

**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 $Q_1 Q_2 / 4\pi\epsilon_0 m_1 m_2 G$ 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 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 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 = $\frac{1}{2} \times 1800 \times 10^{-6} \times (10^2 - 7.5^2)$
= 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* $6.67 \times 10^{-6} \times 12$
= 80 μC 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	[3]	
		+ q : thermal energy / heat supplied to the system	B1		
		+ w : work done on the system	B1		
5	(b)	(i)	(thermal) energy required to change the state of a substance per unit mass	M1	[3]
			without any change of temperature	A1	
	(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		
(a)	(i)	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) / rate of flux cutting	M1	[2]	
			A1		
	(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	[2]		
	frequency = 1.33 Hz	A1			
(c)	graph: smooth correctly shaped curve with peak at f_0 A never zero	M1	[2]		
		A1			
(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	[2]
			frequency = 60 Hz	A1	
	(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	[2]		
	$R = 400 / 9.9^2$ = 4.1 Ω	A1			

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 = $850 \times 1.6 \times 10^{-19}$
 $= 1.36 \times 10^{-16} \text{ J}$
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) $1u = 1.66 \times 10^{-27} \text{ kg}$
 $E = mc^2$
 $= 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$
 $= 1.49 \times 10^{-10} \text{ J}$
 $= (1.49 \times 10^{-10}) / (1.6 \times 10^{-13})$
 $= 930 \text{ MeV}$ C1 M1 A0 [3]
- (c) (i) $\Delta m = 2.0141u - (1.0073 + 1.0087)u$
 $= -1.9 \times 10^{-3}u$
binding energy = $1.9 \times 10^{-3} \times 930$
 $= 1.8 \text{ MeV}$ C1 A1 [2]
- (ii) $\Delta m = (57 \times 1.0087u) + (40 \times 1.0073u) - 97.0980u$
 $= (-)0.69u$
binding energy per nucleon = $(0.69 \times 930) / 97$
 $= 6.61 \text{ MeV}$ C1 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) $V_2 = (1000 / 1128) \times 4.5$
 $= 3.99V$ C1
 $V_{OUT} = 12 \times (3.99 - 4.00)$
 $= (-) 0.12V$ 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]