Version 1.0: 0807

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6451

Specification A

PHA8/W Turning Points in Physics

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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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.

PHA8/W: Turning Points in Physics

Question 1			
(a)		the decay constant is the number of disintegrations per second divided by the number of nuclei/atoms (available) for decay **or** the proportion of nuclei decaying in one a given time period **or** the decay constant λ is the constant of proportionality in the equation $\Delta N/\Delta t = -\lambda N$ ✓ sample X initially has more counts per second/the total count from sample X is always larger ✓ the count rate from sample X falls more rapidly than from sample Y ✓	**3**
(b)	(i)	use of $A = A_0e^{-\lambda t}$ ✓ $1.0 \times 10^2 = 1.0 \times 10^5\ e^{-\lambda \times 6.9 \times 10^6}$ ✓ (or alternative substitution) $\lambda = \ln 1000/6.9 \times 10^6$ ✓ (to give $1.00 \times 10^{-6}\ s^{-1}$)	**7**
	(ii)	$T_{1/2}$ (= ln 2/ λ) = 6.9×10^5 (s) ✓ = 8.0(1) (days) ✓	
	(iii)	(use of $dN/dt = -\lambda N$) $N = 1.0 \times 10^5/1.0 \times 10^{-6}$ ✓ $= 1 \times 10^{11}$ (atoms) ✓	
		Total	**10**

Question 2			
(a)		the beam deflects towards Y ✓ because each electron is acted on by an electric force towards Y (or is attracted to Y or repelled by X) ✓	**2**
(b)	(i)	each electron is acted on by a magnetic force in the opposite direction to the electric force ✓ when $B = B_0$ the magnetic force is equal (and opposite) to the electric force ✓	**4**
	(ii)	magnetic force = Bev, electric force eV/d ✓ $B_0\ ev = eV/d$ (at $B = B_0$) ✓ ($\therefore\ v = V/B_0\ d$)	

(c)	work done on electron (or change of potential energy of electron) = eV_A (where V_A = 3800 V) ✓ $\therefore$ (kinetic energy of electron), ½ mv^2 = eV_A ✓ (rearranging this equation gives) e/m (= $v^2/2V_A$) = $\frac{(3.7\times10^7)^2}{2\times3800}$ = 1.8×10^{11} C kg^{-1} ✓	**3**
	Total	**9**

Question 3		
(a)	radio wave is an electromagnetic wave/includes a magnetic (or electric) wave ✓ magnetic flux (or field or wave) through the loop changes as the waves pass the loop ✓ induced emf is due to changing magnetic flux through the loop ✓ induced emf is alternating because flux (or field or wave) alternates ✓ alternative for last three marks: electric wave passes the loop ✓ electrons in loop forced to oscillate by electric wave ✓ movement of electrons causes an induced emf ✓	**max 3**
(b)	radio waves from T are polarised ✓ magnetic flux through loop decreases as it is rotated ✓ (or component of magnetic flux density perpendicular to loop decreases) at 90º, no magnetic flux passes through loop so induced emf is zero ✓ alternative for last two marks: electric field component parallel to plane of loop decreases as it is rotated (so force on electrons along the loop decreases) ✓ at 90º, no force acts on electrons so induced emf is zero ✓	**max 3**
	Total	**6**

Question 4		
(a) (i)	to see if they could detect the aether (or absolute motion of the Earth through space or absolute rest) ✓	**max 3**
(ii)	light reaches the observer from the light source via each mirror ✓ there is a phase difference between the two light beams ✓ bright fringes are seen where the two light beams are in phase (or dark fringes are seen where the two light beams are out of phase by 180º) ✓	
(b) (i)	Earth's motion through space was thought to affect the speed of light (along each arm of the apparatus) ✓ the distance travelled by each beam of light did not change ✓ the difference in the time taken by light to travel along each arm would change ✓ the phase difference between the two lights beams would change ✓	**max 3**
(ii)	Earth's motion through space does not affect the speed of light ✓ (or aether does not exist or absolute motion does not exist or all motion is relative or absolute rest)	
	Total	**6**

Question 5		
(a) (i)	electron diffraction ✓ in which (a beam of) electrons is diffracted by a thin crystal (or powder or graphite) ✓ or electron interference ✓ in which interference fringes are produced by (a beam of) electrons passed through two closely-spaced slits ✓ or electron tunnelling (in the STM) across a narrow gap ✓ between a metal tip and a conducting surface at different potentials ✓ or α particle tunnelling from a nucleus ✓ in which an α particle tunnels through the potential barrier surrounding the nucleus ✓	**max 4**
(ii)	photoelectric effect ✓ in which electrons are emitted from a metal when it is illuminated by light ✓ when each electron absorbs a photon of light of frequency above a certain value (or when the light frequency $\geq$ the threshold frequency) ✓	
(b)	mass of electron, m (= $\frac{m_0}{(1-v^2/c^2)^{1/2}} = \frac{9.1\times10^{-31}\,\text{kg}}{(1-0.90^2)^{1/2}}$ $= 2.1 \times 10^{-30}$ kg ✓ de Broglie wavelength, λ (= $\frac{h}{mv}$) ✓ $= \frac{6.63\times10^{-34}}{2.1\times10^{-30}\times0.90\times3.0\times10^{8}}$ $= 1.2 \times 10^{-12}$ m ✓ [note; 2nd mark only for correct substitution using 9.1×10^{-31} kg if relativistic mass not used]	**3**
	Total	**7**

Quality of Written Communication: Q1 (a) and/or Q3 (a)	**2**