ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2004

GCE

Physics A

Unit PHA7/W

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.

Units 5 - 9 : Section A

(this question is common to all Option Modules PHA5/W - PHA9/W)

1

(a) (on grid: first arrow to start from $^{210}_{82}\text{Pb}$; arrows must be consecutive;
last arrow must end on $^{206}_{82}\text{Pb}$)
arrow showing the change for an α emission ✓
arrow showing the change for a β emission ✓
correct α and two β emissions in any order ✓ (*3*)

(b) (positron emission) $^{64}_{29}\text{Cu} \rightarrow ^{64}_{28}\text{Ni} + \beta^{+} + \nu_{e}$ (+Q) ✓✓

(electron capture) $^{64}_{29}\text{Cu} + ^{0}_{-1}e \rightarrow ^{64}_{28}\text{Ni} + \nu_{(e)}$ (+Q) ✓✓ (*4*)

(c) (the following examples may be included)

α particles ✓
coulomb/electrostatic/electromagnetic repulsion
[or K.E. converted to P.E. (as α particle approaches nucleus)] ✓
information:
any of the following: proton number, nuclear charge,
upper limit to nuclear radius
mass of nucleus is most of the mass of atom ✓

[alternative
(high energy) electron (scattering) ✓
diffraction of de Broglie Waves <u>by nucleus</u> ✓
information:
any of the following: nuclear radius, nuclear density ✓] (*3*)
(*10*)

Unit 7: Section B

2

(a)(i) $\alpha \left(= \frac{\omega_2 - \omega_1}{t}\right) = \frac{1100 - 0}{4.2} = 260\ \text{rad s}^{-2}$ ✓ $(262\ \text{rad s}^{-2})$

(ii) $T\ (= I\alpha) = 7.6 \times 10^{-4} \times 262 = 0.20\ \text{N m}$ ✓ (*2*)

(b) $I_{\text{liquid}} = 8 \times (3.0 \times 10^{-3} \times (84 \times 10^{-3})^2 = 1.7 \times 10^{-4}\ (\text{kg m}^2)$

$I_{\text{total}} = 7.6 \times 10^{-4} + 1.7 \times 10^{-4} = 9.3 \times 10^{-4}\ (\text{kg m}^2)$ ✓

$\alpha \left(= \frac{T}{I}\right) = \frac{0.20}{9.3 \times 10^{-4}} = 215\ (\text{rad s}^2)$ ✓

$t \left(= \frac{\omega_2 - \omega_1}{\alpha}\right) = \frac{1100}{215}$ ✓ (= 5.1 s)

(allow C.E for value of I_{liquid}) (*3*)

(c) $\theta_1 \left(= \frac{(\omega_1 + \omega_2)}{2} t\right) = \frac{1100}{2} \times 5.0 = 2750\ (\text{rad})$

$\theta_3 = \frac{1100}{2} \times 6.0 = 3300\ (\text{rad})$ ✓ (for both θ_1 and θ_3)

$\theta_2\ (= \omega_2 t) = 1100 \times (60 - 11) = 53900\ (\text{rad})$ ✓

total angle turned $= \theta_1 + \theta_2 + \theta_3 = 60 \times 10^3\ \text{rad}$ ✓ (*3*)

(*8*)

3

(a)(i) $\omega = \frac{480 \times 2\pi}{60} = 50 \text{ rad s}^{-1}$ ✓ (50.3 rad s^{-1})

(ii) (use of $E_k = ½I\omega^2$ gives) $E_k = 0.5 \times 38 \times (50.3)^2$ ✓ (48 kJ) (*2*)

(b)(i) new kinetic energy = (48 – 12) = 36 (kJ)

$\omega = \sqrt{\frac{2 \times 36 \times 10^3}{38}} = 44 \text{ rad s}^{-1}$ ✓

(ii) angular impulse = change of angular momentum (= $I\Delta\omega$)
= 38 × (50 –44) = 230 kg m^2 rad s^{-1} (or N m s) ✓

(iii) torque $\left(\frac{\text{angular impulse}}{\text{time}}\right) = \frac{230}{0.15} = 1.5 \times 10^3$ N m ✓
(allow C.E for value of angular impulse) (*3*)
(*5*)

4

(i) $V = 80 \times 10^{-3} \times 1.77 \times 10^{-4}$ ✓ $(= 1.416 \times 10^{-5})$

$n\left(= \frac{pV}{RT}\right) = \frac{1.03 \times 10^5 \times 1.416 \times 10^{-5}}{8.31 \times 291} = 6.0(3) \times 10^{-4}$ (moles) ✓
(allow C.E. for value of V)

(ii) $p_2 = p_1\left(\frac{V_1}{V_2}\right)^{\gamma}$ ✓

$= 1.03 \times 10^5 \times \left(\frac{80}{2.0}\right)^{1.4} = 1.80 \times 10^7$ Pa ✓

(iii) $T_2 = \frac{p_2V_2}{nR}$ or $T_2 = \frac{p_2V_2T_1}{p_1V_1}$ ✓

$T_2 = \frac{1.80 \times 10^7 \times 2.0 \times 10^{-3} \times 1.77 \times 10^{-4}}{6.03 \times 10^{-4} \times 8.31} = 1.3 \times 10^3$ K ✓ $(1.27 \times 10^3$ K)
allow C.E. for value of p_2 or n) (*6*)
(*6*)

5

(a) P_{in} (= fuel flow rate × calorific value)
$= 4.45 \times 10^{-4} \times 42.9 \times 10^6 = 19$ kW ✓ (19.1 kW) (*1*)

(b)(i) work done = area enclosed by loop ✓
suitable method of finding area (e.g. counting squares) ✓
correct scaling factor used ✓ (to give answer of ≈ 350 J)

(ii) 2400 rev min^{-1} = 40 rev s^{-1} and each two revolutions produce 350 J ✓

$P_{ind} = \frac{350}{2} \times 40 = 7.0\,\text{kW}$ ✓ (5)

(c)(i) power used overcoming friction <u>inside the cylinder</u>
power used in driving valve gear, oil pump, cooling etc
power used in induction and exhaust strokes
any two ✓✓

(ii) efficiency = $\frac{6.3(\text{kW})}{19.1(\text{kW})} = 33\%$ ✓
(allow C.E. for value of P_{in} in (a)) <u>(3)</u>
<u>(9)</u>

Quality of Written Communication (Q1(c) and Q5(c)) ✓✓ <u>(2)</u>
<u>(2)</u>