ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2001

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.

Unit 1: Particles, Radiation and Quantum Phenomena

1(i) protons and neutrons ✓
6p , 8n ✓
[**or** u and d quarks ✓, 20u and 22d ✓]
6 electrons ✓

(ii) electron ✓

(iii) atoms with identical numbers of protons ✓
but different numbers of neutrons ✓ (*6*)
(*6*)

2(a) Φ : work function ✓
minimum energy ✓
required to remove an electron (from the photocathode)
(or energy required to remove electron from surface) ✓

E_k: maximum kinetic energy ✓
of emitted (photo)electron (leaving the metal) ✓ (*5*)

(b)(i) 4.(0) μA ✓
doubling the intensity doubles the number of photons (per sec) ✓
(which) doubles the number of electrons released (per sec) ✓
current = rate of flow of charge ✓
assume one photon liberates one electron
(or assume all the photoelectrons are collected) ✓

(ii) ($f_o = c/\lambda_o$ gives) $f_o = 3.0 \times 10^8/350 \times 10^{-9}$
$= 8.6 \times 10^{14}$ Hz ✓ (8.57×10^{14} Hz)

($\Phi = hf_o$ gives) $\Phi = 6.6(3) \times 10^{-34} \times 8.57 \times 10^{14}$ (allow e.c.f. for f_o)
$= 5.7 \times 10^{-19}$ J ✓ (5.68×10^{-19} J) $_{max}$(*5*)
(*10*)

3(a)(i) 3 (quarks) ✓
(ii) meson ✓
(iii) they consist of quarks (or it experiences the strong nuclear force) ✓ (*3*)

(b)(i) positron or antimuon or antineutrino (or antitau) ✓

(ii) it experiences the weak interaction (**or** not the strong nuclear force) ✓ (*2*)

(c) $n \rightarrow p + \beta^-$ (or e^-) ✓ $+ \overline{\nu}_{(e)}$ ✓ (+Q) (*2*)

(d) n or d quark ✓
p or u quark ✓
$\nu_{(e)}$ ✓ (*3*)
(*10*)

4(a) need for excitation ✓
electrons in an atom can only exist at definite/discrete energy levels/orbits ✓
an electron falls from one level to another ✓
photon emitted ✓
photon has definite wavelength ✓ $_{max}$ (*3*)

(b)(i) an electron is removed from a (neutral) atom ✓

(ii) 2.2×10^{-18} (J) ✓

(iii) ($f_{min} = E/h$ gives) $f_{min} = 2.2 \times 10^{-18}/6.6(3) \times 10^{-34}$ ✓
(allow e.c.f from result of (b)(ii))
$= 3.3(2) \times 10^{15}$ Hz ✓

(iv) ionised electron gains kinetic energy (or electron breaks free of atom) ✓ (*5*)

(c) $\left(f = \frac{(E_2 - E_1)}{h} \text{gives}\right) f = \frac{5.4\times10^{-19} - 2.4\times10^{-19}}{6.6(3)\times10^{-34}}$ ✓ (= 4.52×10^{14} Hz)
($\lambda = c/f$ gives) $\lambda = 3.0 \times 10^8/4.52 \times 10^{14}$ ✓ (allow e.c.f. for f)
$= 6.6(3) \times 10^{-7}$ m ✓ (*3*)
(*11*)

5(a)(i) diagram to show:
ray refracted towards normal ✓
total internal reflection at core-cladding interface ✓
$i = r$ indicated ✓
ray continues whole length of fibre and emerges, without errors ✓

(ii) refraction ✓

(iii) use of ${}_1n_2 = \frac{\sin\theta_1}{\sin\theta_2}$ gives $\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$ ✓
$\frac{1.50}{1.45} = \frac{1}{\sin\theta_2}$ ✓
θ_C (= θ_2) = 75.2° ✓

[**or** sin $\theta_C = 1/n$ gives sin $\theta_C = n_{clad}/n_{core}$ ✓
sin θ_C = 1.45/1.50 ✓
θ_C = 75.2° ✓] $_{max}$(*7*)

(b)(i) to protect outer surface of the core ✓

(ii) greater acceptance angle ✓
enables more light to be collected
(or smaller critical angle makes escape less likely) ✓ (*3*)

(c) endoscopy or communications ✓ (*1*)
(*11*)

6(a)(i) (wave property) (electron) diffraction ✓

(ii) (particle property) photoelectric effect ✓

(iii) (wave property) interference/diffraction/refraction ✓ (*3*)

(b) (momentum of electron =) $mv = 9.11 \times 10^{-31} \times 5.0 \times 10^{6}$ ✓
$(= 4.56 \times 10^{-24}$ (kg ms^{-1}))
[($\lambda = h/mv$ gives) $\lambda = 6.6(3) \times 10^{-34}/4.56 \times 10^{-24}$ ✓
(allow e.c.f for value of mv)
$= 1.5 \times 10^{-10}$ m ✓ (1.45×10^{-10} m) (*3*)
(*6*)

7(i) α particles have a short range in air (3–5 cm)
(or to minimise collisions between α particles and air molecules) ✓

(ii) the α particles must not be absorbed by the foil
(or the α particles must only be scattered once) ✓

(iii) a majority of α particles pass straight through ✓
most α particles do not pass close enough to be deflected
(or few pass close enough to be deflected significantly) ✓

atoms consist mainly of open space ✓
nuclei are very small
(or nucleus much smaller than the atom) ✓
the nucleus is massive
(or most of the mass of the atom is contained in the nucleus) ✓
the nucleus is positively charged
(or the nucleus and the α particle have the same charge) ✓ $_{\text{max}}$(*6*)
(*6*)

The Quality of Written Communication marks are awarded primarily for the quality of answers to Q4(a) and Q7(iii).