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General Certificate of Education
June 2010

Physics A PHYA1

Particles, Quantum Phenomena and Electricity

Unit 1

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 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.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

Set and published by the Assessment and Qualifications Alliance.

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.

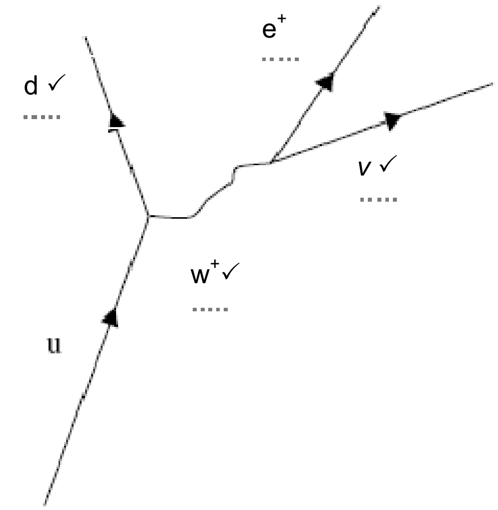
4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other 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)	neutrino ✓	**1**
(b)	proton number = 10 ✓ nucleon number = 22 ✓	**2**
(c)	baryon = neutron ✓ lepton = positron ✓ lepton = neutrino ✓	**3**
(d)	ddu and uud ✓	**1**
(e)	 -1 for each error	**3**
	Total	**10**

Question 2		
(a)	repulsive then attractive ✓ short range (if distance quoted must be of order fm) ✓ correct distance for cross over (accept range 0.1 – 1.0 fm) ✓	**3**
(b) (i)	a helium nucleus (accept 2p and 2n) ✓	**1**
(b) (ii)	$(_{\downarrow}92^{\uparrow}238)\ U \rightarrow (_{\downarrow}90^{\uparrow}234)Th(+_{\downarrow}2^{\uparrow}4)\alpha$ ✓	**2**
(c) (i)	same atomic number/proton number ✓ different number of neutrons/nucleons ✓	**2**
(c) (ii)	evidence of subtraction of mass number or atomic number ✓ (thus atomic number decreases to) **76** ✓ (atomic number of lead is 82 therefore) **6** (82 – 76) beta decays ✓	**3**
	Total	**11**

Question 3			
(a)	(i)	*hf* is energy available/received **or** same energy from photons ✓ energy required to remove the electron varies (hence kinetic energy of electrons will vary) ✓	**2**
(a)	(ii)	(work function is the) minimum energy needed to release an electron ✓ (or not enough energy to release electron) below a certain frequency energy of **photon** is less than work function **or** energy of **photon** correctly related to *f* ✓	**2**
(a)	(iii)	joule ✓ (accept eV)	**1**
(b)	(i)	(use of $E = hf$) energy = $6.63 \times 10^{-34} \times 1.5 \times 10^{15}$ ✓ energy = 9.9×10^{-19} (J) ✓	**2**
(b)	(ii)	number of photons per second = $3.0 \times 10^{-10}/9.9 \times 10^{-19}$ ✓ number of photons per second = 3.0×10^{8} ✓	**2**
(c)	(i)	(time taken = $6.8 \times 10^{-19}/3 \times 10^{-22}$) time taken = 2.3×10^{3} s ✓	**1**
(c)	(ii)	light travels as particles/ photons ✓ (or has a particle(like) nature) (which transfer) energy in discrete packets ✓ **or** 1 to 1 interaction **or** theory rejected/modified (in light of validated evidence)	**2**
		Total	**12**

Question 4		
(a)	(electron) diffraction/interference/superposition ✓	**1**
(b)	(use of $\lambda = h/mv$) $\lambda = 6.63 \times 10^{-34}/(9.11 \times 10^{-31} \times 4.50 \times 10^{5})$ ✓ $\lambda = 1.6 \times 10^{-9}$ (m) ✓	**2**
(c)	$207 \times 9.11 \times 10^{-31}$ ✓ $\times\ v = 6.63 \times 10^{-34}/1.6 \times 10^{-7}$ ✓ v = 2200 (2170) (m s^{-1}) ✓	**3**
	Total	**6**

Question 5			
(a)	(i)	**working** circuit including power supply and thermistor (correct symbol) ✓ voltmeter and ammeter or ohm meter ✓	**2**
(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 the thermistor is connected in a suitable circuit with voltmeter and ammeter or ohmmeter. The candidate gives details of how the thermistor is heated in a beaker of water **or** a water bath and a thermometer is used to measure the temperature at small regular intervals. The candidate states that the resistance is found at various temperatures either directly with an ohmmeter or by dividing voltage by current. The candidate may mention that the water must be stirred to ensure that the thermistor is at the temperature measured by the thermometer. The candidate may give some indication of the range of temperatures to be used. The candidate may refer to repetition of whole experiment. The candidate may plot a graph of resistance against temperature. The candidate may use a digital thermometer. **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 the thermistor is connected in a suitable circuit with voltmeter and ammeter or ohmmeter. The candidate gives details of how the thermistor is heated in a beaker of water and a thermometer is used to measure the temperature. The candidate states that the resistance is found at various temperatures either directly with an ohmmeter or by dividing voltage by current. **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 changes temperature at least once and measures V and I or R. **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.**	**max 6**

(b)	(i)	pd = 6.0 – 1.6 = 4.4 (V) ✓	**1**
(b)	(ii)	current = 4.4/1200 = 3.7×10^{-3} (A) ✓ (not 3.6)	**1**
(b)	(iii)	resistance = 1.6/3.7×10^{-3} = 440 **or** 430 (Ω) ✓ 2 sfs ✓	**2**
(c)		less current now flows **or terminal pd/voltage** lower ✓ (or voltage across cell/external circuit is lower) (hence) pd/voltage across resistor will decrease ✓	**2**
		Total	**14**

Question 6			
(a)		a non-ohmic conductor does not have a constant resistance ✓	**1**
(b)	(i)	curve of decreasing gradient with increasing V ✓ attempt to make graph symmetric in two opposite quadrants ✓	**2**
(b)	(ii)	resistance **increases** as pd increases/current increases ✓	**1**
(c)	(i)	(use of $P = V^2/R$) 36 = 144/R ✓ R = 4.0 (Ω) ✓	**2**
(c)	(ii)	reference to temperature change ✓ (resulting in) a lower resistance ✓ (hence) power rating would be greater ✓	**3**
		Total	**9**

Question 7			
(a)	(i)	work (done)/energy (supplied) per unit charge (by battery) ✓ (or pd across terminals when no current passing through cell or open circuit)	**1**
(a)	(ii)	when switch is closed a **current flows** (through the battery) ✓ hence a pd/lost volts develops across the internal resistance ✓	**2**
(b)		(use of $\varepsilon = V + Ir$) I = 5.8/10 = 0.58 (A) ✓ 6.0 = 5.8 + 0.58r ✓ r = 0.2/0.58 = 0.34 (Ω) ✓	**3**
(c)		need large current/power to start the car ✓ (or current too low) internal resistance limits the current/wastes power(or energy)/reduces terminal pd/increases lost volts ✓	**2**
		Total	**8**