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General Certificate of Education (A-level)
January 2013

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 (e.g. 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 (i.e. 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.

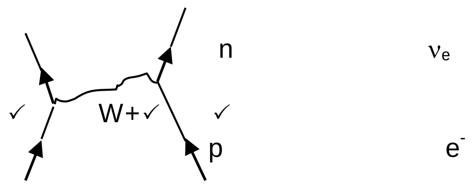
5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter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

1	a	(i)	neutron✓	1	accept symbols symbols e.g. n
1	a	(ii)	electron✓	1	accept symbols
1	a	(iii)	neutron✓	1	accept symbols
1	b	(i)	antineutrino✓	1	$\overline{\upsilon_{(e)}}$
1	b	(ii)	A=99✓ Z= 44 ✓	2	
1	b	(iii)	specific charge = $43 \times 1.6 \times 10^{-19}$ ✓/$99\times1.66\times10^{-27}$ ✓ specific charge = 4.2×10^{7} ✓ C kg^{-1}✓	4	Correct answer no working -1 If include mass of electrons lose 2 and 3 mark

2		(a)	pair production ✓	1	
2		(b)	(energy = 2×rest mass energy) energy = 2 × 0.510999 = 1.021998 (MeV)✓ energy = 1.021998 × 1.60 × 10^{-13} = 1.64 × 10^{-13} J✓ (3 sig figs✓)	3	If miss out 2 factor can get CE Can use $E=2mc^2$ First mark for full substitution and second mark for answer
2		(c)	kinetic energy (of electron and positron) ✓	1	KE of photon gets zero
2		(d)	(meet an electron and) annihilate✓ (converting into two or more) photon<u>s</u>✓ OR gamma rays	2	

3	a	(i)	three✓ OR qqq	1	
3	a	(ii)	mesons✓	1	
3	a	(iii)	experience the strong interaction ✓ made up of quarks OR not fundamental✓ (eventually) decay to proton✓	2_{max}	
3	b		interaction | exchange particle electromagnetic | (virtual)photon✓OR γ weak | W+ or W-or $Z^{(0)}$ ✓	2	W must have superscript
3	c	(i)		3	If no arrow on W boson line then must be clearly slanting in correct direction for second mark e must have - superscript If no clear junctions lose second mark If no arrows on sides -1
3	c	(ii)	<u>lepton number</u> must be conserved ✓ (+1 on lhs must be +1 on rhs)	1	

4	a	(i)	absorbs enough energy (from the incident) electron(by collision) OR incident electron loses energy (to orbital electron) ✓ exact energy/10.1((eV) needed to make the transition/move up to level 2✓	2	For second mark must imply exact energy
4	a	(ii)	(*use of* $E_2 - E_1$*) = hf* -3.41 - - 13.6 = 10.19✓ energy of photon = 10.19 × 1.6 × 10^{-19} = 1.63 × 10^{-18} (J) ✓ 6.63 × 10^{-34} × *f* = 1.63 × 10^{-18} *f* = 2.46 × 10^{15} (Hz)✓ *(accept 2.5 but not 2.4)*	3	CE from energy difference but not from energy conversion
4	a	(iii)	Ek = 1.7 × 10^{-18} - 1.63 × 10^{-18}✓ = 7.0 × 10^{-20} J✓	2	
4	a	(iv)	energy required is 12.09 eV/1.9 × 10^{-18} ✓ energy of incident electron is only 10.63 eV/energy of electron less than this (1.7 × 10^{-18} J)✓	2	State and explain must have consistent units i.e. eV or J
4	b	(i)	Electrons return to lower levels by different routes/cascade/not straight to ground state✓	1	
4	b	(ii)	3✓ n= 3 to n=1 or n=3 to n=2 and n=2 to n=1✓	2	no CE from first mark

5	a		a component with constant resistance OR V ∝ I ✓	1	
5	b	(i)	circuit using correct symbols with means of varying current/voltage✓ correct voltmeter and ammeter✓	2	ignore symbol for component unless it is a variable resistor

5	b	(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. *Candidate draws an appropriate circuit diagram with correctly positioned ammeter and voltmeters. Candidate has a means of varying the current. Sets current to different values and measures pd. Mentions wide range. Has a sensible way of varying current (e.g. variable resistor/ potential divider). Plots a graph of pd against current. Relates constant gradient to a constant resistance.* **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. *Candidate draws an appropriate circuit diagram with correctly positioned ammeter and voltmeters. Candidate has a means of varying the current. Varies current and measures pd. Plots a graph of pd against current. Relates constant gradient to a constant resistance.* **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 measures resistance at least twice to see if constant. Has some means of varying current.* **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.** method for varying current current varied in regular steps pd and current measure resistance calculated graph drawn significance of gradient of the graph discussed	6	Level 1/2 Take several readings of V and I and plot graph or calculate R Level 3/4 Draw best fit line or state R constant Relate **straight** line on graph to ohmic conductor Level 5/6 meaning of line through origin reverse current readings suitable range with suggested values

5	c	(i)	a material with zero resistivity/resistance✓	1	not negligible
5	c	(ii)	material becomes superconducting at/below critical temperature✓	1	accept reverse argument
5	c	(iii)	any correct usage e.g. powerful magnets, mri, maglev trains/bullet train/(high power) transmission lines/particle accelerators/LHC✓	1	
6	a	(i)	**$1/R_{total}$ = 1/(40)** ✓+1/(10+5) ✓= 0.09167 R_{total} = 10.9 kΩ✓	3	
6	a	(ii)	I = 12/10.9k = 1.1 mA✓	1	
6	b		position: pd/V AC: 6.0✓ DF: 4.0✓ CD: 2.0✓	3	C.E. for CD
6	c	(i)	AC: no change✓ constant pd across resistors/parallel branches(AE)✓	2	no CE from first mark
6	c	(ii)	DF: decreases✓ as greater proportion of voltage across fixed/10 kΩ resistor✓	2	no CE from first mark
7	a		(use of ρ=*RA/l*) R=1.7 × 10^{-7}×0.75/1.3 ×10^{-7}✓ R=0.98 Ω✓	2	First mark for sub. and rearranging of equation. Bald 0.98 gets both marks Final answer correct to 2 or more sig. figs.
7	b	(i)	(*use of P=VI) I*= 2.08 A	1	
7	b	(ii)	V=2.08 × 0.98 = 2.04 V	1	C.E. from (a) and (b)(i)

7	b	(iii)	emf = 12 + 2✓× 2.04 = 16.1 V✓	2	C.E. from (b)(ii) If only use one wire then C.E. for second mark
7	c		lamp would be less bright✓ as energy/power now wasted in internal resistance/battery OR terminal pd less OR current lower (due to greater resistance)✓	2	No C.E. from first mark