Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

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| **PHYSICS** | **9702/42** |
| Paper 4 A Level Structured Questions | **March 2017** |
| MARK SCHEME | |
| Maximum Mark: 100 | |

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**Published**

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| Question | Answer | Marks |
|---|---|---|
| 1(a) | work done per unit mass | **M1** |
| | bringing (small test) mass from infinity (to the point) | **A1** |
| 1(b)(i) | $\Delta\phi = (GM/2R) - (GM/5R) = 3GM/10R$ | **A1** |
| 1(b)(ii) | change in GPE = $(3 \times 4.0 \times 10^{14} / 10R) \times 4.7 \times 10^{4}$ | **C1** |
| | $(3 \times 4.0 \times 10^{14} / 10R) \times 4.7 \times 10^{4} = (1.70 - 0.88) \times 10^{12}$<br>$R = 6.88 \times 10^{6}$ | **C1** |
| | distance $= 3 \times 6.88 \times 10^{6}$<br>$= 2.1 \times 10^{7}$ m | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 2(a) | $+\Delta U$ <u>increase</u> in internal energy<br>$+q$ heat (energy) transferred <u>to</u> the system / heating of system<br>$+w$ work done <u>on</u> system | **B2** |
| 2(b)(i) | $W = p\Delta V$<br>$= 5.2 \times 10^{5} \times (5.0 - 1.6) \times 10^{-4}$ (=177 J) | **B1** |
| | $\Delta U = q + w$<br>$= 442 - 177 = 265$ J | **A1** |
| 2(b)(ii) | no (molecular) potential energy | **B1** |
| | internal energy decreases so (total molecular) kinetic energy decreases | **B1** |
| | (mean molecular) kinetic energy decreases so temperature decreases | **B1** |

| Question | Answer | Marks |
|---|---|---|
| 2(b)(iii) | $\Delta U + 265 - 313 = 0$<br>$\Delta U = 48$ J | **A1** |
| 2(b)(iv) | $pV = NkT$ or $pV = nRT$ <u>and</u> $N = nN_A$ | **C1** |
| | $5.2 \times 10^5 \times 1.6 \times 10^{-4} = N \times 1.38 \times 10^{-23} \times (273 + 227)$<br>*or*<br>$5.2 \times 10^5 \times 1.6 \times 10^{-4} = n \times 8.31 \times (273 + 227)$ and $n = N / 6.02 \times 10^{23}$<br><br>$N = 1.2 \times 10^{22}$ | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 3(a) | *m* is constant *or* *k* / *m* is constant <u>and</u> so acceleration / *a* proportional to displacement / *x* | **B1** |
| | negative sign shows that acceleration / *a* is in opposite direction to displacement / *x*<br>*or*<br>negative sign shows acceleration / *a* is towards fixed point | **B1** |
| 3(b) | evidence of comparison to expression to $a = -\omega^2 x$ | **B1** |
| | $\omega^2 = k/m$ *or* $\omega^2 = 4.0/m$ hence $\omega = 2.0/\sqrt{m}$ | **A1** |
| 3(c) | $E_K = ½ m \omega^2 x_0^2$ *or* $E_K = ½mv^2$ <u>and</u> $v = \omega x_0$ | **C1** |
| | $= ½m\ (4.0/m)\ (3.0 \times 10^{-2})^2$ | **C1** |
| | $= 1.8 \times 10^{-3}$ J | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 3(d) | new $x_0 = \sqrt{[(1.8 \times 10^{-3} / 2) \times (2 / m \times (m / 4.0))]}$<br>*or*<br>($E_K \propto x_0^2$ so) new $x_0 = \sqrt{[½ \times (3.0 \times 10^{-2})^2]}$ | **C1** |
| | $= 2.12 \times 10^{-2}$ m | **A1** |
| 3(e) | flux linked to block changes / flux is cut by block which induces an e.m.f. in block | **B1** |
| | (eddy) currents induced in block cause heating | **B1** |
| | thermal / heat energy comes from (kinetic / potential) energy of oscillations / block | **B1** |

| Question | Answer | Marks |
|---|---|---|
| 4 | piezo-electric / quartz crystal / transducer | **B1** |
| | <u>alternating</u> p.d. applied across crystal / transducer | **B1** |
| | causes crystal to vibrate / resonate | **B1** |
| | crystal resonates at ultrasound frequencies / crystal's natural frequency is in the ultrasound range / alternating p.d. is in ultrasound frequency range | **B1** |

| Question | Answer | Marks |
|---|---|---|
| 5(a) | any **three** from:<br>• greater bandwidth<br>• does not suffer from (e.m.) interference / can be used in (e.m.) 'noisy' environments<br>• no / less power / energy radiated / better security / less cross-talk<br>• less attenuation / fewer repeaters / amplifiers needed<br>• less weight / easier to handle / cheaper / occupy less space | **B3** |
| 5(b)(i) | attenuation / gain = 10 log $P_1 / P_2$ | **C1** |
| | $0.50 \times 57 = 10 \log (15 \times 10^{-3}/P)$ so $P = 2.1 \times 10^{-5}$ W<br>*or*<br>$-(0.50 \times 57) = 10 \log (P/15 \times 10^{-3})$ so $P = 2.1 \times 10^{-5}$ W | **A1** |
| 5(b)(ii) | *either* | |
| | (calculation of S / N ratio at receiver)<br>S / N ratio = $10 \log (2.1 \times 10^{-5} / 9.0 \times 10^{-7})$ or S/N ratio = 14 | **M1** |
| | 14 < 24 or S/N ratio < minimum S/N ratio | **A1** |
| | so not able to distinguish signal from noise | **A1** |
| | *or* | |
| | (calculation of minimum acceptable power at receiver)<br>$24 = 10 \log (P / 9.0 \times 10^{-7})$ or $P = 2.3 \times 10^{-4}$ | **(M1)** |
| | $2.1 \times 10^{-5} < 2.3 \times 10^{-4}$ or power < minimum power | **(A1)** |
| | so not able to distinguish signal from noise | **(A1)** |

| Question | Answer | Marks |
|---|---|---|
| 6(a) | similarity: lines are radial / greater separation of lines with increased distance from the sphere | **B1** |
| | difference: gravitational lines directed towards sphere <u>and</u> electric lines directed away from sphere | **B1** |
| 6(b)(i) | $E = Q / 4\pi\varepsilon_0 r^2$ or $E = kQ / r^2$ with $k$ defined / substituted in | **C1** |
| | $4.1 \times 10^{-5} = [Q / (4\pi \times 8.85 \times 10^{-12} \times 0.025^2)] - [Q / (4\pi \times 8.85 \times 10^{-12} \times 0.075^2)]$ | **C1** |
| | $Q = 3.2 \times 10^{-18}$ C | **A1** |
| 6(b)(ii) | smooth curve with gradient decreasing starting at $(0, 4.1 \times 10^{-5})$ to $d$-axis at (2.5, 0) | **B1** |
| | smooth curve with gradient increasing from (2.5, 0) ending at $(5, -4.1 \times 10^{-5})$ | **B1** |
| 6(b)(iii) | acceleration decreases (to zero at mid-point) | **B1** |
| | then acceleration increases in the opposite direction / increasing negative acceleration | **B1** |

| Question | Answer | Marks |
|---|---|---|
| 7(a) | correct grid shape (of wire) | **B1** |
| | fine wire / foil strip | **B1** |
| | plastic / insulating envelope containing the wire | **B1** |
| 7(b)(i) | $2.00 / 6.00 = 153.0 / (R + 153.0)$<br>*or*<br>$4.00 / 6.00 = R / (R + 153.0)$ (so $R = 306.0$) | **C1** |
| | $\Delta R = 306.0 - 300.0 = 6.0$ ($\Omega$) | **C1** |
| | so $\Delta L = 8(.0) \times 10^{-5}$ m | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 7(b)(ii) | $R$ or $\Delta R$ increases | **B1** |
| | $V^+ < V^-$ or $V_A < 2.00$ or $V^+ / V_A$ decreases | **M1** |
| | output is negative / –5 V | **A1** |
| | diode X emits light / is 'on' | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 8(a) | region (of space) where there is a force | **M1** |
| | produced by / on a magnet / magnetic pole / moving charge / current-carrying conductor | **A1** |
| 8(b)(i) | out of (the plane of) the paper / page | **B1** |
| 8(b)(ii) | the force on the particle is (always) perpendicular to the velocity / perpendicular to the direction of travel / towards the centre of path | **B1** |
| | no work is done by the force on the particle / there is no acceleration in the direction of the velocity / the acceleration is (always) perpendicular to the velocity | **B1** |
| 8(b)(iii) | $F = Bqv$ or $F = mv^2/r$ | **C1** |
| | $mv^2/(d/2) = Bqv$ so $d = 2mv / Bq$ | **A1** |
| 8(b)(iv) | time = distance / speed<br>$T_{(F)} = \pi d/2v$ | **C1** |
| | $T_{(F)} = (\pi/2v) \times (2mv/Bq)$<br>$T_{(F)} = \pi m/Bq$ and so $T_{(F)}$ independent of $v$ | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 9(a)(i) | increase flux linkage (with secondary coil) / to reduce flux loss | **B1** |
| 9(a)(ii) | e.m.f. (induced only) when flux (in core/coil) is changing | **B1** |
| | constant / direct voltage gives constant flux / field | **B1** |
| 9(b)(i) | $N_S / N_P = V_S / V_P$ | **C1** |
| | $N_S = (52 / 150) \times 1200$<br>$= 416$ turns | **A1** |
| 9(b)(ii) | 0 ms or 7.5 ms or 15.0 ms or 22.5 ms | **A1** |
| 9(c)(i) | *either* | |
| | mean power = $V^2 / 2R$ and $V = 52$ (V) | **C1** |
| | $R = 52^2 / (2 \times 1.2)$<br>$= 1100\ (1127)\,\Omega$ | **A1** |
| | *or* | |
| | mean power = $V^2 / R$ and $V = 52 / \sqrt{2}$ (= 36.8 V) | **(C1)** |
| | $R = 36.8^2 / 1.2$<br>$= 1100\,\Omega$ | **(A1)** |
| 9(c)(ii) | sinusoidal shape with troughs at zero power | **B1** |
| | only 3 'cycles' | **B1** |
| | each 'cycle' is 2.4 W high and zero power at correct times | **B1** |

| Question | Answer | Marks |
|---|---|---|
| 10(a) | packet / quantum of energy | M1 |
| | of electromagnetic radiation | A1 |
| 10(b)(i) | light is re-emitted in all directions / only part of the re-emitted light is in the direction of the beam | B1 |
| 10(b)(ii) | an arrow between –3.40 eV and –1.51 eV and an arrow between –3.40 eV and –0.85 eV | B1 |
| | all arrows shown point 'upwards' | B1 |
| 10(b)(iii) | $E = hc / \lambda$ *or* $E = hf$ and $c = f\lambda$ | C1 |
| | $2.60 \times 1.60 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / \lambda$ | C1 |
| | $\lambda = 4.8 \times 10^{-7}$ m | A1 |

| Question | Answer | Marks |
|---|---|---|
| 11 | any **five** from:<br><br>• electrons need energy to enter conduction band (from valence band)<br>• (positively-charged) holes are left in valence band<br>• moving charge carriers / holes / electrons are current<br>• (increase of temperature leads to) more (positive and negative) charge carriers / more holes / more electrons so more current<br>• more charge carriers / holes / electrons gives rise to less resistance<br>• (increase of temperature causes) greater (amplitude of) vibrations of atoms / ions / lattice<br>• effect of more charge carriers/holes/electrons is greater than effect of greater vibrations (and so resistance decreases) | **B5** |

| Question | Answer | Marks |
|---|---|---|
| 12(a) | *either* | |
| | (minimum) energy required / work done to separate the nucleons (in a nucleus) | **M1** |
| | to infinity | **A1** |
| | *or* | |
| | energy released when nucleons come together (to form a nucleus) | **(M1)** |
| | from infinity | **(A1)** |
| 12(b)(i) | (total) binding energy of thorium and helium (nuclei) greater than binding energy of uranium (nucleus) | **B1** |
| 12(b)(ii)1 | change in mass = 238.05076 – (234.04357 + 4.00260)<br>= $4.59 \times 10^{-3}$ u | **A1** |
| 12(b)(ii)2 | *either* | |
| | $E = mc^2$<br>$= 4.59 \times 10^{-3} \times 1.66 \times 10^{-27} \times (3.00 \times 10^{8})^2$ | **C1** |
| | $= 6.9 \times 10^{-13}$ J | **A1** |
| | *or* | |
| | 1u = 931 MeV<br>$E = 4.59 \times 10^{-3} \times 931 \times 10^{6} \times 1.6 \times 10^{-19}$ | **(C1)** |
| | $= 6.8 \times 10^{-13}$ J | **(A1)** |
| 12(b)(iii) | Th nucleus / He nucleus / product nucleus has kinetic energy | **M1** |
| | energy of gamma photon must be less than energy released | **A1** |