

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

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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 $Q_1 Q_2 / 4\pi\epsilon_0 m_1 m_2 G$ 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
 $= 0.716 \text{ mol}$ 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
 $= (18 \times 10^{-3}) / 10$
 $= 1800 \mu\text{F}$ 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 = $\frac{1}{2} \times 1800 \times 10^{-6} \times (10^2 - 7.5^2)$
 $= 39 \text{ mJ}$ A1 [2]
- (c) combined capacitance of Y & Z = $20 \mu\text{F}$ *or* total capacitance = $6.67 \mu\text{F}$ C1
p.d. across capacitor X = 8 V *or* p.d. across combination = 12 V C1
charge = $10 \times 10^{-6} \times 8$ *or* $6.67 \times 10^{-6} \times 12$
 $= 80 \mu\text{C}$ 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 M1
greater change in separation of atoms/molecules M1
greater change in volume A1
identifies each difference correctly with ΔU and w [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) $I_{\text{RMS}} \times \sqrt{2} = I_0$ C1
 $I_{\text{RMS}} = 9.9 / \sqrt{2}$
= 7.0 A A1 [2]
- (b) power = $I^2 R$ C1
 $R = 400 / 7.0^2$
= 8.2 Ω A1 [2]

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- 7 (a) wavelength of wave associated with a particle that is moving M1 A1 [2]
- (b) (i) energy of electron = $850 \times 1.6 \times 10^{-19}$
 $= 1.36 \times 10^{-16} \text{ J}$
energy = $p^2 / 2m$ or $p = mv$ and $E_K = \frac{1}{2}mv^2$
momentum = $\sqrt{(1.36 \times 10^{-16} \times 2 \times 9.11 \times 10^{-31})}$
 $= 1.6 \times 10^{-23} \text{ N s}$ M1 A0 [2]
- (ii) $\lambda = h / p$
wavelength = $(6.63 \times 10^{-34}) / (1.6 \times 10^{-23})$
 $= 4.1 \times 10^{-11} \text{ m}$ C1 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 to infinity M1 A1 [2]
- (b) $1\text{u} = 1.66 \times 10^{-27} \text{ kg}$
 $E = mc^2$
 $= 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$
 $= 1.49 \times 10^{-10} \text{ J}$
 $= (1.49 \times 10^{-10}) / (1.6 \times 10^{-13})$
 $= 930 \text{ MeV}$ C1 M1 A0 [3]
- (c) (i) $\Delta m = 2.0141\text{u} - (1.0073 + 1.0087)\text{u}$
 $= -1.9 \times 10^{-3} \text{ u}$
binding energy = $1.9 \times 10^{-3} \times 930$
 $= 1.8 \text{ MeV}$ C1 A1 [2]
- (ii) $\Delta m = (57 \times 1.0087\text{u}) + (40 \times 1.0073\text{u}) - 97.0980\text{u}$
 $= (-)0.69 \text{ u}$
binding energy per nucleon = $(0.69 \times 930) / 97$
 $= 6.61 \text{ MeV}$ C1 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
 $V_1 = 4.0V$ A1 [3]
- (iii) $V_2 = (1000 / 1128) \times 4.5$ C1
 $= 3.99V$
 $V_{OUT} = 12 \times (3.99 - 4.00)$
 $= (-) 0.12V$ 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
 $P_1 = 1.4 \times 10^{-16} \text{ W}$ 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
 $L = 1 \text{ km}$ 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)
 $L = (158 - 24) / 1.9 = 71 \text{ km}$ (A1)
- (b)** less attenuation (per unit length) / longer uninterrupted length of fibre B1 [1]