ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme June 2002

GCE

Physics A

Unit PA10

Unit 10:

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) $^{212}_{83}\mathrm{Bi} \rightarrow {}^{4}_{2}\alpha + {}^{208}_{81}\mathrm{Tl}$

either ✓ (for both atomic mass numbers, 4 and 208)
and ✓(for both atomic numbers, 2 and 81)

[or ✓ for $^{208}_{81}\mathrm{Tl}$ and incorrect α] (*2*)

(b)(i) $E_k = (\tfrac{1}{2}mv^2) = 6.1 \times 10^6 \times 1.6 \times 10^{-19}$ (J) ✓
substitution for $m = 4.0 \times 1.66 \times 10^{-27}$ (kg) ✓

$$v = \left(\frac{2 \times 6.1 \times 10^6 \times 1.6 \times 10^{-19}}{4.0 \times 1.66 \times 10^{-27}}\right)^{1/2}$$ ✓ ($= 1.7 \times 10^7$ m s^{-1})

(ii) correct use of conservation of momentum $m_{Tl}\, v_{recoil} = m_\alpha\, v$ ✓
substitution of $m_{Tl} = 208$u ✓
(allow C.E. for mass = 208)

$$v_{recoil} = \frac{4 \times 1.7 \times 10^7}{208} = 3.3 \times 10^5 \text{ m s}^{-1}$$ ✓

(allow C.E. for value of v) (*6*)

(*8*)

2(i) $V_R = (3.0 - 2.0) = 1.(0)$ (V) ✓

$$R = \frac{1.0}{10 \times 10^{-3}} = 100\ \Omega$$ ✓

(ii) (use of $P = IV$ gives) P_{diode} ($= 10 \times 10^{-3} \times 2.0$) = 0.02(0) W ✓

(iii) (use of $c = f\lambda$ gives) $f \left(= \dfrac{c}{\lambda}\right) = \dfrac{3.0 \times 10^8}{635 \times 10^{-9}} = (4.7 \times 10^{14}$ Hz) ✓
(use of $E = hf$ gives) E ($= 6.63 \times 10^{-34} \times 4.7 \times 10^{14}$) $= 3.1 \times 10^{-19}$ J ✓
(allow C.E. for A.E. in value of f)

(iv) energy supplied in 1 sec = 0.02(0) (J) ✓
(allow C.E. for value of P from (ii))

number of photons emitted in 1 sec $= \dfrac{0.02(0)}{3.1 \times 10^{-19}} = 6.5 \times 10^{16}$ ✓

(allow C.E. for value of E)

(v) all the energy supplied converted to light energy [or 100% efficient]
[or monochromatic light]
[or all photons (emitted by LED) have the same energy] ✓ (*8*)

(*8*)

3(a)(i) fringes formed when light from the two slits overlap (or diffracts) ✓
slits emit waves with a constant phase difference (or coherent) ✓
bright fringe formed where waves reinforce ✓
dark fringe formed where waves cancel ✓
[or if 3rd and 4th not scored, waves interfere ✓]
path difference from slits to fringe =
whole number of wavelengths for a bright fringe ✓
whole number + half a wavelength for a dark fringe ✓
[or phase difference is zero (in phase) for a bright fringe ✓
and 180° for a dark fringe ✓]

(ii) (interference) fringes disappear ✓
single slit diffraction pattern observed
[or single slit interference observed] ✓
central fringe (of single slit pattern) ✓
side fringes narrower than central fringe ✓ $_{\max}(8)$

(b)(i) fringes closer ✓
(because) each fringe must be closer to the centre for the same path difference
[or correct use of formula as explanation] ✓

(ii) $\sin\theta_c \left(= \frac{n_2}{n_1}\right) = \frac{1.32}{1.50}$ ✓ (= 0.88)
$\theta_c = 61.6°$ ✓

(iii) for second light ray, diagram to show:
smaller angle of incidence at P than first ray ✓
point of incidence at core/cladding boundary to right of first ray ✓
total internal reflection drawn correctly or indicated at point of incidence to right of right angle ✓

[alternative if ray enters at P from above:
correct refraction at P ✓
TIR at boundary if refraction at P is correct ✓
angle of incidence visibly ≥ critical angle ✓] (7)

(15)

4(a)(i) uud ✓

(ii) $u\bar{d}$ ✓ (*2*)

(b)(i) $\dfrac{mv^2}{r} = Bev$ [or $r = \dfrac{mv}{Be}$] ✓

$m = 1.67 \times 10^{-27}$ ✓

$r\left(= \dfrac{mv}{Be}\right) = \dfrac{1.67\times10^{-27}\times1.5\times10^{7}}{0.16\times1.6\times10^{-19}}$ ✓

$= 0.98$ m ✓

(ii) pion path more curved than proton path ✓

(iii) path more curved
[or radius (of path) smaller] ✓
for both paths ✓ (*7*)
(*9*)

5(a) energy produced per minute = $4.5 \times 10^3 \times 60$ (J) ✓ (= 2.7×10^5)

volume of gas required = $\dfrac{2.7\times10^5}{39\times10^6}$ (m^3) ✓ (= 6.9×10^{-3} m^3)

[or volume of gas per sec $\left(= \dfrac{4500}{39\times10^6}\right)$ = 1.15×10^{-4} (m^3) ✓

volume of gas per minute = $1.15 \times 10^{-4} \times 60$ (m^3) ✓(= 6.9×10^{-3} m^3)] (*2*)

(b)(i) ($\rho = \dfrac{m}{V}$ gives) $m_{(g)} = 6.9 \times 10^{-3} \times 0.72$ ✓

$= 5.0 \times 10^{-3}$ kg ✓

(ii) mass of one molecule = $\dfrac{1.6\times10^{-2}}{N_A}$ ✓ (= 2.66×10^{-26} kg)

number of molecules = $\left(\dfrac{5.0\times10^{-3}}{2.66\times10^{-26}}\right)$ = 1.9×10^{23} ✓

(allow C.E. for value of m_g)

[or number of moles $\left(= \dfrac{5\times10^{-3}}{1.6\times10^{-2}}\right)$ = 0.31 ✓

number of molecules (= $0.31 \times 6 \times 10^{23}$) = 1.9×10^{23} ✓
(allow C.E. for number of moles) (*4*)

(c) energy per minute (from (a)) = 2.7×10^5 (J) ✓

(use of $\Delta Q = mc\Delta\theta$ gives) $m\ (= \dfrac{\Delta Q}{c\Delta\theta}) = \dfrac{2.7\times10^5}{990\times(36-14)}$ ✓

= 12(.4) kg ✓

[or $m = \dfrac{4500}{990\times(36-14)}$ for 1 second ✓

= 0.21 (kg for 1 second) ✓

(= 0.21 × 60) = 12 kg for 1 minute ✓] (*3*)

(d) (use of $P = IV$ gives) $I\left(=\dfrac{P}{V}=\dfrac{4.5\times10^3}{230}\right) = 19(.6)$ A ✓

current required for 4.5 kW would exceed fuse rating
[or P = 3 kW for 13 A] ✓ (*2*)
(*11*)

6(a) vt_b: distance moved (at speed v) before brakes are applied
[or thinking/reaction distance] ✓

$\dfrac{v^2}{2a}$: distance moved while braking [or after applying brakes]✓ (*2*)

(b)(i) column B: (8.9) 13.3(5)17.822.2(5)26.731.1(5)
(all values correct to 2 or 3 sig. figs ± 0.2) ✓

(ii) column D: 1.3(5) 1.722.022.39 2.733.08
(all values correct to 2 or 3 sig figs ± 0.1) ✓ (*2*)

(c) graph of $\dfrac{s}{v}$ against v [or v against $\dfrac{s}{v}$] ✓

axes labelled correctly ✓ (column D vs column B or A)
appropriate scales ✓
at least four points plotted correctly to 1 square ✓
acceptable straight line ✓ (*5*)
[note: if chosen graph gives a curve (e.g. s against v) than candidate can only score 2nd, 3rd and 4th marks]

(d)(i) (intercept) t_b = 0.66 s ✓ (values in range 0.6 to 0.7 accepted)

(ii) gradient = (any triangle e.g. (3 – 1)/(30 – 4.5)) = 7.8×10^{-2} ($\text{s}^2\ \text{m}^{-1}$) ✓
[other answers, if consistent with graph, acceptable]
gradient = $(1/2a)$ ✓
gives a = 6.4 m s^{-2} ✓ (values in range 6.1 to 6.7 accepted)
(allow C.E. for value of gradient)

[if column D vs column A used, gradient = 0.022
use of conversion factor gives gradient = 0.078 ($\text{s}^2\ \text{m}^{-1}$)]

[if graph of v against $\dfrac{s}{v}$, gradient = 12.8 m s^{-2}

= $2a$ for first two marks] (*4*)
(*13*)

7(a) gravity or force acts towards centre ✓
force acts at right angles to velocity or direction of motion
[or velocity is tangential] ✓
no movement in direction of force ✓
no work done so no change of kinetic energy so no change in speed ✓ $_{\max}(3)$

(b)(i) $B = (56^2 + 17^2)^{1/2} = 59\ \mu\text{T}$ ✓

(ii) $\tan\theta = \frac{17}{56}$ ✓
$\theta = 17^\circ$ ✓ ($\pm 1^\circ$)

(iii) rod sweeps out or cuts (magnetic) flux
[or rod cuts field] ✓ (4)
(7)

8(a)(i) pulse (or sound) takes time to reach the microphone ✓

(ii) pulse (or sound) takes longer to reach microphone ✓

(iii) time taken (= 0.2×3.0) = 0.6(0) ms ✓
speed of sound = $\frac{20 \times 10^{-2}}{0.6 \times 10^{-3}}$ ✓ [or distance/time]
= $330\ \text{m s}^{-1}$ ✓ (5)

(b)(i) coil is acted on by a force due to magnet
when current passes through coil ✓
alternating p.d. (or current) causes an alternating force ✓

(ii) magnet's mass much greater than coil's mass ✓
motion of magnet would be much less than motion of coil ✓
for the same alternating p.d. (or current) ✓ $_{\max}(4)$
(9)

The Quality of Written Communication marks are awarded primarily for the quality of answers to Q3(a) and Q8(b).