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.

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UNIVERSITY of CAMBRIDGE
International Examinations

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 $Q_1Q_2 / 4\pi\varepsilon_0 m_1 m_2 G$ 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
$= (18 \times 10^{-3}) / 10$
$= 1800\ \mu F$ 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 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* $6.67 \times 10^{-6} \times 12$
$= 80\ \mu C$ A1 [3]

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		
			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	
			$I_{RMS} = 9.9 / \sqrt{2}$		
			$= 7.0\,\text{A}$	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	M1	
			that is moving	A1	[2]
	(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)		$1u = 1.66 \times 10^{-27}$ 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)**	$\Delta m = 2.0141u - (1.0073 + 1.0087)u$		
			$= -1.9 \times 10^{-3}u$	C1	
			binding energy $= 1.9 \times 10^{-3} \times 930$		
			$= 1.8$ MeV	A1	[2]
		(ii)	$\Delta m = (57 \times 1.0087u) + (40 \times 1.0073u) - 97.0980u$	C1	
			$= (-)0.69u$		
			binding energy per nucleon $= (0.69 \times 930) / 97$	C1	
			$= 6.61$ MeV	A1	[3]

Section B

Question	Answer		Mark	Total
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
$P_1 = 1.4 \times 10^{-16}$ W A1 [3]

(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]