**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

# MARK SCHEME for the May/June 2011 question paper for the guidance of teachers

# 9702 PHYSICS

**9702/42** Paper 4 (A2 Structured Questions), maximum raw mark 100

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.

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UNIVERSITY of CAMBRIDGE
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**Section A**

| | | | | |
|---|---|---|---|---|
| **1** | **(a)** | region (of space) where a particle / body experiences a force | B1 | [1] |
| | **(b)** | similarity: e.g. force $\propto 1 / r^2$<br>potential $\propto 1 / r$ | B1 | [1] |
| | | difference: e.g. gravitation force (always) attractive | B1 | |
| | | electric force attractive or repulsive | B1 | [2] |
| | **(c)** | *either* ratio is $Q_1Q_2 / 4\pi\varepsilon_0 m_1 m_2 G$ | C1 | |
| | | $= (1.6 \times 10^{19})^2 / 4\pi \times 8.85 \times 10^{12} \times (1.67 \times 10^{27})^2 \times 6.67 \times 10^{11}$ | C1 | |
| | | $= 1.2 \times 10^{36}$ | A1 | [3] |
| | | *or* $F_E = 2.30 \times 10^{28} \times R^{2}$ (C1) | | |
| | | $F_G = 1.86 \times 10^{64} \times R^{2}$ (C1) | | |
| | | $F_E / F_G = 1.2 \times 10^{36}$ (A1) | | |
| **2** | **(a)** | amount of substance | M1 | |
| | | containing same number of particles as in 0.012 kg of carbon-12 | A1 | [2] |
| | **(b)** | $pV = nRT$ | C1 | |
| | | amount = $(2.3 \times 10^5 \times 3.1 \times 10^{3}) / (8.31 \times 290)$<br>$+ (2.3 \times 10^5 \times 4.6 \times 10^{3}) / (8.31 \times 303)$ | C1 | |
| | | = 0.296 + 0.420 | C1 | |
| | | = 0.716 mol | A1 | [4] |
| | | (*give full credit for starting equation* $pV = NkT$ *and* $N = nN_A$) | | |
| **3** | **(a)** | charges on plates are equal and opposite | M1 | |
| | | so no resultant charge | A1 | |
| | | energy stored because there is charge separation | B1 | [3] |
| | **(b) (i)** | capacitance = $Q / V$ | C1 | |
| | | $= (18 \times 10^{3}) / 10$<br>= 1800 μF | A1 | [2] |
| | **(ii)** | use of area under graph *or* energy = $\frac{1}{2}CV^2$ | C1 | |
| | | energy $= 2.5 \times 15.7 \times 10^{3}$ *or* energy $= \frac{1}{2} \times 1800 \times 10^{6} \times (10^2 - 7.5^2)$<br>= 39 mJ | A1 | [2] |
| | **(c)** | combined capacitance of Y & Z = 20 μF *or* total capacitance = 6.67 μF | C1 | |
| | | p.d. across capacitor X = 8 V *or* p.d. across combination = 12 V | C1 | |
| | | charge $= 10 \times 10^{6} \times 8$ *or* $6.67 \times 10^{6} \times 12$<br>= 80 μC | A1 | [3] |

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| **4** | **(a)** $+\Delta U$: increase in internal energy | B1 | |
| | $+q$: thermal energy / heat supplied to the system | B1 | |
| | $+w$: work done on the system | B1 | [3] |
| | **(b) (i)** (thermal) energy required to change the state of a substance | M1 | |
| | per unit mass | A1 | |
| | without any change of temperature | A1 | [3] |
| | **(ii)** when evaporating | | |
| | greater change in separation of atoms/molecules | M1 | |
| | greater change in volume | M1 | |
| | identifies each difference correctly with $\Delta U$ and $w$ | A1 | [3] |
| **5** | **(a) (i)** (induced) e.m.f. proportional to | M1 | |
| | rate of change of (magnetic) flux (linkage) / rate of flux cutting | A1 | [2] |
| | **(ii) 1.** moving magnet causes change of flux linkage | B1 | [1] |
| | **2.** speed of magnet varies so varying rate of change of flux | B1 | [1] |
| | **3.** magnet changes direction of motion (so current changes direction) | B1 | [1] |
| | **(b)** period = 0.75 s | C1 | |
| | frequency = 1.33 Hz | A1 | [2] |
| | **(c)** graph: smooth correctly shaped curve with peak at $f_0$ | M1 | |
| | $A$ never zero | A1 | [2] |
| | **(d) (i)** resonance | B1 | [1] |
| | **(ii)** e.g. quartz crystal for timing / production of ultrasound | A1 | [1] |
| **6** | **(a) (i)** $2\pi f = 380$ | C1 | |
| | frequency = 60 Hz | A1 | [2] |
| | **(ii)** $I_{RMS} \times \sqrt{2} = I_0$ | C1 | |
| | $I_{RMS} = 9.9 / \sqrt{2}$ | | |
| | $= 7.0\,A$ | A1 | [2] |
| | **(b)** power = $I^2R$ | C1 | |
| | $R = 400 / 7.0^2$ | | |
| | $= 8.2\,\Omega$ | A1 | [2] |

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| **7** | **(a)** | wavelength of wave associated with a particle | M1 | |
| | | that is moving | A1 | [2] |
| | **(b) (i)** | energy of electron = 850 × 1.6 × $10^{19}$ | M1 | |
| | | = 1.36 × $10^{16}$ J | | |
| | | energy = $p^2 / 2m$ *or* $p = mv$ <u>and</u> $E_K = ½mv^2$ | | |
| | | momentum = √(1.36 × $10^{16}$ × 2 × 9.11 × $10^{31}$) | M1 | |
| | | = 1.6 × $10^{23}$ N s | A0 | [2] |
| | **(ii)** | $\lambda = h / p$ | C1 | |
| | | wavelength = (6.63 × $10^{34}$) / (1.6 × $10^{23}$) | | |
| | | = 4.1 × $10^{11}$ m | A1 | [2] |
| | **(c)** | diagram or description showing: | | |
| | | electron beam in a vacuum | B1 | |
| | | incident on <u>thin</u> metal target / carbon <u>film</u> | B1 | |
| | | fluorescent screen | B1 | |
| | | pattern of concentric rings observed | M1 | |
| | | pattern similar to diffraction pattern observed with visible light | A1 | [5] |
| **8** | **(a)** | energy required to separate nucleons in a <u>nucleus</u> | M1 | |
| | | to infinity | A1 | [2] |
| | **(b)** | 1u = 1.66 × $10^{27}$ kg | | |
| | | $E = mc^2$ | C1 | |
| | | = 1.66 × $10^{27}$ × $(3.0 \times 10^8)^2$ | M1 | |
| | | = 1.49 × $10^{10}$ J | | |
| | | = (1.49 × $10^{10}$) / (1.6 × $10^{13}$) | M1 | |
| | | = 930 MeV | A0 | [3] |
| | **(c) (i)** | $\Delta m$ = 2.0141u – (1.0073 + 1.0087)u | | |
| | | = –1.9 × $10^{3}$ u | C1 | |
| | | binding energy = 1.9 × $10^{3}$ × 930 | | |
| | | =1.8 MeV | A1 | [2] |
| | **(ii)** | $\Delta m$ = (57 × 1.0087u) + (40 × 1.0073u) – 97.0980u | C1 | |
| | | = (–)0.69 u | | |
| | | binding energy per nucleon = (0.69 × 930) / 97 | C1 | |
| | | = 6.61 MeV | A1 | [3] |

**Section B**

| | | | | | | |
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| **9** | **(a)** | | <u>thin / fine</u> metal wire | | B1 | |
| | | | lay-out shown as a grid | | B1 | |
| | | | encased in plastic | | B1 | [3] |
| | **(b)** | **(i)** | gain (of amplifier) | | B1 | [1] |
| | | **(ii)** | for $V_{OUT} = 0$, then $V^+ = V^-$ *or* $V_1 = V_2$ | | C1 | |
| | | | $V_1 = (1000/1125) \times 4.5$ | | C1 | |
| | | | $V_1 = 4.0\,V$ | | A1 | [3] |
| | | **(iii)** | $V_2 = (1000 / 1128) \times 4.5$ | | | |
| | | | $= 3.99\,V$ | | C1 | |
| | | | $V_{OUT} = 12 \times (3.99 - 4.00)$ | | | |
| | | | $= (-)\ 0.12\,V$ | | A1 | [2] |
| **10** | | | strong / large (uniform) magnetic field | | B1 | |
| | | | nuclei precess / rotate about field direction | (1) | | |
| | | | radio frequency pulse | | B1 | |
| | | | at Larmor frequency | (1) | | |
| | | | causes resonance / nuclei absorb energy | | B1 | |
| | | | on relaxation / de-excitation, nuclei emit r.f. pulse | | B1 | |
| | | | pulse detected and processed | (1) | | |
| | | | non-uniform field superposed on uniform field | | B1 | |
| | | | allows position of resonating nuclei to be determined | | B1 | |
| | | | allows for location of detection to be changed | (1) | | |
| | | | (*six points, 1 each plus any two extra – max 8*) | | | [8] |
| **11** | **(a)** | | e.g. unreliable communication | (M1) | | |
| | | | because ion layers vary in height / density | (A1) | | |
| | | | e.g. cannot carry all information required | (M1) | | |
| | | | bandwidth too narrow | (A1) | | |
| | | | e.g. coverage limited | (M1) | | |
| | | | reception poor in hilly areas | (A1) | | |
| | | | (*any two sensible suggestions, M1 & A1 for each, max 4*) | | | [4] |
| | **(b)** | | signal must be amplified (greatly) before transmission back to Earth | | B1 | |
| | | | <u>uplink</u> signal would be swamped by <u>downlink</u> signal | | B1 | [2] |

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| **12** **(a)** **(i)** | ratio / dB = 10 lg($P_1$ / $P_2$) | C1 | |
| | 24 = 10 lg($P_1$ / {$5.6 \times 10^{19}$}) | C1 | |
| | $P_1 = 1.4 \times 10^{16}$ W | A1 | [3] |
| **(ii)** | attenuation per unit length = 1 / $L$ × 10 lg($P_1$ / $P_2$) | C1 | |
| | 1.9 = 1 / $L$ × 10 lg({$3.5 \times 10^{3}$}/{$1.4 \times 10^{16}$}) | C1 | |
| | $L$ = 1 km | A1 | [3] |
| | *or* | | |
| | attenuation = 10 lg({$3.5 \times 10^{3}$}/{$5.6 \times 10^{19}$}) (C1) | | |
| | = 158 dB | | |
| | attenuation along fibre = (158 – 24) (C1) | | |
| | $L$ = (158 – 24) / 1.9 = 71 km (A1) | | |
| **(b)** | less attenuation (per unit length) / longer uninterrupted length of fibre | B1 | [1] |