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GCE 2005
January Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Physics Specification A

PA10 The Synoptic Unit

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.

Unit 10: PA10
Synoptic Unit

Question 1

(a)(i) (use of $P = VI$ gives) $I = \frac{7.2 \times 10^3}{120}$ ✓

$= 60$ A ✓

(ii) (use of $I = \frac{\Delta Q}{\Delta t}$ gives),

time to deliver charge at 60 A $\left(= \frac{4.8 \times 10^5}{60} \right) = 8000$ (s) ✓

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

range $(= 21 \times 8000) = 1.7 \times 10^5$ m ✓ $(1.68 \times 10^5$ m) (*4*)

(b) power dissipated due to resistive forces/drag/friction is same as in (a) ✓
gravitational potential energy + electrical energy = energy dissipated ✓
electrical power supplied = electrical power supplied in (a) – rate of loss of gravitational potential energy of the car ✓
[or motor power is less going downhill than on horizontal road (at same speed]
current is less than in (a) as
current = electrical power supplied/battery voltage ✓ (*4*)

(*8*)

Question 2

(a)(i) (use of $\rho = \frac{m}{V}$ gives) $m = 1000 \times 1.3 \times 10^{-4} = 0.13$ kg ✓

(ii) energy required to reduce temperature of the water to 0° C (= $mc\Delta\theta$)
$= 0.13 \times 4200 \times 18 = 9.8(3) \times 10^3$ (J) ✓
energy required to freeze the water (= ml) $= 0.13 \times 3.4 \times 10^5 = 44.2 \times 10^3$ (J) ✓
(allow C.E. for value of m from (i))
energy removed per sec $\left(= \frac{9.83 \times 10^3 + 44.2 \times 10^3}{1700}\right) = 31.(8)$ J s^{-1} ✓ (*4*)

(b) energy transferred from mains $= (25 \times 1700) + 31.8 = 4.2(5) \times 10^4$ (J) ✓
total energy transferred to surroundings
$= 4.25 \times 10^4 + 9.83 \times 10^3 + 44.2 \times 10^3 = 96(.5) \times 10^4$ J ✓
[or total energy transferred per sec $= 32 + 25 = 57$ (J)
total energy transferred $= 57 \times 1700 = 9.6(9)$ J]
(allow C.E. for values of energy removed from (a)) (*2*)

(*6*)

Question 3

(a)(i) change of momentum (= 0.44×32) = 14(.1) kg m s^{1} ✓

(ii) (use of $F = \frac{\Delta(mv)}{\Delta t}$ gives) $F = \frac{14.1}{9.2 \times 10^{-3}}$ ✓

$= 1.5(3) \times 10^3$ N ✓

(allow C.E. for value of $\Delta(mv)$ from (i) (*3*)

(b)(i) deceleration = $\frac{24 - 15}{9.2 \times 10^{-3}} = 9.8 \times 10^2$ m s^{-2} ✓ (9.78×10^2 m s^{-2})

(ii) (use of $a = \frac{v^2}{r}$ gives)

centripetal acceleration = $\frac{24^2}{0.62} = 9.3 \times 10^2$ m s^{-2} ✓ (9.29×10^2 m s^{-2})

(iii) before impact: radial pull on knee joint due to centripetal acceleration of boot ✓
during impact: radial pull reduced ✓ (*4*)
(*7*)

Question 4

(a)(i) $\lambda = \frac{3.0 \times 10^8}{1200 \times 10^6}$ ✓ = (0.25 (m))

angular width $\left(= \frac{\lambda}{d}\right) = \frac{0.25}{1.8} = 0.14$ (rad) ✓

$= 8.0°$ ✓

(ii) beam width at 15 000 km = $0.14 \times 15\,000$ (km) ✓ (= 2100 km) (*4*)

(b)(i) gravitational force on satellite of mass $m = \frac{GMm}{(R+h)^2}$ ✓

centripetal acceleration = $\frac{v^2}{(R+h)}$ ✓

for a circular orbit, $\frac{GMm}{(R+h)^2} = \frac{mv^2}{(R+h)}$ ✓ (hence $v = \left(\frac{GM}{(R+h)}\right)^{1/2}$)

(ii) $v = \left(\frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{(6.4 \times 10^6 + 15 \times 10^6)}\right)^{1/2}$ ✓

$= 4.3(2) \times 10^3$ m s^{-1} ✓

time period $(= \frac{2\pi r}{v}) = \frac{2\pi \times 21.4 \times 10^6}{4.3 \times 10^3}$ ✓

$= 3.1(3)$ s $\times 10^4$ ✓

(allow C.E. for values of v)

(iii) beam speed across surface $\left(= \frac{\text{Earth's circumference}}{\text{time period}}\right)$

$= \frac{2\pi \times 6.4\times10^6}{3.1\times10^4}$ ✓ $(= 1.3\times10^3\ \text{m s}^{-1})$

contact time $\left(= \frac{\text{beam width}}{\text{speed}}\right) = \frac{2.1\times10^6}{1.3\times10^3}$ ✓ (= 1615 s = 27 min) *(9)*

(13)

Question 5

(a) circuit diagram to show:

wide end of conducting strip to − of battery, narrow end to + ✓

voltmeter between wide end and probe ✓ *(2)*

(b) resistance gradient increases as x increases ✓

because strip becomes narrower (as x increases) ✓

current constant throughout strip ✓

voltage gradient = current × resistance gradient, so

voltage gradient increases as x increases ✓ *(4)*

(c)(i)

$(2l–x)$	$\ln(2l–x)$
(0.700)	(–0.357)
0.60(0)	–0.511
0.53(0)	–0.635
0.47(0)	–0.755
0.44(0)	–0.821
0.42(0)	–0.868

1st column correct to 2 s.f. ✓

2nd column correct to 3.s.f. ✓✓

(only 4 values correct, ✓)

(ii) suitable scales ✓

axes labelled and units included ✓

5 points correctly plotted ✓

acceptable straight line ✓

straight line confirms equation because equation is of form

$y = mx + c$ with negative gradient ✓

(iii) gradient $= (-)\frac{10.5}{0.68} = (-)\ 15.4\ (\text{V})$ ✓

$1.44\ V_l = 15.4$ gives $V_l = 11$ V ✓ (10.7 ± 0.2 V)

[alternative: $V = V_l$ when $x = l$ and $\ln(2l–x)$ (= ln 0.4) = 0.92 ✓

at $\ln(2l–x) = 0.92$, graph gives $V_l = 11$ V ✓ (10.7 ± 0.2 V)] *(10)*

(16)

Question 6

(a)(i) current in primary coil produces magnetic flux in core ✓
alternating current produces alternating magnetic flux ✓
so alternating voltage induced in secondary coil ✓

(ii) force acts on bar to accelerate it ✓
bending of blades provides force ✓

(iii) magnetic flux in the secondary changes when bar is displaced ✓
secondary voltage proportional to rate of change of magnetic flux
(i.e. amplitude of secondary voltage changes) ✓ $_{\text{max}}$(*6*)

(b)(i) diode allows capacitor to charge every (positive) half cycle ✓
capacitor discharge is very slow during each (negative) half cycle ✓

(ii) discharge would be ten times slower, so voltage would be steadier ✓ (*3*)
(*9*)

Question 7

(a)(i) to reduce the average speed (or kinetic energy) of the fission neutrons ✓

(ii) mean E_k (or $\frac{1}{2}mv^2$) = $^3/_2 kT$ ✓

gives $v\left(=\left[\frac{3kT}{m}\right]^{1/2}\right)=\left(\frac{3\times1.38\times10^{-23}\times700}{1.67\times10^{-27}}\right)^{1/2}$ ✓

$= 4.1(7)\times10^3\ \text{m s}^{-1}$ ✓ (*4*)

(b)(i) mass of carbon 12 nucleus (= $\frac{0.012}{6.02\times10^{23}}$) = 2.0×10^{-26} (kg) ✓
final momentum of neutron and nucleus = initial momentum of neutron ✓
$(1.67\times10^{-21}\times v) + (2.0\times10^{-26}\times6.0\times10^5) = 1.67\times10^{-27}\times3.9\times10^6$ ✓

$v=\frac{6.5\times10^{-21}-12\times10^{-21}}{1.67\times10^{-27}}$ ✓ (= $3.3\times10^6\ \text{m s}^{-1}$)

(ii) initial E_k of neutron (= $\frac{1}{2}\times1.67\times10^{-27}\times(3.9\times10^6)^2$) = 1.27×10^{-14} (J)
final E_k of neutron (= $\frac{1}{2}\times1.67\times10^{-27}\times(3.3\times10^6)^2$) = 9.1×10^{-15} (J)
E_k of carbon nucleus (= $\frac{1}{2}\times2.0\times10^{-26}\times(6.0\times10^5)^2$) = 3.6×10^{-15} (J)
✓ for all correct
initial E_k (= 1.27×10^{-14} J) = final E_k (= 9.1×10^{-15} (J) + 3.6×10^{-15} (J)) ✓

(iii) % E_k transferred $\left(=\frac{3.6\times10^{-15}}{1.27\times10^{-14}}\right)\times100 = 28(.3)\%$ ✓ (*7*)

(*11*)

Question 8

(a)(i) $v\left(=\frac{h}{m\lambda}\right)=\frac{6.63\times10^{-34}}{9.1\times10^{-31}\times1.2\times10^{-9}}$ ✓

$= 6.1 \times 10^{5}\ \mathrm{m\,s^{-1}}$ ✓

(ii) $E_k\left(=\frac{1}{2}mv^2=0.5\times9.1\times10^{-31}\times(6.1\times10^{5})^2\right)=1.7\times10^{-19}\ \mathrm{J}$ ✓

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

(iii) $E\ (= E_k + eV) = 1.7 \times 10^{-19} + (-\,1.6 \times 10^{-19} \times 2.8)$ ✓

$= -\,2.8 \times 10^{-19}\ \mathrm{J}$ ✓

(allow C.E. for value of E_k from (ii)) (5)

(b)(i) $E_{ph}\left(=\frac{hc}{\lambda}=6.63\times10^{-34}\times3.0\times10^{8}\right)=3.1\times10^{-19}\ \mathrm{J}$ ✓

(ii) electron can gain enough energy to escape ✓

since $E_{ph} > E$ ✓ (3)

(8)

Quality of Written Communication marks: Q1 (b) and Q6 (a) ✓✓ (2)

(2)