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

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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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Cambridge is publishing the mark schemes for the May/June 2011 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.

Section A

1	**(a)**	region (of space) where a particle / body experiences a force	B1	
	(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 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]

4 (a) +ΔU: increase in internal energy — B1
+q: thermal energy / heat supplied to the system — B1
+w: work done on the system — B1

(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]

7 **(a)** wavelength of wave associated with a particle — M
that is moving — A1

(b) **(i)** energy of electron $= 850 \times 1.6 \times 10^{-19}$ — M1
$= 1.36 \times 10^{-16}$ J
energy $= p^2 / 2m$ *or* $p = mv$ <u>and</u> $E_K = ½mv^2$
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 <u>thin</u> metal target / carbon <u>film</u> — 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 <u>nucleus</u> — M1
to infinity — A1 — [2]

(b) $1\text{u} = 1.66 \times 10^{-27}$ 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]

Section B

9	**(a)**	<u>thin / fine</u> 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	
		<u>uplink</u> signal would be swamped by <u>downlink</u> signal		B1	[2]

12 (a) (i)	ratio / dB = 10 lg(P_1 / P_2)		C1	
	24 = 10 lg(P_1 / {5.6 × 10^{-19}})		C1	
	P_1 = 1.4 × 10^{-16} W		A1	
(ii)	attenuation per unit length = 1 / L × 10 lg(P_1 / P_2)		C1	
	1.9 = 1 / L × 10 lg({3.5 × 10^{-3}}/{1.4 × 10^{-16}})		C1	
	L = 1 km		A1	[3]
	or			
	attenuation = 10 lg({3.5 × 10^{-3}}/{5.6 × 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]