Version 1.0: 03/06

General Certificate of Education

Physics 5451
Specification A

PHA3/W
Current Electricity and Elastic Properties of Solids

Mark Scheme

2006 examination - January series

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.

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.

PHA3/W Current Electricity and Elastic Properties of Solids

Question 1		
(a)	$I = \frac{\Delta Q}{\Delta t}\left(\text{or } I = \frac{Q}{t}\right)$ ✓ $\Delta Q = 0.25 \times 6 \times 60 = 90\,\text{C}$ ✓	**2**
(b) (i) (ii)	$V = \frac{W}{Q}$ ✓ [or $E = VIt$] $= \frac{9.0\times10^4}{0.25\times20\times60\times60} = 5.0\,\text{V}$ ✓ (use of $P = \frac{W}{t}$ gives) $P = \frac{9.0\times10^4}{20\times60\times60} = 1.2(5)\,\text{W}$ ✓ [or $P = IV$ gives $P = 0.25 \times 5 = 1.2(5)\,\text{W}$] (allow C.E. in alternative method for value of V from (i))	**3**
	Total	**5**

Question 2		
(a) (i) (ii)	(use of $V = IR$ gives) $12 = I \times 270$ and $I = 44.(4)$ mA ✓ two resistors in parallel give resistance less than $110\,\Omega$ ✓ ($\therefore$) total resistance decreases ✓ current increases ✓	**4**
(b)	$V = 44.4 \times 10^{-3} \times 110$ ✓ (= 4.9 V) [or $V = 12\times\left(\frac{110}{110+160}\right)$] (assumption) no current flows through voltmeter ✓ [or voltmeter has very large or infinite resistance]	**2**
(c)	total resistance (in circuit) = 160 (Ω) ✓ $12 = I \times 160$ and $I = 75$ mA ✓	**2**
	Total	**8**

Question 3		
(a) (i)	circuit diagram to show: wire, ammeter, battery, (variable resistor) and switch in series ✓ [or potentiometer with ammeter in correct position] voltmeter across the wire ✓	
(ii)	(method: constant length of wire) measure length (of wire) ✓ measure diameter (of wire) ✓ measure voltage (across) and current (through wire) ✓ vary resistor to obtain different voltage and current ✓ **alternative** [(method: variable length of wire) measure length (each time) ✓ measure diameter ✓ (for full length of wire) measure voltage and current ✓ voltmeter to shorter lengths, measure voltage (and current) ✓]	
(iii)	(use of) $\rho = \frac{RA}{l}$ (to calculate ρ) ✓ (for either method) calculate A from (πr^2) ✓ (for either method) (method: constant length of wire) determine $R\left(=\frac{V}{I}\right)$ for (one) length ✓ repeat readings (for same length and) take mean of ρ or R ✓ [or plot graph of V vs I to give mean R ✓ or gradient $=\frac{\rho l}{A}$ ✓] **alternative** [(method: variable length of wire) determine $R\left(=\frac{V}{I}\right)$ for each length ✓ calculate ρ for each length and take mean ✓ [or graph of R vs l ✓ with correct gradient ✓]	**10**
(b)	(use of $R = \frac{\rho l}{A}$ gives) $\frac{2.0}{4.0} = \frac{1.1\times10^{-7}\,l}{7.8\times10^{-9}}$ ✓ l = 0.035 m ✓	**2**
	Total	**12**

Question 4			
(a)	(i)	electrical energy produced (in the battery) per unit charge ✓ [or potential/voltage across terminals when there is no current]	**Max 2**
	(ii)	there is a current (through the battery) ✓ voltage 'lost' across the internal resistance ✓	
(b)	(i)	$\epsilon = V + Ir$ ✓	**8**
	(ii)	labelled scales ✓ correct plotting ✓ best straight line ✓ ϵ : intercept on y axis ✓ = 9.2 (± 0.1) V ✓ r : (−) gradient ✓ = $\frac{9.2}{0.65}$ = 14.2 Ω ✓ (range 14.0 to 14.3)	
		Total	**10**

Question 5			
(a)		tensile stress: (normal) force per unit cross-sectional area ✓ tensile strain: ratio of extension to original length ✓	**2**
(b)	(i)	loading: obeys Hooke's law from A to B ✓ B is limit of proportionality ✓ beyond/at B elastic limit reached ✓ beyond elastic limit, undergoes plastic deformation ✓ unloading: at C load is removed linear relation between stress and strain ✓ does not return to original length ✓	**Max 9**
	(ii)	ductile ✓ permanently stretched ✓ [or undergoes plastic deformation or does not break]	
	(iii)	AD: permanent strain (or extension) ✓	
	(iv)	gradient of the (straight) line AB (or DC) ✓	
	(v)	area under the graph ABC ✓	
(c)		$E = \frac{Fl}{Ae}$ ✓ $e = \frac{75 \times 3.0}{2.8 \times 10^{-7} \times 2.1 \times 10^{11}}$ = 3.8(3) mm ✓	**2**
		Total	**13**

Quality of Written Communication: Question 2 (a) (ii) and/or Question 5 (b) (i)	**2**