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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 5451

Specification A

PA01 Particles, Radiation and Quantum Phenomena

Mark Scheme

2008 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.

GCE Physics, Specification A, PA01, Particles, Radiation and Quantum Phenomena

Question 1		
(a)	37 protons; 37 electrons ✓ 58 neutrons ✓	**2**
(b)	A = 137 Z = 55 ✓	**1**
(c)	$37 \times 1.6 \times 10^{-19}/95 \times 1.67 \times 10^{-27}$ ✓ 3.73×10^{7} (C kg^{-1}) ✓	**2**
	Total	**5**

Question 2			
(a)	(i)	(to have a small collision area) to reduce the uncertainty in the **scattering angle** ✓	**2**
	(ii)	in order for the α particles to be scattered only **once** ✓	
(b)		maximum 2 from the maximum number of α particles occur at zero scattering angle or in the straight through position ✓ the minimum number of α particles occur at 180° scattering angle or are backscattered along their original path ✓ there is a (smooth) decrease in the number of scattered α particles from 0° to 180° ✓	**max 2**
(c)		radius of nucleus < radius of atom or an atom is mainly an empty space ✓ as most α particles are undeflected ✓ or the positive charge of an atom is (concentrated) in the nucleus ✓ as it provides a strong enough repulsion to cause backscattering of the α particles ✓ or the nucleus contains most of the mass of the atom ✓ for it to be massive enough to backscatter the α particles ✓ **mark any two statements and corresponding reasons**	**4**

(d)	top	largest bend down with minimum radius of curvature closest to nucleus ✓	**3**
	middle	less bending down with minimum radius of curvature closest to nucleus ✓	
	bottom	even less bending down with minimum radius of curvature closest to nucleus ✓	
		Total	**11**

Question 3			
(a)	$\overline{K^0} = s\bar{d}$ ✓ $\pi^- = d\bar{u}$ ✓ $\pi^+ = u\bar{d}$ ✓		**3**
(b)			**2**

	baryon	**lepton**	**hadron**	**charged**
$\overline{K^0}$	×	×	✓	×
π^-	×	×	✓	✓

one mark for each row ✓✓

(c)	(i)	weak interaction ✓	**2**
	(ii)	strangeness is not conserved or it allows a quark to change its flavour or type ✓	
		Total	**7**

Question 4			
	(i)	moving or accelerated electrons (or reference to current flow) ✓	**max 7**
		collide with orbiting electrons/mercury atoms ✓	
		causing the electrons/atoms to jump **up** energy levels ✓	
	(ii)	electromagnetic radiation/photons ✓	
		(mainly) in the ultra violet ✓	
	(iii)	to absorb the electromagnetic radiation/photons ✓	
		and re-radiate at a lower frequency/longer λ or lower energy ✓	
		in the visible region ✓	
		Total	**7**

Question 5			
(a)	(i)	n_{glass} (= sin θ_{air}/sin θ_{glass}) = sin 45°/sin 29° ✓ n_{glass} = 1.46 ✓	**5**
	(ii)	use of ${}_{glass}n_{gel} = n_{gel}/n_{glass}$ = sin θ_{glass}/sin θ_{gel} or sin $\theta_c = \frac{n_2}{n_1}$ or $\frac{n_{gel}}{n_{glass}}$ ✓ n_{gel} = 1.46 × sin 74°/sin 90° ✓ n_{gel} = 1.40 ✓	
(b)		TIR from the bottom surface ✓ with 74° marked ✓ refracting away from the normal from the side of the prism ✓ emergent ray (horizontal) with angles marked ✓	**4**
(c)		v (= c/n) = 3.00 × 10^8/1.59 (= 1.89 × 10^8 m/s) ✓ t (= s/v) = 5.00/1.89 × 10^8 = 2.65 × 10^{-8} s ✓ [2 → 4 sig fig]	**2**
		Total	**11**

Question 6			
(a)	(i)	electrons behave like particles and like waves ✓	**3**
	(ii)	particles - (for example) deflection of electrons in an electric or magnetic field ✓ waves - (for example) diffraction of electrons ✓	
(b)	(i)	v (= $h/m\ \lambda$) = 6.63 × 10^{-34}/9.11 × 10^{-31} × 1.50 × 10^{-6} ✓ = 485 m s^{-1} ✓	**4**
	(iii)	(the momentum of the protons is the same as the electrons to have the same de Broglie wavelength) p = 9.11 × 10^{-31} × 485 = 4.42 × 10^{-28} kg ms^{-1} ✓ [or using $p = h/\lambda$ = 6.63 × 10^{-34}/1.50 × 10^{-6} = 4.42 × 10^{-28} kg ms^{-1} ✓]	
	(iii)	(significant) diffraction occurs when the wavelength is of similar size to the separation ✓ [or the wavelength is (much) larger than the separation ✓]	
		Total	**7**

Quality of Written Communication Q2 (a) (b) (c) and/or Q4	**2**