

**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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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	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  $Q_1 Q_2 / 4\pi\epsilon_0 m_1 m_2 G$  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  $\mu\text{F}$  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 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	43

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 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	A1	
		identifies each difference correctly with $\Delta U$ 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
			2. speed of magnet varies so varying rate of change of flux	B1
			3. magnet changes direction of motion (so current changes direction)	B1
			[1]	
			[1]	
			[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
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	43

- 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	43

## 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	43

- 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]