Version 1.0

General Certificate of Education (A-level)
June 2011

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 candidates' 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 candidates' 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 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.

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.

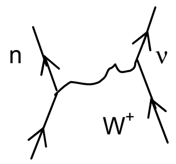
6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. 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

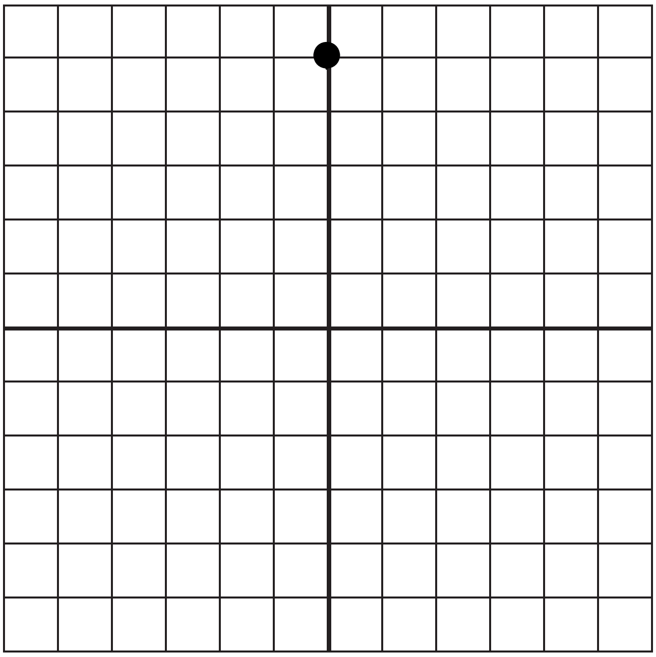
Question 1			
a	i	any two eg proton, neutron ✓✓	**2**
a	ii	$u\bar{d}$ ✓	**1**
b	i	contains a strange quark **or** longer half life than expected **or** decays by weak interaction ✓	**1**
b	ii	the second one is not possible ✓ because lepton number is not conserved ✓	**2**
c	i	weak (interaction) ✓	**1**
c	ii	mention of charge conservation **or** charge conservation demonstrated by numbers ✓	**1**
c	iii	X must be a baryon ✓ baryon number on right hand side is +1 ✓	**2**
c	iv	proton/p ✓	**1**
		Total	**11**

Question 2		
i	same atomic number/number of protons ✓ different mass/nucleon number/different number of neutrons ✓	**2**
ii	${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}\alpha$ ✓✓	**2**
iii	$\frac{q}{m} = \frac{2 \times 1.6 \times 10^{-19}}{4 \times 1.67 \times 10^{-27}}$ ✓✓ $\frac{q}{m} = 4.8 \times 10^{7}\ \mathrm{C\,kg^{-1}}$ ✓✓	**4**
iv	strong nuclear force is short range ✓ no effect at distances larger 3 fm (except any distance less than 10 fm) ✓	**2**
	Total	**10**

Question 3			
a		$^{40}_{19}\mathrm{K} \rightarrow {}^{40}_{18}\mathrm{Ar} + {}^{0}_{1}e + v_e$ ✓✓✓✓ (accept + for 1 and e^+ or β^+)	**4**
b	i	electron/K capture ✓	**1**
b	ii	(inner) shell (of atom) ✓	**1**
b	iii	conservation of **lepton number** ✓	**1**
b	iv	 *n* ✓ *v* ✓ W^+ ✓	**3**
		Total	**10**

Question 4		
a	**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 provides a comprehensive and coherent description which includes a clear explanation of constant energy level differences and how electrons can be excited by electron collisions. The link between the energy of a photon and its frequency should be clear. The description should include a clear explanation of the reason atoms of a given element emit photons of a characteristic frequency **or** there is a clear link between constant energy differences and photon frequency/wavelength (eg E=hf). The candidate should relate the energy **difference** between levels to the energy of emitted photons and state the energy difference is fixed/constant. **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 provides an explanation of energy levels and how excitation takes place by electron collision with **atomic/orbital** electrons. The candidate explains how an orbital/atomic electron loses energy by emitting a photon.	**max 6**

		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. Some mention of energy levels and the idea of excitation of electron. Talk about excitation of atom instead of electron limits the mark to 1. **Incorrect, inappropriate of no response: 0 marks** No answer or answer refers to unrelated, incorrect or inappropriate physics. **The explanation expected in a competent answer should include a coherent account of the significance of discrete energy levels and how the bombardment of atoms by electrons can lead to excitation and the subsequent emission of photons of a characteristic frequency.** electrons bombard atoms of vapour and give energy to electrons in atom electrons move to a higher energy level electrons are excited excited electrons move down to lower energy levels losing energy by emitting photons photons have energy hf photons of characteristic frequencies emitted from atoms of a particular element this is because atoms have discrete energy levels which are associated with particular energy values	
b	i	energy required to (completely) remove an electron from atom/hydrogen ✓ ground state/lowest energy level ✓	**2**
b	ii	$13.6 \times 1.6 \times 10^{-19}$ ✓ = 2.18×10^{-18} (J) ✓ 3 sfs ✓	**3**
		Total	**11**

Question 5		
a		**1**
b i	the **voltage reverse**/**changes** direction/sign ✓ this makes **the spot** move up and down **or** correct explanation of lack of horizontal movement ✓	**2**
b ii	length of line = 8 divisions peak to peak = 8 × 0.5 = 4.0 V ✓✓	**2**
b iii	(peak = 2.0 V) rms = 2.0/√2 ✓ = 1.4 V ✓	**2**
	Total	**7**

Question 6			
a		mention of pd across internal resistance **or** energy loss in internal resistance **or** emf > V ✓ pd across internal resistance/lost volts increases with current **or** correct use of equation to demonstrate ✓	**2**
b	i	*y – intercept* 1.52 V (± 0.01 V) ✓	**1**
b	ii	identifies gradient as *r* **or** use of equation ✓ substitution to find gradient **or** substitution in equation ✓ $r = 0.45 \pm 0.02\,\Omega$ ✓	**3**
c	i	same intercept ✓ double gradient (must go through 1.25, 0.40 ± 1.5 squares) ✓	**2**
c	ii	same intercept horizontal line ✓	**1**
d	i	(use of $Q = It$) $Q = 0.89 \times 15 = 13$ ✓ C ✓	**2**
d	ii	use of $P = I^2r$ ✓ $P = 0.89^2 \times 0.45$ $P = 0.36$ W ✓	**2**
		Total	**13**

Question 7			
a	i	(use of $R = V/I$) $R = 10/2.0 = 5.0\,\Omega$ ✓	**1**
a	ii	$\frac{1}{R} = \frac{1}{3} + \frac{1}{3+3} = \frac{3}{6}$ ✓ $R = 2\,(\Omega)$ ✓ $R_{total} = 2 + 3$ ✓ $(= 5\,\Omega)$	**3**
b	i	voltage across Y = 10.0 – 2.0 × 3.0 = 4.0 V ✓ current in Y = 4.0/3.0 = 1.3 A ✓	**2**
b	ii	current through W = 0.67 A ✓ voltage = 0.67 × 3 = 2.0 V ✓ (**or** 4.0/2 ✓ = 2.0 V ✓)	**2**
		Total	**8**

	UMS conversion calculator www.aqa.org.uk/umsconversion	