GCE 2005
January Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Physics Specification A

PHA3/W Current Electricity and Elastic Properties of Solids

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 3: PHA3/W
Current Electricity and Elastic Properties of Solids

Question 1

(a)(i) (total) resistance = (20 + 60) (Ω) ✓
($V = IR$ gives) $I = \frac{6.0}{80} = 0.075$ A ✓

(ii) with S closed, (effective) resistance = 20 (Ω) ✓
$I = \frac{6.0}{20} = 0.3$ A ✓ max(*3*)

(b) use of same current as in part (i) ✓
voltmeter reading = $0.075 \times 60 = 4.5$ V ✓
[or use potentiometer equation $6 \times \frac{60}{80} = 4.5$ V] *(2)*
(allow C.E. for value of *I* from (a)(i) *(5)*

Question 2

(a)(i) circuit details:
diode (correct symbol) connected in correct direction,
plus ammeter in series with diode ✓
variable battery, variable resistor or potentiometer ✓
voltmeter across diode ✓
ammeter and voltmeter connected to data logger ✓

(ii) description: current and voltage recorded on data logger ✓
change voltage/current in (small) steps by changing
variable resistor/potentiometer/battery ✓

(iii) reverse the diode or battery ✓ max(*6*)

(b) correct characteristic in positive and negative quadrant ✓✓

current heats the filament
[or discussion of collisions with molecules] ✓
hence resistance increases ✓
rate of increase in *I* decreases [or suitable explanation] ✓
same **effect** when current reversed ✓ max(*5*)
(11)

Question 3

(a) at 200 °C: $R_R = 130 \pm 1\ (\Omega)$, $R_{Th} = 18 \pm 1\ \Omega$ ✓ (*1*)

(b)(i) $V_{AB} = V_{in} \dfrac{R_{Th}}{R_{Th} + R_R}$ ✓

$= 12 \times \dfrac{18}{18+130}$ ✓

$= 1.5$ V ✓ (1.46 V)

(allow C.E. for values from (a))

(ii) $R_{th} = R_R$ occurs at 50 °C ✓ (*4*)

(c)(i) (use of $P = \dfrac{V^2}{R}$ gives) $R_b = \dfrac{36}{2} = 18\ \Omega$ ✓

[or use of $P = VI$ and calculate I]

(ii) (S open, $R_{Th} \approx 90\ \Omega$)
bulb and thermistor in parallel ✓
gives lower resistance than thermistor on its own ✓
total resistance in circuit decreases ✓
current increases ∴ $V_R > 6$ V ✓
(hence $V_{th} < 6$ V i.e. decreases)
[or use of potentiometer equation, or ratio of resistances and share of pd] max (*4*)
(*9*)

Question 4

(a) $R = \dfrac{\rho l}{A}$ ✓

ρ is resistivity, l is the length of the wire, A is the cross-sectional area ✓ (*2*)

(b)(i) $P = \dfrac{V^2}{R}$ ✓

$R = \dfrac{230^2}{500} = 106(\Omega)$ ✓ (105.8 Ω)

$l = \left(\dfrac{RA}{\rho}\right) = \dfrac{105.8 \times 8.0 \times 10^{-8}}{1.1 \times 10^{-6}} = 7.7$ m ✓ (7.69 m)

(allow C.E. for incorrect value of R)

(ii) in series, voltage across each < 230 V or pd shared ✓
∴power ($= V^2/R$) is less than 500 W in each ✓
in parallel, voltage across each = 230 V ✓
∴correct rating, ∴conclusion ✓

[or, in series, high resistance or combined resistance ✓

$\therefore$ low current ✓
in parallel, resistance is lower, $\therefore$ higher current ✓
more power, justified ✓] max (6)
(8)

Question 5

(a) ($V = IR$ gives) $V_{rms} = (5.3 \times 10^{-3} \times 2 \times 10^{3}) = 10.6$ (V) ✓
$V_0 = V_{rms}\sqrt{2} = 10.6\sqrt{2} = 15$ V ✓ (14.99 V)
[or calculate I_0 (= 7.5 mA) and then V_0] (2)

(b) (use of $T = \frac{1}{f}$ gives) $T = \frac{1}{500} = 2 \times 10^{-3} = 2$ 0(ms) ✓
trace to show: correct wave shape (sinusoidal) ✓
correct amplitude (3 divisions) ✓
correct period (8 divisions) ✓ (4)
(6)

Question 6

(a) tensile stress: force/tension per unit cross-sectional area or $\frac{F}{A}$
with F and A defined ✓
tensile strain: extension per unit length or $\frac{e}{l}$ with e and l defined ✓
the Young modulus: $\frac{\text{tensile stress}}{\text{tensile strain}}$ ✓ (3)

(b)(i) $E_S = \frac{F_S}{A}\frac{l}{e}$ and $E_B = \frac{F_B}{A}\frac{l}{e}$ ✓ hence $\frac{E_S}{E_B} = \frac{F_S}{F_B}$

(ii) $\frac{E_S}{E_B} = 2$ ✓
$\therefore F_S = 2F_B$ ✓

$F_S + F_B = 15$ N ✓ gives $F_S = 10$ N
[or any alternative method]

(iii) $\left(E = \frac{F}{A}\frac{l}{e} \text{ gives}\right)$ $e = \left(\frac{F}{A}\frac{l}{E}\right) = \frac{10 \times 1.5}{1.4 \times 10^{-6} \times 2.0 \times 10^{11}}$ ✓
$= 5.36 \times 10^{-5}$ m ✓ (6)
(9)

Quality of Written Communication marks: Q2 (a) (ii) and Q2 (b) ✓✓ (2)
(2)