AQA

AS
Physics

PHYA1 – Particles, Quantum Phenomena and Electricity
Mark scheme

2450
June 2016

Version: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer 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 associates 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 associate understands and applies it in the same correct way. As preparation for standardisation each associate 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, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

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Question	Answers	Additional Comments/Guidance	Mark	ID details
1(a)	(isotopes have) same number of protons✓ different numbers of neutrons✓	allow atomic mass /proton number allow mass number /nucleon number TO where mix up atomic number and mass number	2	
1(b)	$92 \times 1.60 \times 10^{-19}$✓ correct power (+)$1.47 \times 10^{-17}$ (C) ✓ penalise minus sign on answer line	Allow 2 sf answer 1.5×10^{-17} (C) Pay attention to powers on answer line	2	
1(c)	$(4.8 \times 10^{-19} \div 1.60 \times 10^{-19} =) 3$✓ $(92 - 3 =) 89$✓ 95 on answer line 1 mark	or $1.47 \times 10^{-17} - 4.8 \times 10^{-19}$ $(= Q)$ (ecf) $(n = \frac{Q}{e} = \frac{1.47 \times 10-17 - 4.8 \times 10-19}{1.6 \times 10^{-19}}) = 89$ (ecf) Integer value for n	2	
1(d)	${}^{237}_{92}U \rightarrow {}^{237}_{93}Np + {}^{0}_{-1}\beta + \overline{\nu_{(e)}}$✓✓✓	one mark for: • both numbers correct on Np • both numbers correct on β^- • correct symbol for (electron) antineutrino	3	
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
2(a)	$\bar{u}s$; $uu\bar{s}$; $u\bar{s}$ ✓ ; $\bar{d}\bar{d}s$	only third box from top ticked Allow crosses in any other box	1	
2(b) (i)	(lepton number of K^+ = 0) lepton number of μ+ = -1 lepton number of ν_μ = +1✓ (hence lepton number zero before and after)	need to see 0 → -1 + 1 ✓ (And 0 → 0) Must be in correct order	1	
2(b) (ii)	Strangeness (number)✓	allow rest mass Not meson number	1	
2(b) (iii)	see table below	one mark for each correct row ticks in correct boxes only allow crosses in other box(es)	3	

	charged	hadron	meson	baryon	lepton
K^+	(✓)	✓	✓		
μ^+	(✓)				✓
ν_μ					✓

2(c)	cannot be a lepton (to conserve lepton number)/ cannot be a baryon (to conserve baryon number) / must be a meson cannot have a charge (to conserve charge) ✓ (must be) π^0 ✓	maximum of one mark for either of first marking point can be done by BLQ table for first two marks TO on conservation wrong statements (-1 for each incorrect applied to the first two marking points) allow K^0 as must be a meson allowing strangeness to be conserved	3	

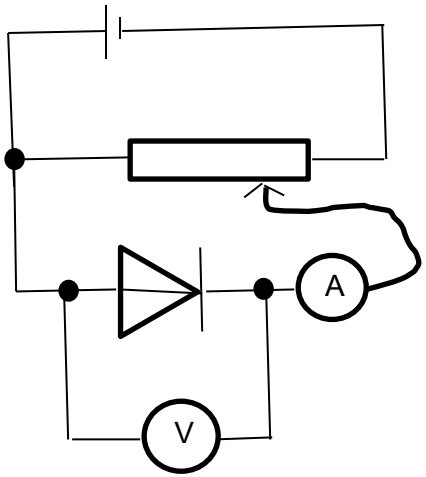
Total			9

Question	Answers	Additional Comments/Guidance	Mark	ID details
3(a)	pair production✓		1	
3(b) (i)	energy of photon needs to provide at least the rest masses ✓ of the electron and positron / of (both) particles / of particle and antiparticle✓ (allow particles or products) TO on nay suggestion of particles have KE	Or • at least the rest energy ✓ Of the electron and positron / of (both) particles of particle and antiparticle✓ Can't score 2nd mark without having scored 1st	2	
3(b) (ii)	minimum energy = $2 \times 0.510999 = 1.021998$ (MeV) ✓ allow detailed argument in reverse 0.5 Mev close to 0.511 MeV	must see working **and** final answer must be at least 3 sf Or $E=mc^2$ leading to 1.024875 MeV Or $2 \times 5.5 \times 10^{-4} \times 931.5 = 1.02$ MeV	1	
3(b) (iii)	(electron/positron have) kinetic energy✓	thermal energy n/e Momentum n/e	1	
3(b) (iv)	(attempts to convert energy to joules) energy = $1.0 \times 10^{6} \times 1.60 \times 10^{-19} = 1.6 \times 10^{-13}$ (J) ✓ (use of $E=hf$) Their energy ÷ 6.63×10^{-34} = f ✓	Condone power 10 error on MeV conversion to J Must see subject or their f on answer line consistent with working	4	

	$f = 2.4 \times 10^{20}$ ✓ cao Hz (condone s^{-1}) ✓	 Capital H and lower case z (for symbol) Allow word written as Hertz (h lower case)		

Total			9

Question	Answers	Additional Comments/Guidance	Mark	ID details
4(a) (i)	electrons passing through tube collide with electrons in mercury atom✓ transferring energy / atom gains energy from a collision✓ causing orbital electrons/electrons in mercury atom to move to higher energy level✓	Allow mercury atoms collide with each other Atomic electrons move from ground state	3	
4(a) (ii)	(each) excited electron / atom relaxes to a lower (energy) level✓ emitting a photon of energy equal to the energy difference between the levels✓	allow excited electron / atom de-excites / relaxes Allow excited electron / atom relaxes to ground state Condone moves for relaxes	2	
4(b)	coating absorb (uv) photons (causing excitation) / (uv)photons collide with electrons in the coating (causing excitation) / electrons in coating are excited Atomic electrons de-excite indirectly to previous lower level (and in doing so emit lower energy photons) ✓	allow atoms in coating absorb (uv) photons (causing excitation) Owtte (must convey smaller difference between energy levels in a transition) cascade	2	
Total			7	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5(a) (i)	 correct diode bias for variable supply, must have some attempt to vary pd✓ correct symbols and positions for voltmeter, ammeter: voltmeter in parallel with diode only ammeter in series with diode✓ allow voltmeter across ammeter and diode	Condone variable resistor (condone missing arrow) don't allow thermistor symbol Allow mA symbol instead of A symbol for ammeter Allow symbols for diode without line through triangle and / or with a circle Diode symbol must consist of a triangle and a straight line at nose perpendicular to wiring in circuit. 	2	

5(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. *Candidate explains how to obtain sufficient values of I and V. They mention the need to limit the current through the diode and give an indication of the range and frequency of measurements. They discuss an advantage of using a data logger. voltage does not exceed 1.0V, diode is forward biased* **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 explains how to obtain sufficient values of I and V. includes mention of diode is forward biased or suitable voltage for switch on mentioned or advantage of data logger*	**Lower band** vary pd obtain several readings of *I* and *V* *or* an advantage of using data logger or low level safety and action to minimise risk **Middle band** vary pd and obtain several readings of *I* and *V*, at least 6 different values **including** an advantage of using data logger or mention of forward bias or mention of switch on voltage (0.6V) or safety **Top Band** Mention of how to vary pd (seen in viable circuit) obtain several readings of *I* and *V* , at least 6 different values (range given where maximum value of pd does not exceed 1.0V) mention of limiting current through diode using protective resistor consider advantage of data logger mention forward bias must include potentiometer for 6 marks must have voltage as independent , no current led arguments in Top band	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. vary pd obtain several readings of *I* and *V* *or* an advantage of using data logger or forward biased low level safety may include switch off / avoid overheating type arguments / don't touch **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.** means of controlling pd across diode indication of range and frequency of measurement mention of limiting current to avoid damage to diode a consideration of the advantages of a datalogger e.g. many readings, computer display of results use of potential divider instead of series resistor All signs of quality that could lift mark	Data logger advantages: Not more accurate Not removes human error		

5 (a) (iii)	reverse connections to the power supply/battery/cell / reverse diode ✓	not switch wires around (need clear link to reversing connections at supply's terminals)	1	
5(b) (i)	divide *V* by *I for a reading from graph* **or** uses $R = {}^{V}/_{I}$ *for a reading from graph*✓ repeat for different values of *V* and *I*✓	Treat gradient = $\frac{1}{R}$ as TO Must score 1st mark to achieve 2nd	2	
5(b) (ii)	(Resistance) decreases✓	Or resistance starts off very high and then becomes much lower	1	
Total			12	

Question	Answers	Additional Comments/Guidance	Mark	ID details
6(a) (i)	$230 \times \sqrt{2} = 325$ (V) ✓ (2 × 325 =) 650 to 651 V✓	 allow doubling their incorrect peak voltage (162.6 x 2) by use of $\sqrt{2}$ as an attempt to find peak-to-peak for 1 mark but not just 2 x 230	2	
6(a) (ii) Must see 6(a) (i)	(*use of* $P = V^2/R$) $P = 230^2/12$✓ $P = 4.4 \times 10^3$ (W)✓ cao 2 sig. figs. Incorrect <u>answer must be supported by working</u> ✓	Allow their incorrect answer (a)(i)$^2 \div 12$ **Or** $325^2 \div 12$ as a use of for 1 mark Alternative For first mark $I = \frac{V}{R}$ **and** $P=VI$ allowing their incorrect answer (a)(i) or 325 as sub for V *for 1 mark* Answers 8.8 kW (325V) and 35 kW (650V)	3	

6(b) (i)	there is a pd/voltage across the cable ✓ pd/voltage across cooker is 230 V minus this pd/voltage ✓ 2nd mark depends on 1st mark in all	The current is lower due to the resistance of cable / The current is lower as circuit resistance increases✓ pd across oven is lower <u>since</u> V=I x Resistance of element ✓ **or** Resistance of the cable is in series with element✓ Voltage splits (in ratio) across these resistances ✓	2	
6(b) (ii)	resistance of cable = 2 × 3.15 × 0.0150 = 0.0945✓ $V = \frac{12}{12 + R_{cable}} \times 230$✓ =228 V ✓ cao	Allow power 10 error here **Or** $I = \frac{230}{12 + R_{cable}}$ **and** $V = \left(\frac{230}{12 + R_{cable}}\right) \times 12$ Allow their incorrect R_{cable} correctly substituted for 2nd marking	3	

6(b) (iii)	230 – their (b) (ii) or 19 (A) quoted for current or equivalent seen in equation (230 / 12.0945)✓ (P =) 34.2 to 42.3(W) ✓ correct working ecf as P = (230- (b)(ii))^2 / their R_{cable}		2	
6(b) (iv)	minimise power loss / maximise efficiency of oven / ensure element gets as hot as possible✓ avoid overheating/fires✓	not just to carry a large current / larger pd across element Either order	2	
Total			14	

Question	Answers	Additional Comments/Guidance	Mark	ID details
7(a)	time base is (switched) off✓ TO for y-input switched off	not affected by x plates because these plates are not switched on	1	
7(b) (i)	emf (of battery)✓	not just terminal pd TO applied for non-emf statements Allow explanation of emf	1	
7(b) (ii)	(emf = 3 × 2.0 =) 6.0 V✓	penalise 1 sf	1	
7(c)	Because the pd across the y plates has decreased✓ there is a current (in the battery)✓ there is a pd/voltage across the internal resistance **or** there are (now) lost volts✓ terminal pd decreases **or** terminal pd now less than emf **or** $IR = \varepsilon - Ir$ ✓	MAX 3	3	
7(d)	$V = 2.5 \times 2.0 = 5$ V **or** (use of V=IR) by I = their incorrect voltage $\div 18$ ✓ I = 0.28 (A) ✓ cao	Must see I as subject or their working leading to answer line for use of	2	

7(e)	(*use of* $\mathcal{E}=IR+Ir$) $6.0 = 2.5 \times 2.0 + 0.28 \times r$ or correct rearrangement to make r subject or sets $\boldsymbol{R_{(T)}} = \frac{\varepsilon}{0.28}$ = 21.2 to 21.4 (ohms) with subject seen or $r = \frac{1}{0.28}$ ✓ r = 3.4 to3.6 Ω ✓	$r = \frac{\varepsilon - IR}{I}$ Ecf for I and V $\quad ecf\ ans = \frac{6 - their\ V}{their\ I}$	2	

Total			10