GCE 2005
January Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Physics Specification A

PHA7/W Applied Physics

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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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

Nuclear Instability

This question is common to all the Option Modules PHA5/W – PHA9/W

Question 1

(a) graph to show:
electron intensity decreasing with angle of diffraction ✓
to a non-zero first minimum ✓ (*2*)

(b)(i) last column of table completed correctly ✓
with either

$A^{1/3}$
5.93
4.93
3.83
3.04
2.29

or

$R^3/(10^{-45}\ m^3)$
295
165
82.3
40.4
18.8

axes cover more than 50% of graph sheet ✓
all points plotted correctly using labelled axes
(i.e. x-axis $A^{1/3}$, y-axis $R/10^{-15}$ m or x axis A, y-axis $R^3/10^{-45}$ m^3) ✓

(ii) gradient = r_0 ✓ [or gradient = r_0^3]
gives $r_0 = (1.1 \pm 0.1) \times 10^{-15}$ m ✓ (*5*)

(c) electrons are not subject to the strong nuclear force ✓
(so) electron scattering patterns are easier to interpret ✓
electrons give greater resolution
[or electrons are more accurate because they can get closer]
[or α particles cannot get so close to the nucleus because of electrostatic repulsion] ✓
electrons give less recoil ✓
(high energy) electrons are easier to produce
[or electrons have a lower mass/ larger Q/m, so easier to accelerate] ✓
(in Rutherford scattering) with α particles, the closest distance of approach, not R is measured ✓ max(*3*)

(*10*)

Unit 7: PHA7/W Section B
Applied Physics

Question 2

(a) moment of inertia of the rockets
$= (2 \times 0.54 \times (0.80)^2) + (2 \times 0.54 \times (0.50)^2) = 0.96$ (kg m^2) ✓
total moment of inertia = 0.96 + 0.14 (kg m^2) ✓ (= 1.10 kg m^2) (2)

(b)(i) torque = $(2 \times 3.5 \times 0.80) + (2 \times 3.5 \times 0.50) = 9.1$ N m ✓

(ii) $\alpha \left(= \frac{T}{I}\right) = \frac{9.1}{1.1} = 8.3$ rad s^{-2} ✓ (8.27 rad s^{-2})
(allow C.E. for value of torque from (i))

(iii) one turn = 6.28 rad ✓
$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$ gives $6.28 = 0.5 \times 8.3 \times t^2$ and $t = 1.2(3)$ s ✓
(allow C.E. for value of α from (ii)) (4)

(c) frictional couple (due to air resistance) increases as angular speed increases ✓
when frictional couple = driving torque [or when no resultant torque],
then no acceleration ✓ (2)
(8)

Question 3

(a) energy supplied = $15 \times 10^3 \times 3 \times 60 = 2.7$ MJ ✓
(use of $E_k = \frac{1}{2}I\omega^2$ gives) $2.7 \times 10^6 = 0.5 \times 9.5 \times \omega^2$ ✓
(gives $\omega = 754 \approx 750$ rad s^{-1}) (2)

(b)(i) impulse (= $\Delta I\omega$) = (–)9.5 × 754
= (–)7.2 × 10^3 N m s (or kg m^2 rad s^{-1}) ✓ (7.16 × 10^3 N m s)
(use of ω = 750 gives impulse = 7.1(3) × 10^3 N m s)

(ii) average torque $\left(= \frac{\text{angular impulse}}{\text{time}}\right) = \frac{7.16 \times 10^3}{4.5} = 1600$ N m ✓

[or $T_{av} = I\alpha$, where $\alpha = \frac{750}{4.5} = 167$ (rad s^{-2})
$T_{av} = 9.5 \times 167 = 1600$ N m ✓] (2)

(c) area under curve = angular impulse = $T_{av} \times t$ ✓
area found by counting squares (or correct alternatives) ✓
$T_{av} = \frac{\text{angular impulse}}{t}$, where t is obtained from graph ✓ (3)

(7)

Question 4

(a) $p_1V_1 = 7.8 \times 10^5 \times 1.6 \times 10^{-4} = 125\ (\text{Pa m}^3)$
$p_2V_2 = 1.9 \times 10^5 \times 6.6 \times 10^{-4} = 125\ (\text{Pa m}^3)$ ✓
suitably correct comment ✓ (*2*)

(b)(i) adiabatic → no heat enters (or leaves) gas,
rapid expansion so no time for heat transfer ✓

(ii) $(p_1V_1^{\gamma} = p_2V_2^{\gamma})$ gives $V_2 = \left(\frac{p_1V_1^{\gamma}}{p_2}\right)^{1/\gamma} = \left(\frac{1.9\times10^5\times(6.6\times10^{-4})^{1.4}}{9.8\times10^4}\right)^{1/1.4}$ ✓
$= 1.1(0) \times 10^{-3}\ \text{m}^3$ ✓ (*3*)
(*5*)

Question 5

(a)(i) work done = area enclosed by curve ABCD = 20 kJ (± 2 kJ) ✓
satisfactory method of finding the area ✓

(ii) power = 20 kJ per cycle × 3 cycles per sec = 60 kJ (± 6 kJ) ✓

(iii) input power = fuel flow rate × calorific value
$= 2.4 \times 10^{-3} \times 34 \times 10^6 = 820\ \text{kW}$ ✓ (816 kW)
efficiency $= \frac{P_{out}}{P_{in}} = \frac{60\times10^3}{816\times10^3}\times100 = 7.3(5)\%$ ✓
(use of input power = 820 gives 7.3%)
(allow C.E. for values of output power and input power) (*5*)

(b) modified engine:
same steam requirement ✓
less fuel supplied because of recycled heat ✓
greater work output per cycle (because loop larger) ✓
same speed, therefore greater power output ✓
greater efficiency as P_{out} greater, P_{in} less ✓ max(*3*)
(*8*)

Quality of Written Communication marks: Q1 (c) and Q5 (b) ✓✓ (*2*)
(*2*)