Version 1.0: 0809

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 1451

Specification A

PHYA1 Particles, Quantum Phenomena and Electricity

Mark Scheme

2009 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.

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX
Dr Michael Cresswell Director General

Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; 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 scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	
Modest - Adequate	*see specific mark scheme*	
Poor - Limited	*see specific mark scheme*	
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. 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.

4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA1, Particles, Quantum Phenomena and Electricity

<table>
<tr><td>Question 1</td><td></td><td></td></tr>
<tr><td>(a)</td><td>isotopes (are varieties of the same element that) have the same number of protons/atomic number/proton number ✓

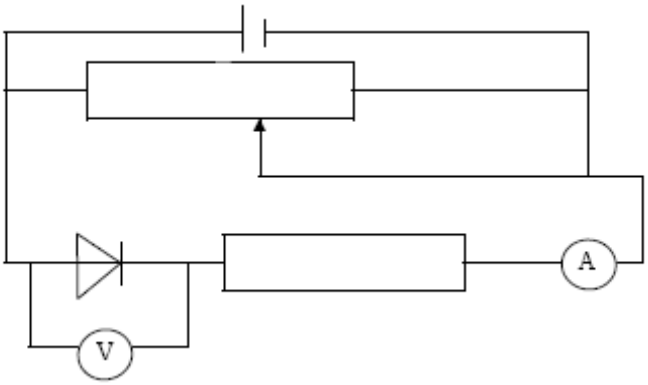
but different numbers of neutrons/nucleons/atomic mass ✓</td><td>2</td></tr>
<tr><td>(b)</td><td>(i)/
(ii)/
(iii)/
(iv)

<table>
<tr><td></td><td>number of protons</td><td>number of neutrons</td><td>specific charge of nucleus/
C kg^{-1} ✓</td></tr>
<tr><td>first isotope</td><td>92</td><td>143</td><td>$=92 \times 1.6 \times 10^{-19}$ ✓
$/(92 \times 1.67 \times 10^{-27}$
$+143 \times 1.67 \times 10^{-27})$ ✓
$= 3.8 \times 10^{7}$ ✓</td></tr>
<tr><td>second isotope</td><td>92 ✓</td><td>$3.7 \times 10^{7} = 92 \times 1.6 \times 10^{-19}$
$/(A \times 1.67 \times 10^{-27})$ ✓
$A \times 1.67 \times 10^{-27} = 92 \times 1.6 \times 10^{-19}/3.7 \times 10^{7}$
A = 238 ✓
number of neutrons
= 238 - 92=146 ✓ or
148 if used u or 147
(depends on rounding)</td><td>3.7×10^{7}</td></tr>
</table>
</td><td>8</td></tr>
<tr><td></td><td>Total</td><td>10</td></tr>
</table>

Question 2		
(a)	the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication	
QWC	**descriptor**	**mark range**
good - excellent	Uses accurately appropriate grammar, spelling, punctuation and legibility. Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [May include formulae or equations]. Answer refers to at least 5 of the relevant points listed below.	**5 - 6**
modest - adequate	Only a few errors. Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. Answer refers to at least 3 or the relevant points listed below.	**3 - 4**
poor - limited	Several significant errors. Answer lacking structure, arguments not supported by evidence and contains limited information. Answer refers to no more than 2 of the relevant points.	**1 – 2**
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	**0**
	The explanation expected in a competent answer should include a coherent selection of the following physics ideas.	
	electron in atoms can only occupy certain (discrete) energy levels ✓	
	the ground state is the lowest energy state an electron/atom can occupy ✓	
	electrons collide with (orbital) electrons ✓	
	giving the electrons the energy necessary to move to a higher level ✓	
	electrons later return to a lower level/ground state losing energy ✓	
	by emitting photons of a characteristic/different/discrete/certain/varying frequencies **or** $\Delta E = hf$ **or** frequency depends on energy difference ✓	
(b) (i)	the 5.5 eV electron does not have enough energy to excite an (orbital) electron/atom ✓	**7**
	the 9.0 eV electron provide enough energy to excite an (orbital) electron/atom ✓	
(ii)	energy = $9.0 \times 1.6 \times 10^{-19}$ ✓ = 1.44×10^{-18} (J) ✓	
(iii)	$E = 1.44 \times 10^{-18} - 1.6 \times 10^{-19} = 1.28 \times 10^{-18}$ ✓ (J)	
	$6.63 \times 10^{-34} \times f = 1.28 \times 10^{-18}$ ✓	
	$f = 1.28 \times 10^{-18} / 6.63 \times 10^{-34} = 1.9 \times 10^{15}$ Hz ✓	
	Total	**12**

Question 3			
(a)	(i)	three ✓	**2**
	(ii)	one ✓	
(b)	(i)	charge ✓ baryon number ✓ lepton number ✓ mass ✓ energy ✓ momentum ✓ **max 2**	**5**
	(ii)	strangeness ✓	
	(iii)	weak interaction/(nuclear) force ✓	
	(iv)	proton ✓	
		Total	**7**

Question 4			
(a)	(i)	the (maximum) kinetic energy/speed/velocity/momentum of released electrons increases ✓ this is because increasing the frequency of the photons increases their energy **or** correct application of photoelectric equation ✓	**4**
	(ii)	the number of electrons emitted (per second) increases ✓ because there are now more photons striking the metal surface (per second) ✓	
(b)		experiment/observation needs to be performed (to test a theory) ✓ the results of (the experiment) need to be proved/repeatable/replicated/ confirmed ✓ [**or** threshold frequency ✓ could not be explained by the wave model ✓]	**2**
(c)	(i)	(use of $\phi = hf_0$) $\phi = 6.63 \times 10^{-34} \times 5.5 \times 10^{14}$ ✓ $\phi = 3.65 \times 10^{-19}$ ✓ J ✓	**6**
	(ii)	$E_k = 6.63 \times 10^{-34} \times 6.2 \times 10^{14}$ ✓ - 3.65×10^{-19} ✓ $E_k = 4.6 \times 10^{-20}$ J (accept 5.1×10^{-20} J) ✓	
		Total	**12**

Question 5		
(a) (i)		**3**
	suitable variable input (variable power supply or variable resistor) ✓	
	protective resistor **and** diode **forward** biased ✓	
	correct current **and** pd measuring devices ✓	
(ii)	the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication	
QWC	**descriptor**	**mark range**
good - excellent	Uses accurately appropriate grammar, spelling, punctuation and legibility. Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [May include bullet points and/or formulae or equations]. Answer refers to at least 5 of the relevant points listed below.	**5 - 6**
modest - adequate	Only a few errors. Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. Answer refers to at least 3 or the relevant points listed below.	**3 - 4**
poor - limited	Several significant errors. Answer lacking structure, arguments not supported by evidence and contains limited information. Answer refers to no more than 2 of the relevant points.	**1 – 2**
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	**0**
	The explanation expected in a competent answer should include a coherent selection of the following physics ideas.	
	connect circuit up ✓	
	measure current (I) and pd/voltage (V) ✓	
	vary resistance/voltage ✓	
	obtain a range of results ✓	
	reverse connections to power supply (and repeat) ✓	
	plot a graph (of pd against current) ✓	
	mention of significance of 0.6 V **or** disconnect between readings **or** change range on meters when doing reverse bias ✓	

(b)	(i)	(use of $I = V/R$) I = 12/8 ✓= 1.5 A ✓	**5**
	(ii)	I = (12-0.65 ✓)/4 = 2.8 A ✓ sig figs ✓	
		Total	**14**

Question 6			
(a)	(i)	use of 1.5 cycles ✓ conversion to time eg time for 1.5 cycles = 10 × 1.5 = 15 ms ✓ calculation of frequency eg frequency = 1 / 0.010 = 100 ± 3 Hz ✓	**7**
	(ii)	peak voltage = 1.5 × 2 ✓ = 3.0 V ✓	
	(iii)	rms voltage = 3.0/√2 ✓ (ce from (a) (i)) rms voltage = 2.12 V ✓	
(b)		vertical line is formed ✓ of length equal to twice the peak voltage ✓ because trace no longer moves horizontally **or** spot moves **just** up and down ✓	**max 2**
		Total	**9**

Question 7		
(a)	(use of $E = V + Ir$) 12 = V + 420 × 0.0095 ✓ V = 8.0(1) V ✓	**2**
(b)	$\rho = RA/l$= 1.6 × 10^{-3} × 7.9 × 10^{-5}/0.75 ✓ R = 1.7 × 10^{-7} ✓ Ω m ✓	**3**
	Total	**5**