Mark scheme January 2003

GCE

Physics A

Unit PHA7/W

Unit 7: Applied Physics

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.

Section A (common to all Option Modules PHA5/W - PHA9/W)

1

(a) (use of ‘isotope’ instead of ‘nucleus’ not accepted)
there is equal probability of any nucleus decaying,
it cannot be known which particular nucleus will decay next,
it cannot be known at what time a particular nucleus will decay,
the rate of decay is unaffected by the surrounding conditions,
it is only possible to estimate the proportion of nuclei decaying in the next time interval

any two statements ✓✓ (*2*)

(b) continuous curve starting at 5.5×10^5 Bq
plus correct 1st half-life (2.6 yrs, 2.75×10^5 Bq ✓
correct 2nd half-life (5.2 years, 1.4×10^5 Bq) ✓
(allow C.E. for incorrect 1st half-life) (*2*)

(c)(i) (use of $T_{1/2} = \dfrac{\ln 2}{\lambda}$ gives) $\lambda = \dfrac{\ln 2}{2.6 \times 3.15 \times 10^7}$ ✓
$= 8.5 \times 10^{-9}$ (s^{-1}) ✓ (8.46×10^{-9} (s^{-1}))

(c)(ii) (use of $\dfrac{dN}{dt} = -\lambda N$ gives) $N = \dfrac{5.5 \times 10^5}{8.5 \times 10^{-9}}$ ✓
$= 6.5 \times 10^{13}$ (atoms) ✓
(allow C.E. for value of λ from (i))

(c)(iii) (use of $N = N_o e^{-\lambda t}$ and $A \propto N$ gives)
$t\left(= \dfrac{\ln(A_0 / A)}{\lambda}\right) = \dfrac{\ln(1.0 \times 10^5 / 0.75 \times 10^5}{8.5 \times 10^{-9}}$ ✓
$= 3.4 \times 10^7$ (s) ✓
(allow C.E. for value of λ from (i)) (*6*)

(*10*)

Section B

2

(a)(i) angular impulse = <u>change</u> in angular momentum ✓
$I\omega - 0 = 1.2$, $\therefore \Delta(I\omega) = 1.2$ kg m^2 rad s^{-1} ✓

(a)(ii) $I\omega = 1.2$ gives $\omega = \dfrac{1.2}{4.8\times10^{-2}}$ = 25 rad s^{-1} ✓

(a)(iii) (torque × time = angular impulse gives)
torque = $\dfrac{1.2}{2.8}$ = 0.43 N m ✓ (*4*)

(b) $\theta = \dfrac{(\omega_1+\omega_2)t}{2} = \dfrac{(30+0)14}{2}$ = 210 (rad) ✓
number of turns = $\dfrac{210}{2\pi}$ = 33.4 i.e. 33 complete turns ✓
(allow C.E. for value of θ) (*2*)
(*6*)

3

(a)(i) energy = power × time = $150\times10^3\times4.4 = 6.6\times10^5$ J ✓

(a)(ii) increase in kinetic energy = energy supplied during acceleration ✓
$6.6\times10^5 = 0.5\,I\,(\omega_2^2 - \omega_1^2)$ ✓
(allow C.E. for energy value from (i))
$I = \dfrac{6.6\times10^5\times2}{7.4^2-1.6^2}$ = $2.5(3)\times10^4$ kg m^2 ✓ (*4*)

(b) greater moment of inertia (I) ✓
($E_k \propto I$) more kinetic energy must be given in the <u>same time</u> ✓ (*2*)
(*6*)

4

(a) $T_H = 273 + 820 = 1093$ (K), $T_C = 273 + 77 = 350$ (K) ✓

efficiency $= \dfrac{T_H - T_C}{T_H} = \dfrac{1093 - 350}{1093} = 0.68$ or 68% ✓ (*2*)

(b) rotational speed of output shaft $= \dfrac{1800}{2 \times 60} = 15$ rev s^{-1} ✓

(work output each cycle = 380 J, 2 rev ≡ 1 cycle in a 4-stroke engine))

indicated power = 15 × 190 = 5.7 kW ✓ (*2*)

(c) power lost (= indicated power –actual power) = 5.7 – 4.7 = 1.0 kW ✓

(allow C.E. for incorrect value from (b)) (*1*)

(d) energy supplied per sec (= fuel flow rate × calorific value)

$= \dfrac{2.1 \times 10^{-2}}{60} \times 45 \times 10^{6} = 16$ kW (15.8 kW) ✓ (*1*)

(e) efficiency $= \dfrac{\text{net power output}}{\text{power input}} = \dfrac{4.7}{16} = 0.29$ or 29%

$\left[\dfrac{4.7}{15.8} = 0.30 \text{ or } 30\%\right]$

(allow C.E. for value from (d)) ✓ (*1*)

(*7*)

5

(a) pV = constant for any two points on line AB ✓

two points chosen and constant calculated ✓

(e.g. at A, $pV = 1.0 \times 10^5 \times 1.0 \times 10^{-3} = 100$ (J)

at B, $pV = 5.0 \times 10^5 \times 0.2 \times 10^{-3} = 100$ (J)) (*2*)

(b) A→B and C→A ✓ (*1*)

(c) $W = p\Delta V$ ✓

$= 5.0 \times 10^5 \times (1.0 - 0.2) \times 10^{-3} = 400$ J ✓ (*2*)

(d)(i) C ✓ (*1*)

(d)(ii) $pV = nRT$ ✓

$5.0 \times 10^5 \times 1.0 \times 10^{-3} = 6.9 \times 10^{-2} \times 8.3 \times T$ ✓

$T = 870$ K (872 K) ✓

(allow C.E. if wrong point in (i)) (*4*)

(*9*)

The Quality of Written Communication marks are to be awarded for the quality of answers to Q1(a) and Q3(b) ✓ ✓ (*2*)

(*2*)