UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

# MARK SCHEME for the October/November 2010 question paper for the guidance of teachers

## 9702 PHYSICS

**9702/43** Paper 4 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE
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## Section A

| | | | | | |
|---|---|---|---|---|---|
| **1** | **(a)** | **(i)** | rate of change of angle / angular displacement | M1 | |
| | | | swept out by radius | A1 | [2] |
| | | **(ii)** | $\omega \times T = 2\pi$ | B1 | [1] |
| | **(b)** | | centripetal force is provided by the gravitational force | B1 | |
| | | | *either* $mr(2\pi/T)^2 = GMm/r^2$ *or* $mr\omega^2 = GMm/r^2$ | M1 | |
| | | | $r^3 \times 4\pi^2 = GM \times T^2$ | A1 | |
| | | | $GM/4\pi^2$ is a constant ($c$) | A1 | |
| | | | $T^2 = cr^3$ | A0 | [4] |
| | **(c)** | **(i)** | *either* $T^2 = (45/1.08)^3 \times 0.615^2$ *or* $T^2 = 0.30 \times 45^3$ | C1 | |
| | | | $T$ = 165 years | A1 | [2] |
| | | **(ii)** | speed = $(2\pi \times 1.08 \times 10^8) / (0.615 \times 365 \times 24 \times 3600)$ | C1 | |
| | | | = 35 km s$^{-1}$ | A1 | [2] |
| **2** | **(a)** | | atoms / molecules / particles behave as elastic (identical) spheres | (1) | |
| | | | volume of atoms / molecules negligible compared to volume of containing vessel | (1) | |
| | | | time of collision negligible to time between collisions | (1) | |
| | | | no forces of attraction or repulsion between atoms / molecules | (1) | |
| | | | atoms / molecules / particles are in (continuous) random motion | (1) | |
| | | | (*any four, 1 each*) | B4 | [4] |
| | **(b)** | | $pV = \frac{1}{3}Nm<c^2>$ and $pV = nRT$ or $pV = NkT$ | B1 | |
| | | | $\frac{1}{3}Nm<c^2> = nRT$ or $= NkT$ and $<E_K> = ½m<c^2>$ | B1 | |
| | | | $n = N/N_A$ or $k = R/N_A$ | B1 | |
| | | | $<E_K> = \frac{3}{2} \times R/N_A \times T$ | A0 | [3] |
| | **(c)** | **(i)** | reaction represents *either* build-up of nucleus from light nuclei | | |
| | | | *or* build-up of heavy nucleus from nuclei | M1 | |
| | | | so fusion reaction | A1 | [2] |
| | | **(ii)** | proton and deuterium nucleus will have equal kinetic energies | B1 | |
| | | | $1.2 \times 10^{-14} = \frac{3}{2} \times 8.31 / (6.02 \times 10^{23}) \times T$ | C1 | |
| | | | $T = 5.8 \times 10^8$ K | A1 | [3] |
| | | | (*use of $E = 2.4 \times 10^{-14}$ giving $1.16 \times 10^9$ K scores 1 mark*) | | |
| | | **(iii)** | *either* inter-molecular / atomic / nuclear forces exist | | |
| | | | *or* proton and deuterium nucleus are positively charged / repel | B1 | [1] |

| | | | |
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| **3 (a) (i)** | 8.0 cm | A1 | [1] |
| **(ii)** | $2\pi f = 220$ | C1 | |
| | $f = 35$ (*condone unit*) | A1 | [2] |
| **(iii)** | line drawn mid-way between AB and CD (*allow* ±2 *mm*) | B1 | [1] |
| **(iv)** | $v = \omega a$ | C1 | |
| | $= 220 \times 4.0$ | | |
| | $= 880$ cm s$^{-1}$ | A1 | [2] |
| **(b) (i)** | **1.** line drawn 3 cm above AB (*allow* ±2 *mm*) | B1 | [1] |
| | **2.** arrow pointing upwards | B1 | [1] |
| **(ii)** | **1.** line drawn 3 cm above AB (*allow* ±2 *mm*) | B1 | [1] |
| | **2.** arrow pointing downwards | B1 | [1] |
| **(iii)** | $v = \omega\sqrt{(a^2 - x^2)}$ | | |
| | $= 220 \times \sqrt{(4.0^2 - 2.0^2)}$ | C1 | |
| | $= 760$ cm s$^{-1}$ | A1 | [2] |
| | (*incorrect value for x, 0/2 marks*) | | |
| **4 (a) (i)** | work done moving unit positive charge | M1 | |
| | from infinity to the point | A1 | [2] |
| **(ii)** | charge / potential (difference) (*ratio must be clear*) | B1 | [1] |
| **(b) (i)** | capacitance = $(2.7 \times 10^{-6}) / (150 \times 10^3)$ | C1 | |
| | (*allow any appropriate values*) | | |
| | capacitance = $1.8 \times 10^{-11}$ (*allow 1.8 ±0.05*) | A1 | [2] |
| **(ii)** | *either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ *and* $Q = CV$ | C1 | |
| | energy = $\frac{1}{2} \times 1.8 \times 10^{-11} \times (150 \times 10^3)^2$ *or* $\frac{1}{2} \times 2.7 \times 10^{-6} \times 150 \times 10^3$ | | |
| | $= 0.20$ J | A1 | [2] |
| **(c)** | *either* since energy $\propto V^2$, capacitor has $(\frac{1}{2})^2$ of its energy left | | |
| | *or* full formula treatment | C1 | |
| | energy lost = 0.15 J | A1 | [2] |

| | | | |
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| **5** **(a)** | magnetic flux = $BA$ | | |
| | $= 89 \times 10^{-3} \times 5.0 \times 10^{-2} \times 2.4 \times 10^{-2}$ | C1 | |
| | $= 1.07 \times 10^{-4}$ Wb | A1 | [2] |
| **(b)** **(i)** | e.m.f. = $\Delta\phi / \Delta t$ | C1 | |
| | (for $\Delta\phi = 1.07 \times 10^{-4}$ Wb), $\Delta t = 2.4 \times 10^{-2} / 1.8 = 1.33 \times 10^{-2}$ s | C1 | |
| | e.m.f. $= (1.07 \times 10^{-4}) / (1.33 \times 10^{-2})$ | | |
| | $= 8.0 \times 10^{-3}$ V | A1 | [3] |
| **(ii)** | current $= 8.0 \times 10^{-3} / 0.12$ | M1 | |
| | $\approx 70$ mA | A0 | [1] |
| **(c)** | force on wire = $BIL$ | | |
| | $= 89 \times 10^{-3} \times 70 \times 10^{-3} \times 5.0 \times 10^{-2}$ | C1 | |
| | $\approx 3 \times 10^{-4}$ (N) | M1 | |
| | suitable comment e.g. this force is too / very small (to be felt) | A1 | [3] |
| **6** **(a)** | power / heating depends on $I^2$ | M1 | |
| | so independent of current direction | A1 | [2] |
| **(b)** | *either* maximum power = $I_0^2R$ *or* average power = $I_{RMS}^2R$ | M1 | |
| | $I_0 = \sqrt{2} \times I_{RMS}$ | M1 | |
| | maximum power = 2 × average power | | |
| | ratio = 0.5 | A1 | [3] |
| **7** **(a)** | force due to *E*-field is <u>equal and opposite</u> to force due to *B*-field | B1 | |
| | $Eq = Bqv$ | B1 | |
| | $v = E/B$ | B1 | [3] |
| **(b)** | *either* charge and mass are not involved in the equation in **(a)** | | |
| | *or* $F_E$ and $F_B$ are both doubled | | |
| | *or* *E*, *B* and *v* do not change | M1 | |
| | so no deviation | A1 | [2] |
| **8** **(a)** | minimum frequency for electron to be emitted (from surface) | M1 | |
| | of electromagnetic radiation / light / photons | A1 | [2] |
| **(b)** | $E = hc / \lambda$ *or* $E = hf$ <u>and</u> $c = f\lambda$ | C1 | |
| | *either* threshold wavelength $= (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (5.8 \times 10^{-19})$ | | |
| | $= 340$ nm | | |
| | *or* energy of 340 nm photon $= 4.4 \times 10^{-19}$ J | | |
| | *or* threshold frequency $= 8.7 \times 10^{14}$ Hz | | |
| | *or* 450 nm $\rightarrow 6.7 \times 10^{14}$ Hz | A1 | |
| | appropriate comment comparing wavelengths / energies / frequencies | B1 | |
| | so no effect on photo-electric current | B1 | [4] |

## Section B

| | | | | | |
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| 9 | (a) | (i) | edges can be (clearly) distinguished | B1 | [1] |
| | | (ii) | e.g. size of X-ray source / anode / target / aperture<br>scattering of X-ray beam<br>pixel size<br>(*any two, 1 each*) | B2 | |
| | | | further detail e.g. use of lead grid | B1 | [3] |
| | (b) | | X-ray image involves a <u>single</u> exposure | B1 | |
| | | | CT scan: exposure of a <u>slice</u> from many different angles | M1 | |
| | | | repeated for different slices | A1 | |
| | | | CT scan involves a (much) <u>greater exposure</u> | B1 | [4] |
| 10 | (a) | | e.g. infinite input impedance / resistance<br>zero output impedance / resistance<br>infinite gain<br>infinite bandwidth<br>infinite slew rate<br>(*any three, 1 each*) | B3 | [3] |
| | (b) | (i) | with switch open, $V^-$ is less (positive) than $V^+$ | M1 | |
| | | | output is positive | A1 | |
| | | | with switch closed, $V^-$ is more (positive) than $V^+$ so output is negative<br>(*allow similar scheme if $V^-$ more positive than $V^+$ treated first*) | A1 | [3] |
| | | (ii) | **1.** diodes connected correctly between output and earth | M1 | |
| | | | **2.** green identified correctly<br>(*do not allow this mark if not argued in **(i)***) | A1 | [2] |
| 11 | (a) | (i) | $I / I_0 = \exp(-1.5 \times 2.9)$ | C1 | |
| | | | $= 0.013$ | A1 | [2] |
| | | (ii) | $I / I_0 = \exp(-4.6 \times 0.95)$<br>$= 0.013$ | A1 | [1] |
| | (b) | | attenuation (coefficients) in muscle and in fat are similar | B1 | |
| | | | attenuation (coefficients) in bone and muscle / fat are different | B1 | |
| | | | contrast depends on difference in attenuation | B1 | [3] |

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| **12 (a) (i)** | **1.** signal has same variation (with time) as the data | B1 | |
| | **2.** consists of (a series of) 'highs' and 'lows' | B1 | |
| | *either* analogue is continuously variable (between limits) | | |
| | *or* digital has no intermediate values | B1 | [3] |
| **(ii)** | e.g. can be regenerated / noise can be eliminated | | |
| | extra data can be added to check / correct transmitted signal | | |
| | (*any two reasonable suggestions, 1 each*) | B2 | [2] |
| **(b) (i)** | analogue signal is sampled at (regular time) intervals | B1 | |
| | sampled signal is converted into a binary number | B1 | [2] |
| **(ii)** | one channel is required for each bit (of the digital number) | B1 | [1] |