Cambridge International AS & A Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary and Advanced Level

**PHYSICS** **9702/43**

Paper 4 A Level Structured Questions **May/June 2017**

MARK SCHEME

Maximum Mark: 100

**Published**

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2017 series for most Cambridge IGCSE®, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

® IGCSE is a registered trademark.



© UCLES 2017

| Question | Answer | Marks |
|---|---|---|
| 1(a) | gravitational force (of attraction between satellite and planet) | **B1** |
| | provides / is centripetal force (on satellite about the planet) | **B1** |
| 1(b) | $M = (4/3) \times \pi R^3 \rho$ | **B1** |
| | $\omega = 2\pi / T$ **or** $v = 2\pi nR / T$ | **B1** |
| | $GM / (nR)^2 = nR\omega^2$ **or** $v^2 / nR$ | **M1** |
| | substitution clear to give $\rho = 3\pi n^3 / GT^2$ | **A1** |
| 1(c) | $n = (3.84 \times 10^5) / (6.38 \times 10^3) = 60.19$ or 60.2 | **C1** |
| | $\rho = 3\pi \times 60.19^3 / [(6.67 \times 10^{-11}) \times (27.3 \times 24 \times 3600)^2]$ | **C1** |
| | $\rho = 5.54 \times 10^3$ kg m$^{-3}$ | **A1** |

© UCLES 2017

| Question | Answer | Marks |
|---|---|---|
| 2(a) | e.g. period = 3 / 2.5 | **C1** |
| | frequency = 0.83 Hz | **A1** |
| 2(b) | light (damping) | **B1** |
| 2(c) | at 2.7 s, $A_0$ = 1.5 (cm) | **B1** |
| | energy = $\frac{1}{2} m \times 4\pi^2 f^2 A_0^2$ | **B1** |
| | = $\frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (1.5 \times 10^{-2})^2$<br>= $5.51 \times 10^{-4}$ (J) | **C1** |
| | at 7.5 s, $A_0$ = 0.75 (cm) | **B1** |
| | energy = $\frac{1}{4} \times 5.51 \times 10^{-4}$<br>**or**<br>energy = $\frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (0.75 \times 10^{-2})^2$ | **C1** |
| | energy = $1.38 \times 10^{-4}$ (J)<br>change = $(5.51 \times 10^{-4} - 1.38 \times 10^{-4}) = 4.13$ J | **A1** |

© UCLES 2017

| Question | Answer | Marks |
|---|---|---|
| 3(a)(i) | signal consists of (a series of) 1s and 0s **or** offs and ons **or** highs and lows | **B1** |
| 3(a)(ii) | component X: parallel-to-serial converter | **B1** |
| | component Y: DAC/digital-to-analogue converter | **B1** |
| 3(a)(iii) | sample the (analogue) signal | **M1** |
| | at regular intervals and converts the analogue number to a digital number | **A1** |
| 3(b)(i) | attenuation in fibre = $84 \times 0.19$ (= 16 dB) | **C1** |
| | ratio = 16 + 28<br>= 44 dB | **A1** |
| 3(b)(ii) | ratio / dB = 10 lg ($P_2$ / $P_1$) | **C1** |
| | $44 = 10 \lg (\{9.7 \times 10^{-3}\} / P)$<br>**or**<br>$-44 = 10 \lg (P / \{9.7 \times 10^{-3}\})$ | **C1** |
| | power = $3.9 \times 10^{-7}$ W | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 4(a) | random/haphazard | **B1** |
| | constant velocity **or** speed in a straight line between collisions<br>**or**<br>distribution of speeds/different directions | **B1** |
| 4(b) | (small) specks of light/bright specks/pollen grains/dust particles/smoke particles | **M1** |
| | moving haphazardly/randomly/jerky/in a zigzag fashion | **A1** |
| 4(c)(i) | $pV = \frac{1}{3} Nm\langle c^2 \rangle$<br><br>$1.05 \times 10^5 \times 0.0240 = \frac{1}{3} \times 4.00 \times 10^{-3} \times \langle c^2 \rangle$ | **C1** |
| | $\langle c^2 \rangle = 1.89 \times 10^6$ | **C1** |
| | **or** | |
| | $\frac{1}{2} m\langle c^2 \rangle = (3 / 2)\, kT$<br><br>$0.5 \times (4.00 \times 10^{-3} / 6.02 \times 10^{23}) \times \langle c^2 \rangle = 1.5 \times 1.38 \times 10^{-23} \times 300$ | **(C1)** |
| | $\langle c^2 \rangle = 1.87 \times 10^6$ | **(C1)** |
| | **or** | |
| | $nRT = \frac{1}{3} Nm\langle c^2 \rangle$<br><br>$1.00 \times 8.31 \times 300 = \frac{1}{3} \times 4.00 \times 10^{-3} \times \langle c^2 \rangle$ | **(C1)** |
| | $\langle c^2 \rangle = 1.87 \times 10^6$ | **(C1)** |
| | $c_{\text{r.m.s.}} = 1.37 \times 10^3\ \text{m s}^{-1}$ | **A1** |

© UCLES 2017

| Question | Answer | Marks |
|---|---|---|
| 4(c)(ii) | $\langle c^2 \rangle \propto T$ | **C1** |
| | $\langle c^2 \rangle$ at 177 °C = $1.89 \times 10^6 \times (450 / 300)$ | **C1** |
| | $c_{r.m.s.}$ at 177 °C = $1.68 \times 10^3$ m s$^{-1}$ | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 5(a) | (loss in) kinetic energy of $\alpha$-particle = $Qq / 4\pi\varepsilon_0 r$<br>**or**<br>$7.7 \times 10^{-13} = Qq / 4\pi\varepsilon_0 r$ | **C1** |
| | $7.7 \times 10^{-13} = 8.99 \times 10^9 \times 79 \times 2 \times (1.60 \times 10^{-19})^2 / r$ | **M1** |
| | $r = 4.7 \times 10^{-14}$ m<br><br>$r$ is closest distance of approach so radius less than this | **A1** |
| 5(b) | force = $Qq / 4\pi\varepsilon_0 r^2 = 4\text{u} \times a$ | **C1** |
| | $8.99 \times 10^9 \times 79 \times 2 \times (1.60 \times 10^{-19})^2 / (4.7 \times 10^{-14})^2 = 4 \times 1.66 \times 10^{-27} \times a$ | **C1** |
| | $a = 2.5 \times 10^{27}$ m s$^{-2}$ | **A1** |
| 5(c) | so that single interactions between nucleus and $\alpha$-particle can be studied<br>**or**<br>so that multiple deflections with nucleus do not occur | **B1** |

© UCLES 2017

| Question | Answer | Marks |
|---|---|---|
| 6(a)(i) | lamp needs 'high' power/'large' current/'large' voltage | **B1** |
| | op-amp can deliver only a small current/small voltage | **B1** |
| 6(a)(ii) | correct symbol for relay coil connected between output and earth | **B1** |
| | switch between mains supply and lamp | **B1** |
| 6(b)(i) | vary light intensity at which lamp is switched on/off | **B1** |
| 6(b)(ii) | so that relay operates for only one current/voltage direction<br>**or**<br>so that relay/lamp operates for either dark or light conditions | **B1** |
| 6(c) | when light level increases, LDR resistance decreases | **B1** |
| | ($R_{LDR}$ low,) so $V^- > V^+$, so $V_{OUT}$ negative/–5 V (must be consistent with B1 mark) | **M1** |
| | **or** | |
| | when light level decreases, LDR resistance increases | **(B1)** |
| | ($R_{LDR}$ high,) so $V^- < V^+$, so $V_{OUT}$ is positive/+5 V (must be consistent with B1 mark) | **(M1)** |
| | lamp comes on as light level decreases<br>**or**<br>lamp goes off as light level increases | **A1** |

© UCLES 2017

| Question | Answer | Marks |
|---|---|---|
| 7(a) | (magnetic) force (always) normal to velocity/direction of motion | **M1** |
| | (magnitude of magnetic) force constant<br>**or**<br>speed is constant/kinetic energy is constant | **M1** |
| | so provides the centripetal force | **A1** |
| 7(b) | increase in KE = loss in PE **or** $\frac{1}{2}mv^2 = qV$ | **M1** |
| | $p = mv$ with algebra leading to $p = \sqrt{(2mqV)}$ | **A1** |
| 7(c) | $Bqv = mv^2 / r$<br><br>$mv = Bqr$ **or** $p = Bqr$ | **C1** |
| | $(2 \times 9.11 \times 10^{-31} \times 1.60 \times 10^{-19} \times 120)^{1/2} = B \times 1.60 \times 10^{-19} \times 0.074$ | **C1** |
| | $B = 5.0 \times 10^{-4}$ T | **A1** |
| 7(d) | greater momentum | **M1** |
| | ($p = Bqr$ and) so $r$ increased | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 8 | strong (uniform) magnetic field | **B1** |
| | * nuclei precess/rotate about field (direction) | |
| | radio frequency pulse/RF pulse (applied) | **B1** |
| | * RF or pulse is at Larmor frequency / frequency of precession | |
| | causes resonance / excitation (of nuclei)/nuclei to absorb energy | **B1** |
| | on relaxation/de-excitation, nuclei emit RF/pulse | **B1** |
| | * (emitted) RF/pulse detected and processed | |
| | non-uniform field (superposed on uniform field) | **B1** |
| | allows positions of (resonating) nuclei to be determined | **B1** |
| | * allows for position of detection to be changed/different slices to be studied | |
| | *max. 2 of additional detail points marked ** | **B2** |

© UCLES 2017

| Question | Answer | Marks |
|---|---|---|
| 9(a)(i) | core reduces loss of (magnetic) flux linkage/improves flux linkage | **B1** |
| 9(a)(ii) | reduces (size of eddy) currents in core | **B1** |
| | (so that) heating of core is reduced | **B1** |
| 9(b) | alternating voltage gives rise to changing magnetic flux in core | **M1** |
| | (changing) flux links the secondary coil | **A1** |
| | induced e.m.f. (in secondary) only when flux is changing/cut | **B1** |

| Question | Answer | Marks |
|---|---|---|
| 10(a)(i) | penetration of beam | **M1** |
| | greater hardness means greater penetration/shorter wavelength/higher frequency/higher photon energy | **A1** |
| 10(a)(ii) | greater accelerating potential difference<br>**or**<br>greater p.d. between anode and cathode | **B1** |
| 10(b) | $I = I_0 \exp(-\mu x)$<br><br>ratio = (exp {–1.5 × 2.9}) / (exp {–4.0 × 0.95}) (= exp {–0.55}) | **C1** |
| | = 0.58 | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 11(a) | electrons (in gas atoms/molecules) interact with photons | **B1** |
| | photon energy causes electron to move to higher energy level/to be excited | **B1** |
| | photon energy = difference in energy of (electron) energy levels | **B1** |
| | when electrons de-excite, photons emitted in all directions (so dark line) | **B1** |
| 11(b)(i) | photon energy $\propto 1 / \lambda$ | **C1** |
| | energy = 1.68 eV | **A1** |
| | **or** | |
| | $E = hc / \lambda$<br>$E = 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / (740 \times 10^{-9})$<br>$= 2.688 \times 10^{-19}$ J | **(C1)** |
| | energy = 1.68 eV | **(A1)** |
| 11(b)(ii) | 3.4 eV → 1.5 eV<br>3.4 eV → 0.85 eV<br>3.4 eV → 0.54 eV<br>*all correct and none incorrect 2/2*<br>*2 correct and 1 incorrect or only 2 correctly drawn 1/2* | **B2** |

© UCLES 2017

| Question | Answer | Marks |
|---|---|---|
| 12(a) | $x = 7$ | **A1** |
| 12(b)(i) | $E = mc^2$ | **C1** |
| | $= 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$<br>$= 1.494 \times 10^{-10}$ J | **C1** |
| | division by $1.6 \times 10^{-13}$ clear to give 934 MeV | **A1** |
| 12(b)(ii) | $\Delta m = (235.123 + 1.00863) – (94.945 + 138.955 + 2 \times 1.00863 + 7 \times 5.49 \times 10^{-4})$<br>**or**<br>$\Delta m = 235.123 – (94.945 + 138.955 + 1 \times 1.00863 + 7 \times 5.49 \times 10^{-4})$ | **C1** |
| | $= 0.21053$ u | **C1** |
| | energy $= 0.21053 \times 934$<br>$= 197$ MeV | **A1** |
| 12(c) | kinetic energy of nuclei/particles/products/fragments | **B1** |
| | $\gamma$–ray photon energy | **B1** |

© UCLES 2017