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General Certificate of Education (A-level)
January 2012

Physics A PHYA1

(Specification 2450)

Unit 1: Particles, quantum phenomena and electricity

Final

Mark Scheme

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 events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised 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 students' 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.

Further copies of this Mark Scheme are available from: aqa.org.uk

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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</td><td>
<table>
<tr><td>particle</td><td>quark structure</td><td>charge</td><td>strangeness</td><td>baryon number</td></tr>
<tr><td>proton ✓</td><td>uud</td><td>+ 1 ✓</td><td>0</td><td>1 ✓</td></tr>
<tr><td>sigma$^+$</td><td>uus</td><td>+ 1</td><td>– 1 ✓</td><td>1 ✓</td></tr>
<tr><td>π^+ ✓</td><td>$u\bar{d}$</td><td>+ 1 ✓</td><td>0</td><td>0</td></tr>
</table>
</td><td>7</td></tr>
<tr><td>b i</td><td>examples:
proton, antiquarks ✓</td><td>1</td></tr>
<tr><td>b ii</td><td>consists of 3 antiquarks ✓</td><td>1</td></tr>
<tr><td>b iii</td><td>same (rest) mass (energy) ✓
difference eg baryon number/charge ✓</td><td>2</td></tr>
<tr><td></td><td>Total</td><td>11</td></tr>
</table>

Question 2		
a	the ratio of charge to mass of nucleus ✓ $\mathrm{C\,kg^{-1}}$ ✓	**2**
b i	number of protons and neutrons the same **or** number of neutrons less **or** mass the same ✓ but more protons therefore greater charge ✓	**2**
b ii	answers add up to 10 ✓ number of protons = 4 ✓ number of neutrons = 10 – 4 = 6 ✓ evidence of correct calculation ✓ eg 5q = 1.25 × ?q ? = 4	**4**
	Total	**8**

Question 3		
a	photon interacts with (orbital) electron/nucleus/atom ✓ energy of photon used to create particle antiparticle pair ✓ to conserve momentum photon needs to interact with interacting particle ✓	**max 2**
b	energy of photon depends on frequency ✓ if energy/frequency is below a certain value there is not enough energy ✓ to provide mass/rest energy of particles ✓	**3**
c	any two ✓✓ eg charge lepton number baryon number strangeness	**2**
	Total	**7**

Question 4		
a i	when electrons/atoms are in their lowest/minimum energy (state) **or** most stable (state) they (are in their ground state) ✓	**1**
a ii	in either case an electron receives (exactly the right amount of) energy ✓ excitation promotes an (orbital) electron to **a higher energy/up a** level ✓ ionisation occurs (when an electron receives enough energy) **to leave** the atom ✓	**3**
b	electrons occupy discrete energy levels ✓ and need to absorb an exact amount of/enough energy to move to a higher level ✓ photons need to have certain frequency to provide this energy **or** e = hf ✓ energy required is the same for a particular atom or have different energy levels ✓ all energy of photon absorbed ✓ in 1 to 1 interaction or clear **a/the photon** and **an/the electron** ✓	**max 4**
c	energy = $13.6 \times 1.60 \times 10^{-19} = 2.176 \times 10^{-18}$ (J) ✓ $hf = 2.176 \times 10^{-18}$ ✓ $f = 2.176 \times 10^{-18} \div 6.63 \times 10^{-34} = 3.28 \times 10^{15}$ Hz ✓ 3 sfs ✓	**4**
	Total	**12**

Question 5		
a i	circuit with ammeter and voltmeter correct or ohmmeter ✓ some means of heating eg water bath ✓ thermometer in water bath ✓	**3**
a ii	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. *The candidate states that resistance is measured using an ohmmeter or voltmeter ammeter method. The wire is heated in a beaker of water and the temperature measured with a thermometer. Ice is added to the water and the water is stirred as the water is heated. Details of how resistance is calculated and how results are presented e.g. graph of resistivity against temperature.* **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. *The candidate states that resistance is measured using an ohmmeter or voltmeter ammeter method. The wire is heated in a beaker of water and the temperature measured with a thermometer. Ice is added to the water. Details of how resistance is calculated.* **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. *The candidate states that resistance is measured using an ohmmeter or voltmeter ammeter method. The wire is heated in a beaker of water and the temperature measured with a thermometer.*	**max 6**

	The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. • resistance measured calculated • water bath used • ice added to water • water stirred • temperature measured with thermometer • resistance calculated • graph drawn	
b	the temperature at **or** below which a material ✓ becomes a superconductor **or** has **zero** resistance/resistivity ✓	**2**
	Total	**11**

Question 6		
a	(use of $P = VI$) $I = 36/12 = 3.0$ A ✓ $I = 2.0/4.5 = 0.44$ A ✓	**2**
b i	pd = 24 – 12 = 12 V ✓	**1**
b ii	current = 3.0 + 0.44 = 3.44 A ✓	**1**
b iii	$R_1 = 12/3.44 = 3.5\,\Omega$ ✓	**1**
b iv	pd = 12 – 4.5 = 7.5 V ✓	**1**
b v	$R_2 = 7.5/0.44 = 17\,\Omega$ ✓	**1**
c i	(circuit) resistance increases ✓ current is lower (reducing voltmeter reading) ✓ **or** correct potential divider argument	**2**
c ii	pd across Y **or** current through Y increases ✓ hence power/rate of energy dissipation greater **or** temperature of lamp increases ✓	**2**
	Total	**11**

Question 7		
a i	(use of $V = IR$) R_{total} = 1 (ohm) ✓ $V = 1 \times 1 = 1.0\,V$ ✓	**2**
a ii	(use of $V = IR$) $R = 9.0/1.0 = 9.0\,\Omega$ ✓ $r = 9.0 - 1.0 - 6.0 = 2.0\,\Omega$ ✓ **or** use of ($E = I(R + r)$) $9.0 = 1(7 + r)$ ✓ $r = 9.0 - 7.0 = 2.0\,\Omega$ ✓	**2**
a iii	(use of $W = VIt$) $W = 9.0 \times 1.0 \times 5 \times 60$ ✓ $W = 2700\,J$ ✓	**2**
a iv	energy dissipated in internal resistance = $1^2 \times 2.0 \times 5 \times 60 = 600\,(J)$ ✓ percentage = $100 \times 600/2700 = 22\%$ ✓ CE from part aii	**2**
b	internal resistance limits current ✓ hence can provide higher current ✓ **or** energy wasted in internal resistance/battery ✓ less energy wasted (with lower internal resistance) ✓ **or** charges quicker ✓ as current higher or less energy wasted ✓ **or** (lower internal resistance) means higher terminal pd/voltage ✓ as less pd across internal resistance or mention of lost volts ✓	**max 2**
	Total	**10**

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