

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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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2011	9702	42

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 $Q_1Q_2 / 4\pi\epsilon_0m_1m_2G$ 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]

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2011	9702	42

4	(a)	+ ΔU : increase in internal energy	B1		
		+ q : thermal energy / heat supplied to the system	B1		
		+ w : work done on the system	B1	[3]	
4	(b)	(i)	(thermal) energy required to change the state of a substance per unit mass	M1	
			without any change of temperature	A1	
		(ii)	when evaporating	M1	
			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 rate of change of (magnetic) flux (linkage) / rate of flux cutting	M1	
				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 A never zero	M1		
			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	
		(ii)	$I_{\text{RMS}} \times \sqrt{2} = I_0$	C1	
			$I_{\text{RMS}} = 9.9 / \sqrt{2}$ $= 7.0 \text{ A}$	A1	[2]
	(b)	power = $I^2 R$	C1		
		$R = 400 / 7.0^2$ $= 8.2 \Omega$	A1	[2]	

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2011	9702	42

- 7 (a) wavelength of wave associated with a particle that is moving M1
A1 [2]
- (b) (i) energy of electron = $850 \times 1.6 \times 10^{19}$ M1
 $= 1.36 \times 10^{16} \text{ J}$
energy = $p^2 / 2m$ or $p = mv$ and $E_K = \frac{1}{2}mv^2$
momentum = $\sqrt{(1.36 \times 10^{16} \times 2 \times 9.11 \times 10^{31})}$ M1
 $= 1.6 \times 10^{23} \text{ N s}$ A0 [2]
- (ii) $\lambda = h / p$ C1
wavelength = $(6.63 \times 10^{34}) / (1.6 \times 10^{23})$
 $= 4.1 \times 10^{11} \text{ m}$ 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) $1u = 1.66 \times 10^{27} \text{ kg}$
 $E = mc^2$ C1
 $= 1.66 \times 10^{27} \times (3.0 \times 10^8)^2$ M1
 $= 1.49 \times 10^{10} \text{ J}$
 $= (1.49 \times 10^{10}) / (1.6 \times 10^{13})$ M1
 $= 930 \text{ MeV}$ A0 [3]
- (c) (i) $\Delta m = 2.0141u - (1.0073 + 1.0087)u$
 $= -1.9 \times 10^{-3}u$ C1
binding energy = $1.9 \times 10^{-3} \times 930$
 $= 1.8 \text{ MeV}$ A1 [2]
- (ii) $\Delta m = (57 \times 1.0087u) + (40 \times 1.0073u) - 97.0980u$ C1
 $= (-)0.69u$
binding energy per nucleon = $(0.69 \times 930) / 97$ C1
 $= 6.61 \text{ MeV}$ A1 [3]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2011	9702	42

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]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2011	9702	42

- 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]