ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2003

GCE

Physics A

Unit PA10

Unit 10: Synoptic Written Exam

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)(i) mass per sec (= density × vol per sec) = 1000 × 1.4 ✓
= 1400 kg (s^{-1}) ✓

(a)(ii) loss of E_P per sec (= $\frac{mgh}{t}$) = 1400 × 9.8 × 750 ✓
= 1.0×10^7 J (s^{-1}) ✓ (1.03×10^7 J s^{-1})
(allow C.E. for value of mass per sec from (i))

(a)(iii) efficiency (= $\frac{\text{power output}}{\text{loss of } E_P \text{ per sec}}$) = $\frac{2.0\times10^6}{1.0\times10^7}$ ✓
= 0.2 ✓ (*6*)
(allow C.E. for value from (ii))

(b)(i) (use of $P = IV$ gives) $I_{rms} = \frac{2.0\times10^6}{25\times10^3}$ ✓
= 80 A ✓

(b)(ii) power output = (0.95 × power input) = 0.95 × 2.0 (MW) = 1.9 (MW) ✓
$I = \frac{1.9(\text{MW})}{275(\text{kV})}$ = 6.9 A ✓
[or I for 100% efficiency $\left(= \frac{2\times10^6}{275\times10^3}\right)$ = 7.3 (A) ✓
I for 95% efficiency = 95% of 7.3 = 6.9 A] (*4*)
(*10*)

2

(a)(i) molecules have a range of speeds ✓
motion of a molecule changes unpredictably
[or collisions with other molecules changes
direction of motion/speed unpredictably] ✓
no preferred direction of motion ✓

(a)(ii) no loss of total kinetic energy in an impact ✓ max(*3*)

(b)(i) $E_K = \frac{3kT}{2}$ ✓
$= \frac{3\times1.38\times10^{-32}\times300}{2}$ ✓ (= 6(.21) × 10^{-21} J)

(b)(ii) work function is the energy required by an electron to escape ✓
an electron in a metal at 300 K has insufficient energy to escape ✓

(b)(iii) an electron can escape if it absorbs a photon of sufficient energy ✓
photon energy = hf ✓
to escape, $f > \frac{W}{h}$ ✓ max(*5*)
(*8*)

3

(a)(i) $\lambda_{\text{disc}} = \dfrac{635}{1.53}$ ✓

$= 420$ nm ✓ (415 nm)

(a)(ii) path difference = 2 × depth ✓

path difference = 0.5 × λ_{disc} for destructive interference ✓

$\therefore$ depth $= \dfrac{420}{4} = 110$ nm ✓ (105 nm) (415 gives 100 (104) nm)

(allow C.E. for λ_{disc} from (i)) $_{\text{max}}(4)$

(b)(i) $\sin c = \dfrac{1}{1.53} = 0.65$ ✓

$c = 41^{\circ}$ ✓

(b)(ii) diagram to show:

light ray totally internally reflected ✓

reflected ray and incident ray at same angle to normal ✓ (4)

(8)

4

(a)(i) magnetic flux (linkage) through the coil changes each time a magnet sweeps past ✓

induced emf produced by change of magnetic flux ✓

induced emf is + as magnet approaches and – as magnet recedes ✓

+ area = – area, as increase of flux on approach = decrease of flux on receding ✓

no emf until next magnet approaches ✓

(a)(ii) (use of $f = \dfrac{1}{T}$ gives) $f = \dfrac{1}{8 \times 0.2(\text{s})}$ ✓

$= 0.63$ Hz ✓

(a)(iii) (use of $v = \dfrac{2\pi r}{T}$ gives) $v = \dfrac{2\pi 0.09}{0.2 \times 8} = 0.35$ m s^{-1} ✓

(use of $a = \dfrac{v^2}{r}$ gives) $a = \dfrac{0.35^2}{0.09} = 1.4$ m s^{-2} ✓

(allow C.E. for value of v) $_{\text{max}}(6)$

(b) graph to show: pulses 0.1 s apart ✓

higher pulses ✓

sharper pulses ✓ $_{\text{max}}(2)$

(8)

5

(a)(i) $(35 \times 9.81) = 343$ N ✓

(a)(ii) tension in each cable $(= \frac{mg}{2}) = 172$ N ✓ (*2*)

(b) area of cross -section $(= \frac{\pi d^2}{4}) = \frac{\pi(8.26\times10^{-3})^2}{4} = 5.36 \times 10^{-5}$ (m^2) ✓

$e = \frac{Fl}{EA}$ ✓

$= \frac{172\times2.5}{5.36\times10^{-5}\times2.1\times10^{11}}$ ✓

$= 3.8 \times 10^{-5}$ m ✓ (*4*)

(c)(i) moments about T_2, (cable B) gives

$5.52\ T_1$ ✓ $= 343 \times 2.76$ ✓ $+ 196 \times 4.52$ ✓

$T_1 = \left(\frac{1833}{5.52}\right)$ ✓ (= 332 N)

(c)(ii) $T_1 + T_2 = 343 + 196 = 539$ (N) ✓

$T_2 = 539 - 332 = 207$ N ✓

(allow C.E. for value of T_1 from (i))

[or moments about T_1 gives $5.52\ T_2 = (343 \times 2.76) + (196 \times 1.)$ ✓

$T_2 = 1143/5.52 = 207$ N ✓] (*6*)

(*12*)

6

(a) circuit diagram to show:

ammeter in series, voltmeter in parallel ✓

variable source (e.g. battery + rheostat or potential divider) ✓ (*2*)

(b)(i) $R_X = \frac{0.70}{12.5\times10^{-3}} = 56\ \Omega$ ✓

(b)(ii) $R_X =$ (e.g.) $\frac{0.90}{39\times10^{-3}} = 23\ (\Omega)$ ✓

R_X depends on current (or voltage) $\therefore$ non-ohmic ✓ (*3*)

(c)(i)

col C	col D
0.15	2.53
0.20	2.83
0.25	3.09
0.30	3.37
0.35	3.66
0.40	3.94

four pairs of values correct ✓

all six pairs correct and col D to no more than 4 s.f. ✓

(c)(ii) axes labelled ✓
suitable scales chosen ✓
at least five points plotted correctly ✓
acceptable straight line ✓

(c)(iii) k = gradient ✓
gradient = $\dfrac{3.95 - 1.68}{0.40}$ = 5.7 (V^{-1}) ✓
intercept on y-axis = ln A ✓
(intercept = 1.68 gives) $A = e^{1.68}$ = 5.4 (mA) ✓
unit for k or A correct ✓

(c)(iv) the points define a straight line ✓
valid over given range ✓ max*(10)*
(15)

7

(i) mass of one atom = $\dfrac{0.21}{6.0 \times 10^{23}} = 3.5 \times 10^{-25}$ kg ✓

(ii) energy supplied = $23 \times 10^3 \times 3.5 \times 10^{-25}$ ✓
$= 8.1 \times 10^{-21}$ J ✓ (8.05×10^{-21} J)
(allow C.E. for value from (i))

(iii) (use of $\frac{1}{2}mv^2 = E_K$ gives) $\frac{1}{2} \times 3.5 \times 10^{-25} \times v^2 = 8.1 \times 10^{-21}$ ✓
$v = \left(\dfrac{2.0 \times 8.1 \times 10^{-21}}{3.5 \times 10^{-25}}\right)^{1/2}$ = 220 m s^{-1} ✓ (215 m s^{-1})
($E_K = 8.05 \times 10^{-21}$ gives v = 214 m s^{-1})
(allow C.E. for value of E_K from (ii)) *(5)*
(5)

8

(a)(i) (use of $E_P = \dfrac{e^2}{4\pi\varepsilon_o r}$ gives) $E_P = \dfrac{\left(1.6\times10^{-19}\right)^2}{4\pi\times8.85\times10^{-12}\times1.0\times10^{-15}}$ ✓

$= 2.3 \times 10^{-13}$ (J) ✓

(a)(ii) E_K at least distance apart = 0 ✓

E_K of (each) proton = $0.5 \times 2.3 \times 10^{-13}$ (J) ✓

= (1.15×10^{-13} (J)) = 0.72 MeV ✓ (0.719 MeV) (*5*)

(b)(i) uud ✓

(b)(ii) $u\bar{d}$ ✓ (*2*)

(c)(i) $Q = -1$(e) ✓

$B = 0$ ✓

(c)(ii) π^- ✓

$\bar{u}d$ ✓

(c)(iii) mass of extra particles produced from total initial kinetic energy ✓

extra mass possible in (a) = 1.4 MeV/c^2 ✓

pions rest mass in (b) >> extra mass in (a) ✓ max(*5*)

(12)

The Quality of Written Communication marks are to be awarded for the quality of answers to Q2(b) and Q4(a)(i) ✓ ✓ (*2*)

(*2*)