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

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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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]

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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 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]

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

(b) **(i)** energy of electron = $850 \times 1.6 \times 10^{-19}$ — M1
$= 1.36 \times 10^{-16}$ 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) 1u = 1.66×10^{-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]

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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]

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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 = $1 / L \times 10\lg(P_1 / P_2)$ 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]

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