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ASSESSMENT and
QUALIFICATIONS
ALLIANCE

General Certificate of Education

Physics 1451

Specification A

PHYA1 Particles, Quantum Phenomena and Electricity

Mark Scheme

2010 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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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*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
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><th>Question 1</th><th></th><th></th></tr>
<tr><td>(a) (i)</td><td>particles that experience the strong (nuclear) force/interaction ✓</td><td>1</td></tr>
<tr><td>(a) (ii)</td><td>particles composed of three quarks ✓</td><td>1</td></tr>
<tr><td>(a) (iii)</td><td>particles composed of a quark and an antiquark ✓</td><td>1</td></tr>
<tr><td>(b)</td><td>similarity: but the same (rest) mass or rest energy ✓
difference: opposite quantum states eg charge ✓</td><td>2</td></tr>
<tr><td>(c)</td><td><table>
<tr><th></th><th>charge/C</th><th>baryon number</th><th>quark structure</th></tr>
<tr><td>antiproton</td><td>-1.6×10^{-19}</td><td>–1</td><td>$\overline{u}\overline{u}\overline{d}$</td></tr>
</table>
-1 for each error</td><td>2</td></tr>
<tr><td>(d) (i)</td><td>weak interaction ✓
strange not conserved or there is a change/decay of quark (flavour) ✓</td><td>2</td></tr>
<tr><td>(d) (ii)</td><td>any two
eg charge
baryon number
(muon) lepton number</td><td>2</td></tr>
<tr><td></td><td align="right">Total</td><td>11</td></tr>
</table>

Question 2		
(a) (i)	an electron/atom is at a higher level than the ground state ✓ **or** electron jumped/moved up to another/higher level	**1**
(a) (ii)	electrons (or electric current) flow through the tube ✓ and collide with orbiting/atomic electrons or mercury atoms ✓ raising the electrons to a higher level (in the mercury atoms) ✓	**3**
(a) (iii)	photons emitted from mercury atoms are in the **ultra violet** (spectrum) **or** high energy photons ✓ these photons are absorbed by the powder **or** powder changes frequency/wavelength ✓ and the powder emits photons in the visible spectrum ✓ incident photons have a variety of different wavelengths ✓	**max 3**
(b) (i)	(use of $E = hf$) $-0.26 \times 10^{-18} - 0.59 \times 10^{-18}$ ✓ $= 6.63 \times 10^{-34} \times f$ ✓ $f = 0.33 \times 10^{-18}/(6.63 \times 10^{-34}) = 5.0 \times 10^{14}$ (Hz) ✓	**3**
(b) (ii)	**one** arrow between n=3 and n=2 ✓ in correct direction ✓	**2**
	Total	**12**

Question 3			
(a)	(i)	an electron ✓	**1**
(a)	(ii)	change in *A* = 0 ✓ change in *Z* = +1 ✓	**2**
(b)	(i)	${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \overline{\nu_e}$ ✓ **or** $n \rightarrow p + e^{-} + \overline{\nu_e}$ **or** $d \rightarrow u + e^{-} + \overline{\nu_e}$	**1**
(b)	(ii)	lepton number must be conserved ✓ lepton number before decay equals zero hence after decay lepton number of electrons cancels with lepton number of anti-neutrino **or** zero on both sides ✓	**2**
(b)	(iii)	hypothesis needs to be tested by experiment ✓ experiment must be repeatable ✓ **or** hypothesis rejected	**2**
		Total	**8**

Question 4			
(a)	(i)	**below a certain** frequency (called the threshold frequency) no electrons emitted ✓ **or** minimum frequency for electrons to overcome work function	**1**
(a)	(ii)	(light travels as photons) energy of a photon depends on frequency ✓ below threshold frequency (photon) does not have enough **energy** to liberate an electron ✓ **or** reference to work function eg a photon does not have enough **energy** (to allow the electron) to overcome the work function	**2**
(b)	(i)	(use of $E = hc/\lambda$) $E = 6.63 \times 10^{-34} \times 3.00 \times 10^{8}/5.40 \times 10^{-7}$ ✓ $E = 3.68 \times 10^{-19}$ (J) ✓	**2**
(b)	(ii)	(use of $hf = E_k + \phi$) $3.68 \times 10^{-19} = E_k + 1.40 \times 10^{-19}$ ✓ $E_k = 2.28 \times 10^{-19}$ (J) ✓	**2**

(b) (iii)	(use of $E_k = mv^2/2$) $2.28 \times 10^{-19} = 1/2 \times 9.11 \times 10^{-31} \times v^2$ ✓ $v^2 = 2 \times 2.28 \times 10^{-19}/9.11 \times 10^{-31} = 5.0 \times 10^{11}$ $v = 7.1 \times 10^5$ (m s^{-1}) ✓	**2**
(b) (iv)	(use of $\lambda = h/mv$) $\lambda = 6.63 \times 10^{-34}(9.11 \times 10^{-31} \times 7.1 \times 10^5)$ ✓ $\lambda = 1.03 \times 10^{-9}$ (m) ✓	**2**
	Total	**11**

Question 5		
(a) (i)	(use of $R = \rho l/A$) $R = 4.0 \times 10^{-3} \times 0.060$ ✓$/(\pi \times 0.012^2)$ ✓ $R = 0.53$ (Ω) ✓ 2 significant figures ✓	**4**
(a) (ii)	halving the diameter **will** increase resistance by factor of 4 or increasing the length by a factor of 4 will increase resistance by factor of 4 ✓ (hence) resistance will be 16 times greater ✓	**2**

(b)	the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication circuit must include: voltmeter and ammeter connected correctly ✓ power supply with means of varying current ✓	2
QWC	**descriptor**	**mark range**
good - excellent	(i) Uses accurately appropriate grammar, spelling, punctuation and legibility. (ii) 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] An excellent candidate will have a working circuit diagram with correct description of measurements (including range of results) and processing. An excellent candidate uses a range of results and finds a mean value or uses a graphical method, eg *I*-*V* characteristics. They also mention precision eg use of vernier callipers.	**5 - 6**
modest - adequate	(i) Only a few errors. (ii) Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. An adequate candidate will have a working circuit and a description with only a few errors, eg do not consider precision. They have not taken a range of results and fail to realise that the diameter needs to be measured in several places.	**3 - 4**
poor - limited	(i) Several significant errors. (ii) Answer lacking structure, arguments not supported by evidence and contains limited information. Several significant errors, eg important measurement missed, incorrect circuit, no awareness of how to calculate resistivity.	**1 – 2**
incorrect, inappropriate or no response		**0**
	The explanation expected in a good answer should include a coherent account of the procedure and include most of the following points. • length with a ruler • thickness/diameter with vernier callipers/micrometer • measure voltage • measure current • calculate resistance • use of graph, eg *I*-*V* or resistance against length • use of diameter to calculate cross-sectional area • mention of precision, eg vernier callipers or full scale readings for V and I • flat metal electrodes at each end to improve connection	
	Total	**14**

Question 6			
(a)	(i)	6.0 (Ω) ✓	**1**
(a)	(ii)	4.5 (V) ✓	**1**
(a)	(iii)	(use of *I* = *V*/*R*) *I* = 4.5/6.0 = 0.75 (A) ✓ current through cell A = 0.75/2 = 0.375 (A) ✓	**2**
(a)	(iv)	charge = 0.375 × 300 = 112 ✓ C ✓	**2**
(b)		cells C and D will go flat first or A and B last longer ✓ current/charge passing through cells C and D (per second) is double/more than that passing through A or B ✓ energy given to charge passing through cells **per second** is double or more than in cells C and D ✓ or in terms of power	**3**
		Total	**9**

Question 7		
(i)	10.0 (V) ✓	**1**
(ii)	V_{rms} = 10.0/√2 = 7.1 (V) ✓	**1**
(iii)	time period = 3 × 2 = 6 (ms) ✓	**1**
(iv)	frequency = 1/0.006 or 1/6 ✓ frequency = 167 ✓ (Hz)	**2**
	Total	**5**