $^{3}_{1}\mathrm{T}$) ✓

(ii) charge/unit mass = $\dfrac{1.60\times10^{-19}}{3\times1.67\times10^{-27}}$ [or $^{1}/_{3}\ e/m_{\mathrm{p}}$] ✓
$= 3.19\times10^{7}\ (\mathrm{C\,kg^{-1}})$ ✓ (allow C.E. from (i)) (*3*)
(*7*)

2(i) (use of $f = \dfrac{c}{\lambda}$ gives) $f = \dfrac{3.00\times10^{8}}{4.50\times10^{-7}}$ ✓ $(= 6.67\times10^{14}\ \mathrm{Hz})$
(use of $E = hf$ gives) $E = 6.63\times10^{-34}\times6.67\times10^{14}$ ✓
$= 4.42\times10^{-19}\ (\mathrm{J})$ ✓

(ii) (use of $\lambda = \dfrac{h}{mv}$ gives) $v\ (= \dfrac{h}{\lambda m}) = \dfrac{6.63\times10^{-34}}{4.50\times10^{-7}\times9.11\times10^{-31}}$ ✓
$= 1.62\times10^{3}\ \mathrm{m\,s^{-1}}$ ✓ (*5*)
(*5*)

3(a) the energy of each photon/the light increases with frequency ✓
electrons need a minimum amount of energy to leave the <u>metal</u> ✓
this amount of energy is equal to the work function ✓ (*3*)

(b)(i) (use of $v = f\lambda$ gives) $\lambda = \dfrac{3.00\times10^{8}}{9.70\times10^{14}}$ ✓
$= 3.09\times10^{-7}\ \mathrm{m}$ ✓

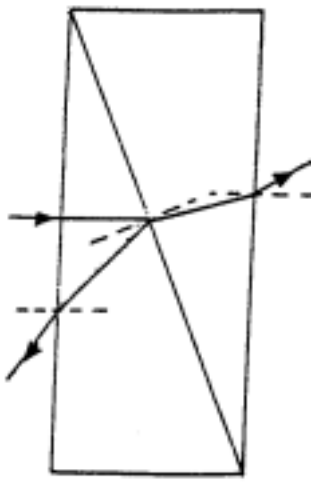
(ii) (use of $E = hf$ gives) $E = 6.63\times10^{-34}\times9.70\times10^{14}$ ✓
$= 6.43\times10^{-19}\ (\mathrm{J})$ ✓

(iii) (use of $hf = \phi + E_{\mathrm{k}}$ gives) $6.43\times10^{-19} = \phi + 2.49\times10^{-19}$ ✓
(allow C.E. from (b)(ii))
$\phi = 3.94\times10^{-19}\ (\mathrm{J})$ ✓

(iv) $\phi = \left(\dfrac{3.94\times10^{-19}}{1.60\times10^{-19}}\right) = 2.46\ (\mathrm{eV})$ ✓ (allow C.E. from (b)(iii)) (*7*)

(*10*)

4(a) Ray diagram to show:



(i) refraction towards normal at boundary ✓
emerging ray refracted away from normal ✓

(ii) reflection at boundary with $i \approx r$ ✓
emerging ray refracted away from normal ✓

(4)

(b)(i) 20^{o} ✓

(ii) $_1n_2 = \frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$ ✓

$\frac{1.60}{1.40} = \frac{\sin 20^{o}}{\sin\theta_2}$ ✓

$\theta_2 = 17(.4)^{o}$ ✓ *(4)*

(c) ($\sin\theta_c = 1/n$ gives) $\sin\theta_c = 1/1.60$ ✓

$\theta_c = 38.7^{o}$ ✓ *(2)*

(10)

5(a) (energy of each photon) $= 1.0 \times 10^{6} \times 1.6 \times 10^{-19} = 1.6 \times 10^{-13}$ (J) ✓ *(1)*

(b)

a neutron is a stable particle	false
an antineutron is an unstable particle	true

✓

a neutron has a rest mass of 1.67×10^{-27} kg	true
an antineutron has a rest mass of -1.67×10^{-27} kg	false

✓

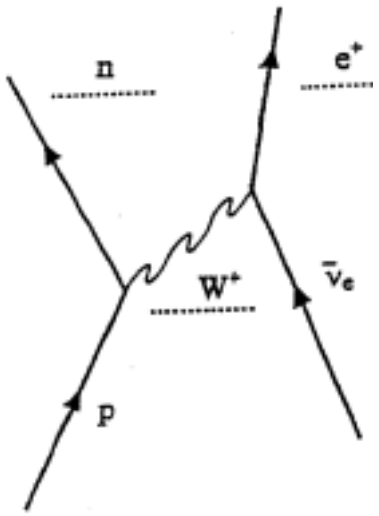
a neutron has no charge	true
an antineutron has a charge of 1.60×10^{-19} C	false

✓ *(3)*

(c)(i) (particle) gamma ray or photons ✓
(interaction) electromagnetic ✓

[or gluons or π mesons, with strong nuclear force]
[or gravitons with gravity]

(ii)



n ✓
e^+ ✓
W^+ ✓

(5)
(9)

6(a)(i) hadrons (are not fundamental) are composed of quarks
[or hadrons may interact through the strong nuclear force
(as well as all the other interactions)] ✓

(ii) (neutron) udd ✓
(neutral pion) $u\bar{u}$ or $d\bar{d}$ ✓

(iii) (kaon) meson ✓
(muon) lepton ✓ (5)

(b) proton ✓ (1)

(c)(i) (X) baryon ✓

(ii) (A) not possible ✓
charge not conserved ✓
(allow C.E. from previous line)
(B) not possible ✓
baryon number not conserved ✓
(allow C.E. from previous line) (5)
(11)

7(i) an electron is removed from the atom ✓

(ii) 2.18×10^{-18} (J) ✓

(iii) (single photon):electron loses energy [or falls] from level $n = 3$ to $n = 1$ and emits a single photon ✓

(two photons): electron falls from level $n = 3$ to $n = 2$, emitting a photon ✓
followed by a fall from level $n = 2$ to $n = 1$, emitting another photon ✓

(iv) level $n = 5$ to the ground state [or $E_5 \rightarrow E_1$] ✓

(v) (use of $hf = E_1 - E_5$ gives) $f = \dfrac{(-0.54 \times 10^{-18} - -2.18 \times 10^{-18})}{6.63 \times 10^{-34}}$ ✓

$= 2.47 \times 10^{15}$ Hz ✓ (*8*)

(*8*)

The Quality of Written Communication marks are awarded primarily for the quality of answers to Q3(a) and Q7(iii).