Version 1.0

**General Certificate of Education (A-level)**
**June 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.

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| Question | Part | Sub Part | Marking Guidance | Mark | Comments |
|---|---|---|---|---|---|
| 1 | (a) | (i) | protons = 20✓<br>neutrons = 28✓<br>electrons = 18✓ | 3 | |
| 1 | (a) | (ii) | $2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ ✓(C) | 1 | -ve sign loses mark |
| 1 | (a) | (iii) | specific charge = $3.2 \times 10^{-19}/(48 \times 1.67 \times 10^{-27} + 18 \times 9.11 \times 10^{-31})$ ✓<br>specific charge = $4.0 \times 10^{6}$ C kg$^{-1}$ ✓ | 2 | Allow 1.66<br>Allow CE from (ii)<br>First mark is for mass if miss out electron mass and do not justify lose first mark |
| 2 | (a) | | A = down✓<br>B = $W^{+}$✓<br>C = positron and D= (electron) neutrino✓ | 3 | symbols OK<br>NOT neutron<br>C and D either way round |
| 2 | (b) | (i) | weak✓ | 1 | |
| 2 | (b) | (ii) | B/$W^{(+)}$✓ | 1 | |
| 2 | (b) | (iii) | $W^{+}$/B/exchange particle is charged/$\gamma$ no charge OR $W^{+}$/B/exchange particle has (rest) mass/$\gamma$ has zero (rest) mass OR photon has <u>infinite</u> range✓ | 1 | exchange particle must be clearly identified<br>don't accept $W^{+}$ <u>more</u> mass or <u>shorter</u> range |
| 2 | (c) | | Any two pairs<br>Quantity: lepton number✓ $e^{+}(-1) + \nu_{(e)}(1) = 0$ after same as before✓<br>Quantity: charge✓u( +2/3) before 1-d(1/3) = +2/3 after decay✓<br>Quantity: baryon number✓<br>proton 1 and neutron 1 (can be shown through quarks) ✓ | 4 | can use p(+1) and $e^{+}$(+1)to show charge conserved<br>Each number must be correctly linked to a particle at least once for second mark<br>Strangeness not allowed |

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| 3 | (a) | | **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**<br>The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.<br><br>**High Level (Good to excellent): 5 or 6 marks**<br>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.<br><br>*Candidate gives correct examples of hadrons and leptons. Identifies the differences between hadrons and leptons (hadrons affected by strong nuclear reaction and are made of quarks). Leptons are fundamental and do not experience the strong nuclear reaction. Hadrons are divided into baryons and mesons. Baryons three quarks, mesons quark anti-quark pair. Similarities between groups all experience weak interaction and if charged the electromagnetic interaction. All have rest mass.*<br><br>**Intermediate Level (Modest to adequate): 3 or 4 marks**<br>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.<br><br>*Candidate gives correct examples of hadrons and leptons. Identifies one difference between hadrons and leptons (e.g. hadrons affected by strong nuclear reaction or are made of quarks). Leptons are fundamental Hadrons are divided into baryons and mesons.*<br><br>**Low Level (Poor to limited): 1 or 2 marks**<br>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.<br><br>*Identifies two correct properties of hadrons and leptons.* | 6 | **Lower band**<br><br>1 or 2 correct facts about hadrons leptons eg Leptons are fundamental/hadrons made of quarks<br><br>**Middle band**<br><br>Only hadrons experience strong nuclear interaction (need this to get in middle band)<br>Hadrons are mesons or baryons<br>Examples of each<br><br>**Top Band**<br><br>Both have rest mass<br>Mention electromagnetic interaction<br>Correct quark structure of mesons and baryons<br>Both hadrons and leptons interact/decay through weak interaction<br>For 6 marks must have last <u>two</u> points |

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| | | | **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.**<br>example of hadron and lepton<br>mention of strong interaction<br>mention of quark structure hadrons<br>leptons are fundamental<br>identify baryons and mesons<br>gives quark structure of baryons and mesons<br>similarities e.g. all have rest mass<br>all affected by weak interaction<br>if charged both experience electromagnetic interaction | | |

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| 3 | (b) | (i) | a correct example of particle e.g. electron<br>and correct example of antiparticle e.g. positron✓ | 1 | Allow correct symbols<br>Allow antielectron for positron<br>Also allow pi zero and gamma |

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| 3 | (b) | (ii) | correct difference e.g. opposite charge/other named quantum number✓ | 1 | must be consistent with (i) |

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| 4 | (a) | | energy of photon is constant/fixed OR energy given to electron is fixed✓<br>energy required for electron to leave/escape/emit from the surface/metal OR electron has to overcome work function✓<br>maximum kinetic energy is the energy of photon minus the work function✓<br>deeper electrons require energy to get to the surface OR have less $E_k$ than surface electrons✓ | $3_{max}$ | mention of energy levels means can only score first mark<br>photoelectric equation alternative for third mark if $\phi$ and hf defined |

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| 4 | (b) | (i) | (*use of E = hf*)<br>energy of photon = $6.63 \times 10^{-34} \times 3.0 \times 10^{15}$ ✓ = $1.989 \times 10^{-18}$ (J)<br>work function = $hf – E_k = 1.989 \times 10^{-18} – 1.7 \times 10^{-18} = 2.89 \times 10^{-19}$ ✓<br>work function = $2.89 \times 10^{-19}/1.6 \times 10^{-19}$✓= (1.8 eV) | 3 | hf gets first mark even if in wrong equation |

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| 4 | b | (ii) | work function = $hf_0$<br>$f_0 = 1.8 \times 1.6 \times 10^{-19}/6.63 \times 10^{-34}$ ✓= $4.3 \times 10^{14}$ ✓(Hz)✓(2 sig figs) | 3 | 2 sig . fig stand alone mark<br>Accept $4.4 \times 10^{14}$ |

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| 4 | (c) | (i) | decrease the energy of( incident) photons✓<br>decrease the maximum kinetic energy of electrons✓<br>OR<br>decrease the energy of( incident) photons✓<br>hence fewer deeper electrons escape✓<br>OR<br>below threshold frequency✓<br>no electrons emitted✓<br>OR<br>as energy of each photon decreases but intensity is constant ( there are more photons/sec)✓<br>number of emitted electrons(/sec) must increase✓ | 2 | for last two alternatives must get first mark before can qualify for second mark |
| 4 | (c) | (ii) | increase in photons cause increase in (emitted) electrons✓<br>double number of electrons/photons OR reference to rate/per second✓ | 2 | if refer to energy levels/atoms can only award first mark |
| 5 | (a) | (i) | 128 V✓ | 1 | |
| 5 | (a) | (ii) | 64 V | 1 | CE from (i) |
| 5 | (a) | (iii) | $V_{rms}$= 64/√2 ✓=45.3 V✓ | 2 | CE from (ii) |
| 5 | (a) | (iv) | frequency = 1/0.01✓= 100✓ Hz✓ | 3 | do not accept kHz for unit mark unless correct for candidate value<br>if use 10 s instead of 10 ms then can score second two marks |
| 5 | (b) | | horizontal line✓<br>through y = 45 (44 – 48) x =0 ✓ | 2 | CE from (a)(iii)+/- half square<br>straight line must extend to at least to 6.0 ms |

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| 5 | (c) | | connect to *y-input*✓<br>adjust/change time base✓<br>so that each division is 2.0 ms OR 20 ms across screen✓<br>reference to y-gain/sensitivity✓ | $3_{max}$ | if inappropriate numbers quoted for y gain then lose last mark |
| 6 | (a) | (i) | (*use of V=Ir*)<br>V= 4.2 × 1.5✓ = 6.3 (V) | 1 | |
| 6 | (a) | (ii) | pd = 12 – 6.3 = 5.7 V✓ | 1 | NO CE from (i) |
| 6 | (a) | (iii) | (*use of I = V/R*)<br>*I* = 5.7/2.0 = 2.8(5) A✓ | 1 | CE from (ii)<br>(a(ii)/2.0)<br>accept 2.8 or 2.9 |
| 6 | (a) | (iv) | *I* = 4.2 – 2.85 = 1.3(5) A ✓ | 1 | CE from (iii)<br>(4.2 –(a)(iii))<br>accept 1.3 or 1.4 |
| 6 | (a) | (v) | *R*= 5.7/1.35 =4.2 Ω ✓ | 1 | CE from (iv)<br>(a(ii)/(a)(iv))<br>Accept range 4.4 to 4.1 |
| 6 | (a) | (vi) | $\frac{1}{R_{parallel}} = \frac{1}{4.2} + \frac{1}{2.0} = 0.737$ ✓<br>$R_{parallel} = 1.35\,\Omega$<br>$R_{total}$ = 1.35 + 1.5✓ = 2.85 Ω<br>OR<br>R = 12/4.2✓<br>R= 2.85 Ω✓ | 2 | CE from (a)(v)<br><br>second mark for adding internal resistance |

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| 6 | (b) | (i) | <table><tr><td>resistor</td><td>Rate of energy dissipation (W)</td></tr><tr><td>1.5 Ω internal resistance</td><td>$4.2^2 \times 1.5 = 26.5$ ✓</td></tr><tr><td>2.0 Ω</td><td>$2.85^2 \times 2.0 = 16.2$ (15.68 – 16.82)✓</td></tr><tr><td>R</td><td>$1.35^2 \times 4.2 = 7.7$ (7.1 – 8.2)✓</td></tr></table> | 3 | CE from answers in (a) but not for first value<br>2.0: a(iii)$^2$×2<br>R: a(iv)$^2$×a(v) |
| 6 | (b) | (ii) | energy provided by cell per second = 12 × 4.2 = <u>50.4</u> (W)✓<br>energy dissipated in resistors per second = 26.5 + 16.2 + 7.7 = 50.4✓<br>(hence energy input per second equals energy output) | 2 | if not equal can score second mark if an appropriate comment |
| 7 | (a) | (i) | (*use of I = V/R*)<br>I = 6.0/(50 000+35 000+5000) ✓= $6.7 \times 10^{-5}$ A✓ | 2 | first mark for adding resistance values 90 k Ω<br>accept $7 \times 10^{-5}$ or dotted $6 \times 10^{-5}$<br>but not $7.0 \times 10^{-5}$ and not $6.6 \times 10^{-5}$ |
| 7 | (a) | (ii) | V=$6.7 \times 10^{-5}$ × 5000 ✓= 0.33 (0.33 – 0.35) V✓<br>OR<br>V=5/90×6✓ = 0.33( V) ✓ | 2 | CE from (i)<br>BALD answer full credit<br>0.3 OK and dotted 0.3 |
| 7 | (b) | | resistance of LDR decreases✓<br>reading increase because greater <u>proportion/share</u> of the voltage across R OR higher current✓ | 2 | need first mark before can qualify for second |
| 7 | (c) | | I= 0.75/5000 = $1.5 \times 10^{-4}$ (A) ✓<br>(pd across LDR = 0.75 (V))<br>pd across variable resistor = 6.0 – 0.75 – 0.75 = 4.5 (V) ✓<br>*R*=4.5/$1.5 \times 10^{-4}$ = 30 000 Ω ✓<br>OR<br>I= 0.75/5000 = $1.5 \times 10^{-4}$ (A) ✓<br>$R_{total}$I = 6.0/$1.5 \times 10^{-4}$ = 40 000 Ω ✓<br>*R* = 40 000 – 5000 – 5000 = 30 000 Ω ✓ | 3 | |