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

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

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UNIVERSITY of CAMBRIDGE
International Examinations

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	GCE AS/A LEVEL – May/June 2011	9702	43

Section A

1 **(a)** region (of space) where a particle / body experiences a force B1 [1]

(b) similarity: e.g. force $\propto 1 / r^2$
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 $= (2.3 \times 10^5 \times 3.1 \times 10^{-3}) / (8.31 \times 290)$
$+ (2.3 \times 10^5 \times 4.6 \times 10^{-3}) / (8.31 \times 303)$ 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
$= (18 \times 10^{-3}) / 10$
$= 1800\ \mu F$ 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 $= \frac{1}{2} \times 1800 \times 10^{-6} \times (10^2 - 7.5^2)$
$= 39$ mJ A1 [2]

(c) combined capacitance of Y & Z $= 20\ \mu F$ *or* total capacitance $= 6.67\ \mu F$ C1
p.d. across capacitor X $= 8$ V *or* p.d. across combination $= 12$ V C1
charge $= 10 \times 10^{-6} \times 8$ *or* $6.67 \times 10^{-6} \times 12$
$= 80\ \mu C$ A1 [3]

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 ΔU 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]

7 **(a)** wavelength of wave associated with a particle — M1
that is moving — A1 [2]

(b) **(i)** energy of electron = $850 \times 1.6 \times 10^{-19}$
$= 1.36 \times 10^{-16}$ J
energy = $p^2 / 2m$ *or* $p = mv$ and $E_K = \frac{1}{2}mv^2$
momentum = $\sqrt{(1.36 \times 10^{-16} \times 2 \times 9.11 \times 10^{-31})}$ — M1
$= 1.6 \times 10^{-23}$ N s — A0 [2]

(ii) $\lambda = h / p$ — C1
wavelength = $(6.63 \times 10^{-34}) / (1.6 \times 10^{-23})$
$= 4.1 \times 10^{-11}$ m — A1 [2]

(c) diagram or description showing:
electron beam in a vacuum — B1
incident on thin metal target / carbon film — 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 nucleus — M1
to infinity — A1 [2]

(b) $1\text{u} = 1.66 \times 10^{-27}$ kg
$E = mc^2$ — C1
$= 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$ — M1
$= 1.49 \times 10^{-10}$ J
$= (1.49 \times 10^{-10}) / (1.6 \times 10^{-13})$ — M1
= 930 MeV — A0 [3]

(c) **(i)** $\Delta m = 2.0141\text{u} - (1.0073 + 1.0087)\text{u}$
$= -1.9 \times 10^{-3}$ u — C1
binding energy = $1.9 \times 10^{-3} \times 930$
= 1.8 MeV — A1 [2]

(ii) $\Delta m = (57 \times 1.0087\text{u}) + (40 \times 1.0073\text{u}) - 97.0980\text{u}$ — C1
$= (-)0.69$ u
binding energy per nucleon = $(0.69 \times 930) / 97$ — C1
= 6.61 MeV — A1 [3]

Section B

9 **(a)** thin / fine 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
uplink signal would be swamped by downlink signal B1 [2]

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 = $1 / L \times 10\lg(P_1 / P_2)$ C1
$1.9 = 1 / L \times 10\lg(\{3.5 \times 10^{-3}\}/\{1.4 \times 10^{-16}\})$ 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]