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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6451

Specification A

PA04 Waves, Fields and Nuclear Energy

Mark Scheme

2007 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.

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Dr Michael Cresswell Director General

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.

PA04 Waves, Fields and Nuclear Energy

Section A

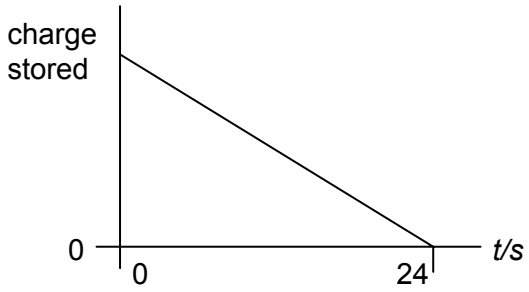
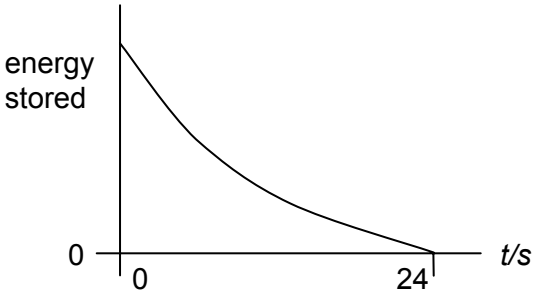
This component is an objective test for which the following list indicates the correct answers used in marking the candidates' responses.

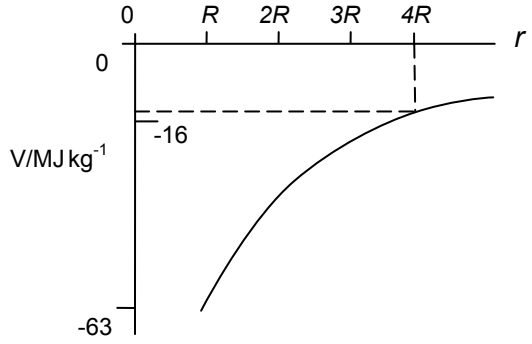
	Keys to Objective Test Questions															
	1 A	**2** B	**3** D	**4** A	**5** C	**6** B	**7** C	**8** D	**9** A	**10** B	**11** D	**12** B	**13** D	**14** C	**15** A	

Section B

Question 1			
(a)	(i)	$\lambda = \left(\frac{ws}{D}\right) = \frac{2.0 \times 3.2}{16} = 0.40\,\text{m}$ ✓	**2**
	(ii)	$c\ (= f\lambda) = 850 \times 0.40 = 340\,\text{ms}^{-1}$ ✓	
(b)	(i)	speakers act as coherent sources or have constant phase relation ✓ light is emitted from sources in (incoherent) bursts ✓ light sources are not coherent or phase relation not constant ✓	**max 5**
	(ii)	use of double slit ✓ wavefronts are divided at slits ✓ slits act as coherent sources ✓ slit sources have the same frequency ✓ slit sources have a constant phase relation ✓	
		Total	**7**

Question 2			
(a)		light waves diffract on passing through slits ✓ narrow slits (or $d \approx \lambda$) give wide diffraction ✓ diffracted waves meet or overlap or interfere ✓ maxima when waves are in phase or when path difference is $n\lambda$ ✓	**max 3**
(b)	(i)	$n_1\lambda_1 = n_2\lambda_2$ (or $3 \times 420 = 2\lambda$) ✓ (gives $\lambda = 630\,\text{nm}$)	**5**
	(ii)	$d\ \left(= \frac{n\lambda}{\sin\theta}\right) = \frac{3 \times 420 \times 10^{-9}}{\sin 44^\circ}\ (= 1.81 \times 10^{-6}\,\text{m})$ ✓ no of lines $\text{m}^{-1} = 1/1.81 \times 10^{-6} = 5.5 \times 10^5\ (5.51 \times 10^5)$ ✓	
	(iii)	when $\sin\theta = 1$, $n\left(= \frac{d}{\lambda}\right) = \frac{1.81 \times 10^{-6}}{420 \times 10^{-9}}\ (= 4.31)$ ✓ $\therefore$ highest order maximum is 4^{th} ✓	
		Total	**8**

Question 3			
(a)	(i)	$Q\ (= I\,t) = 35 \times 10^{-6} \times 24 = 8.4 \times 10^{-4}\,\text{C}\ (840\,\mu\text{C})$ ✓	**2**
	(ii)	$C\left(=\frac{Q}{V}\right) = \frac{8.4 \times 10^{-4}}{6.0} = 1.4 \times 10^{-4}\,\text{F}\ (140\,\mu\text{F})$ ✓	
(b)	(i)	line showing charge decreasing as time increases ✓ linear graph meets time axis at 24 s ✓  	**4**
	(ii)	curve of decreasing negative gradient ✓ curve meets time axis at 24 s ✓  	
		Total	**6**

Question 4		
(a)	force per unit mass ✓ [or force on a 1 kg mass or $g = F/m$ with terms explained] vector ✓	**2**
(b) (i)	$F\left(=\frac{GMm}{r^2}=\frac{6.67\times10^{-11}\times6.00\times10^{24}\times2.5\times10^{3}}{\left(1.6\times10^{7}\right)^2}\right)$ ✓ = 3900 N (3910) ✓	**max 5**
(ii)	$V_{\text{orbit}}\left(=-\frac{GM}{r}\right)=-\frac{6.67\times10^{-11}\times6.00\times10^{24}}{1.6\times10^{7}}$ ✓ $= -25\,(\text{MJ kg}^{-1})$ (–25.0) ✓ [or $\frac{V_{\text{orbit}}}{V_{\text{surface}}}=\frac{r_{\text{surface}}}{r_{\text{orbit}}}$ ✓ gives $V_{\text{orbit}}=-\left(\frac{6.4\times10^{6}}{1.6\times10^{7}}\right)\times63=-25\,(\text{MJ kg}^{-1})$ (–25.2) ✓]	
	$\Delta V = (63-25)\times10^{6} = 38\times10^{6}$ (J kg^{-1}) ✓ ΔE_p ($= m\,\Delta V$) $= 2.5\times10^{3}\times38\times10^{6} = 9.5\times10^{10}$ J ✓	
(c)	line starts at (R, –62.5) and ends at a finite value ✓ curve of decreasing positive gradient ✓ correct (1/r) relationship shown by axis values ✓  	**3**
	Total	**10**

Question 5			
(a)	(i)	into plane of diagram ✓	**7**
	(ii)	magnetic field is perpendicular to velocity ✓ force is perpendicular to both magnetic field and velocity ✓ (or Fleming's left hand rule) (hence) force acts perpendicular to velocity ✓ force changes direction of velocity but not its magnitude ✓ force remains perpendicular to velocity as direction changes ✓ reference to centripetal force (or force acts towards a fixed point) ✓ **max 4**	
	(iii)	$BQv = \frac{mv^2}{r}$ ✓ $\therefore d = 2r = \frac{2mv}{BQ}$ ✓	
(b)		$\frac{Q}{m}\left(=\frac{2v}{Bd}\right)=\frac{2\times 7.5\times 10^4}{0.34\times 0.110}$ ✓ = $4.0\times 10^6\,\mathrm{C\,kg^{-1}}$ ✓	**2**
(c)	(i)	ions have different mass ✓ diameter of path $d \propto m$ ✓ isotopes ✓ **or** mutual repulsion of ions ✓ because ions are all positively charged ✓ causes smearing of spot around R ✓	**max 3**
	(ii)	ions are doubly ionised ✓ diameter of path $d \propto 1/Q$ ✓	
		Total	**12**

Quality of Written Communication: Q1 (b) and/or Q5 (a) (ii)	**2**