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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 - June 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	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
	C	B	A	C	A	B	D	C	B	C	D	B	D	C	A	

Section B

Question 1			
(a)	(i)	P at any peak or trough ✓ Q at any point where velocity is zero and slope is negative ✓	**4**
	(ii)	R at any point where velocity is zero ✓ acceleration is gradient of v/t graph which is a maximum at R [**or** in SHM acceleration is greatest when velocity is zero (or equivalent statement)] ✓	
(b)	(i)	$mg = ke \therefore$ static extension $e = \frac{0.40 \times 9.81}{28}$ = 0.14(0) m ✓	**4**
	(ii)	total extension = 0.140 + 0.060 = 0.200 m ✓ energy stored ($= ½ F e$) $= ½ \times (28 \times 0.200) \times 0.200$ ✓ = 0.56 J ✓ (allow ✓ for use of $½ Fe$ if incorrect value is taken for *e*) **or** E_P stored at equilibrium (= $½ Fe$) = $½ \times (28 \times 0.14) \times 0.14$ = 0.274 (J) ✓ maximum E_K of oscillating mass (= $½ m (2 \pi f A)^2$) = 0.050 (J) ✓ total E_P stored = 0.274 + 0.050 + $m g A$ = 0.324 + $(0.40 \times 9.81 \times 60 \times 10^{-3})$ = 0.324 + 0.235 = 0.56 J ✓	
		Total	**8**

Question 2		
(a)	speed is magnitude of velocity **or** speed is a scalar but acceleration (or velocity) is a vector ✓ direction changes continuously ✓ velocity is changing ✓ acceleration is rate of change of velocity ✓ **or** speed is magnitude of velocity **or** speed is a scalar but acceleration (or velocity) is a vector ✓ force (or acceleration) acts towards centre of circle ✓ force (or acceleration) is always perpendicular to velocity **or** has no component in direction of velocity ✓ force changes direction of velocity but not its magnitude ✓	**max 3**
(b)	$\omega\ (= 2\pi f) = 2\pi \times (78/60) = 8.17\,(\text{rad s}^{-1})$ ✓ $F\left(=\frac{mv^2}{r}\right) = m\omega^2 r$ ✓ gives $r\left(=\frac{F}{m\omega^2}\right) = \frac{0.50}{0.10 \times 8.17^2}$ ✓ $r = 7.5 \times 10^{-2}\,\text{m}$ ✓	**4**
	Total	**7**

Question 3			
(a)		at nodes displacement is always zero or a minimum ✓ at antinodes the displacements have maximum amplitude ✓ (not displacement is a maximum)	**2**
(b)		two waves of same frequency or wavelength (or dippers D and E vibrate at the same frequency) ✓ waves travelling in opposite directions ✓ waves travel at same speed ✓ [**or** waves have equal and opposite velocities ✓✓] waves meet or overlap or superpose or interfere ✓ constructive or destructive superposition explained ✓ (e.g. by reference to phase or antiphase of waves)	**max 4**
(c)	(i)	$\lambda_1\ (= 2 \times 12) = 24\,\text{mm}$ ✓ $c = 24 \times 10^{-3} f$ and $c = 20 \times 10^{-3}(f + 2)$ ✓ gives $f = 10\,\text{Hz}$ ✓	**4**
	(ii)	$c\ (= 24 \times 10^{-3} \times 10\ ) = 0.24\,\text{m s}^{-1}$ ✓ (allow CE from (c) (i))	
		Total	**10**

Question 4			
(a)	(i)	$E\left(=\frac{Q}{4\pi\varepsilon_0 r^2}\right)=\frac{79\times1.6\times10^{-19}}{4\pi\times8.85\times10^{12}\times\left(3.0\times10^{-14}\right)^2}$ ✓ (gives E = 1.3×10^{20} V m^{-1} (1.26×10^{20}))	**5**
	(ii)	$F\,(=EQ')$ = $1.26\times10^{20}\times2\times1.60\times10^{-19}$ ✓ = 40 N (40.3) ✓	
	(iii)	$V\left(=\frac{Q}{4\pi\varepsilon_0 r}\right)=\frac{79\times1.6\times10^{-19}}{4\pi\times8.85\times10^{-12}\times3.0\times10^{-14}}$ ✓ gives V = 3.8×10^6 V (or J C^{-1}) (3.79×10^6) ✓	
(b)	(i)	kinetic energy → electric potential energy → kinetic energy ✓	**4**
	(ii)	initial kinetic energy = potential energy at point P ✓ $=(2e)V$ ✓ = $2\times1.60\times10^{-19}\times3.79\times10^6$ = 1.21×10^{-12} (J) ✓	
		Total	**9**

Question 5			
(a)	(i)	two small or light nuclei combine ✓ electrostatic repulsion has to be overcome ✓ nuclei have to be given kinetic energy for them to meet ✓	**max 6**
	(ii)	a large or heavy nucleus splits into two smaller nuclei ✓ neutrons are released ✓ fission is usually brought about by neutron bombardment ✓	
	(iii)	binding energy per nucleon increases when light nuclei (Z < 10) combine ✓ binding energy per nucleon also increases when heavy nuclei split ✓ [appropriate references to b.e. nucleon^{-1} curve to be equivalent to marks in (iii)]	
(b)		Δm = 219.9641 − (213.94899 + 4.00150) = 2.01361 (u) ✓ ΔE = 2.01361×931.3 = 1880 (MeV) ✓ = $1880\times1.60\times10^{-13}$ = 3.0×10^{-10} J ✓	**3**
		Total	**9**

Quality of Written Communication: Q5 (a) and/or Q3 (b)	**2**