UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2010 question paper

for the guidance of teachers

9702 PHYSICS

9702/42 Paper 4 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1 **(a)** force per unit mass (*ratio idea essential*) B1 [1]

(b) graph: correct curvature M1
from (R,1.0 g_S) & at least one other correct point A1 [2]

(c) **(i)** fields of Earth and Moon are in opposite directions M1
either resultant field found by subtraction of the field strength
or any other sensible comment A1
so there is a point where it is zero A0 [2]
(*allow* $F_E = –F_M$ *for 2 marks*)

(ii) $GM_E / x^2 = GM_M / (D – x)^2$ C1
$(6.0 \times 10^{24}) / (7.4 \times 10^{22}) = x^2 / (60R_E – x)^2$ C1
$x = 54\,R_E$ A1 [3]

(iii) graph: $g = 0$ at least ⅔ distance to Moon B1
g_E and g_M in opposite directions M1
correct curvature (by eye) and $g_E > g_M$ at surface A1 [3]

2 **(a)** **(i)** no forces (of attraction or repulsion) between atoms / molecules / particles B1 [1]

(ii) sum of kinetic and potential energy of atoms / molecules M1
due to random motion A1 [2]

(iii) (random) kinetic energy increases with temperature M1
no potential energy
(so increase in temperature increases internal energy) A1 [2]

(b) **(i)** zero A1 [1]

(ii) work done $= p\Delta V$ C1
$= 4.0 \times 10^5 \times 6 \times 10^{-4}$
$= 240$ J (*ignore any sign)* A1 [2]

(iii)

change	work done / J	heating / J	increase in internal energy / J
P → Q	**+240**	–600	**–360**
Q → R	0	+720	**+720**
R → P	**–840**	+480	**–360**

(*correct signs essential*)
(*each horizontal line correct, 1 mark – max 3*) B3 [3]

3	(a)	(i)	resonance	B1	[1]
		(ii)	amplitude 16 mm <u>and</u> frequency 4.6 Hz	A1	[1]
	(b)	(i)	$a = (-)\omega^2 x$ and $\omega = 2\pi f$	C1	
			$a = 4\pi^2 \times 4.6^2 \times 16 \times 10^{-3}$	C1	
			$= 13.4\,\text{m s}^{-2}$	A1	[3]
		(ii)	$F = ma$	C1	
			$= 150 \times 10^{-3} \times 13.4$		
			$= 2.0\,\text{N}$	A1	[2]
	(c)		line always 'below' given line and never zero	M1	
			peak is at 4.6 Hz (or slightly less) and flatter	A1	[2]
4	(a)		charge / potential (difference) (*ratio must be clear)*	B1	[1]
	(b)	(i)	$V = Q / 4\pi\varepsilon_0 r$	B1	[1]
		(ii)	$C = Q / V = 4\pi\varepsilon_0 r$ and <u>$4\pi\varepsilon_0$ is constant</u>	M1	
			so $C \propto r$	A0	[1]
	(c)	(i)	$r = C / 4\pi\varepsilon_0 r$	C1	
			$r = (6.8 \times 10^{-12}) / (4\pi \times 8.85 \times 10^{-12})$	C1	
			$= 6.1 \times 10^{-2}\,\text{m}$	A1	[3]
		(ii)	$Q = CV = 6.8 \times 10^{-12} \times 220$		
			$= 1.5 \times 10^{-9}\,\text{C}$	A1	[1]
	(d)	(i)	$V = Q/C = (1.5 \times 10^{-9}) / (18 \times 10^{-12})$		
			$= 83\,\text{V}$	A1	[1]
		(ii)	*either* energy $= \frac{1}{2}CV^2$	C1	
			$\Delta E = \frac{1}{2} \times 6.8 \times 10^{-12} \times 220^2 - \frac{1}{2} \times 18 \times 10^{-12} \times 83^2$	C1	
			$= 1.65 \times 10^{-7} - 6.2 \times 10^{-8}$		
			$= 1.03 \times 10^{-7}\,\text{J}$	A1	[3]
			or energy $= \frac{1}{2}QV$	(C1)	
			$\Delta E = \frac{1}{2} \times 1.5 \times 10^{-9} \times 220 - \frac{1}{2} \times 1.5 \times 10^{-9} \times 83$	(C1)	
			$= 1.03 \times 10^{-7}\,\text{J}$	(A1)	

5	(a)		field into (the plane of) the paper	B1	[1]
	(b)		force due to magnetic field <u>provides</u> the centripetal force	B1	
			$mv^2 / r = Bqv$	C1	
			$B = (20 \times 1.66 \times 10^{-27} \times 1.40 \times 10^5) / (1.6 \times 10^{-19} \times 6.4 \times 10^{-2})$	B1	
			$= 0.454\,T$	A0	[3]
	(c)	(i)	<u>semicircle</u> with diameter greater than 12.8 cm	B1	[1]
		(ii)	new flux density = $\frac{22}{20} \times 0.454$	C1	
			$B = 0.499\,T$	A1	[2]
6	(a)	(i)	e.g. prevent flux losses / improve flux linkage	B1	[1]
		(ii)	flux in core is changing	B1	
			e.m.f. / current (induced) <u>in core</u>	B1	
			induced current in core causes heating	B1	[3]
	(b)	(i)	that value of the direct current producing same (mean) power / heating	M1	
			in a resistor	A1	[2]
		(ii)	power in primary = power in secondary	M1	
			$V_P I_P = V_S I_S$	A1	[2]
7	(a)	(i)	e.g. electron / particle diffraction	B1	[1]
		(ii)	e.g. photoelectric effect	B1	[1]
	(b)	(i)	6	A1	[1]
		(ii)	change in energy = 4.57×10^{-19} J		
			$\lambda = hc / E$	C1	
			$= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (4.57 \times 10^{-19})$		
			$= 4.4 \times 10^{-7}$ m	A1	[2]
8	(a)		splitting of a heavy nucleus (*not atom/nuclide*)	M1	
			into two (lighter) nuclei of <u>approximately same mass</u>	A1	[2]
	(b)		$^{1}_{0}n$		
			$^{4}_{2}He$ (*allow* $^{4}_{2}\alpha$)	M2	
			$^{7}_{3}Li$	A1	[3]
	(c)		emitted particles have kinetic energy	B1	
			range of particles in the control rods is short / particles stopped in rods / lose kinetic energy in rods	B1	
			kinetic energy of particles converted to thermal energy	B1	[3]

Section B

9	(a)	(i)	non-inverting (amplifier)	B1	[1]
		(ii)	(G =) $1 + R_2 / R_1$	B1	[1]
	(b)	(i)	gain = 1 + 100 / 820	C1	
			output = 17 mV	A1	[2]
		(ii)	9 V	A1	[1]
			(R_2 / R_1 scores 0 in **(a)(ii)** but possible 1 mark in each of **(b)(i)** and **(b)(ii)** ($1 + R_1 / R_2$) scores 0 in **(a)(ii)**, no mark in **(b)(i)**, possible 1 mark in **(b)(ii)** ($1 – R_2 / R_1$) or R_1 / R_2 scores 0 in **(a)(ii), (b)(i)** and **(b)(ii)**)		
10	(a)	(i)	density × <u>speed of wave</u> (in the medium)	B1	[1]
		(ii)	ρ = (7.0 × 10⁶) / 4100 → $\rho = (7.0 \times 10^6) / 4100$ = 1700 kg m^{-3}	A1	[1]
	(b)	(i)	$I = I_T + I_R$	B1	[1]
		(ii)	**1.** $\alpha = (0.1 \times 10^6)^2 / (3.1 \times 10^6)^2$	C1	
			= 0.001	A1	[2]
			2. $\alpha \approx 1$	A1	[1]
	(c)	*either*	very little transmission at an air-skin boundary	M1	
			(almost) complete transmission at a gel-skin boundary	M1	
			when wave travels in or out of the body	A1	[3]
		or	no gel, majority reflection	(M1)	
			with gel, little reflection	(M1)	
			when wave travels in or out of the body	(A1)	
11	(a)	(i)	unwanted random power / signal / energy	B1	[1]
		(ii)	loss of (signal) power / energy	B1	[1]
	(b)	(i)	*either* signal-to-noise ratio at mic. = 10 lg (P_2 / P_1)	C1	
			= 10 lg ({2.9×10^{-6}} / {3.4×10^{-9}})		
			= 29 dB	A1	
			maximum length = (29 – 24) / 12	C1	
			= 0.42 km = 420 m	A1	[4]
			or signal-to-noise ratio at receiver = 10 lg (P_2 / P_1)	(C1)	
			at receiver, 24 = 10 lg(P / {3.4×10^{-9}})		
			$P = 8.54 \times 10^{-7}$ W	(A1)	
			power loss in cables = 10 lg({2.9×10^{-6}} / {8.54×10^{-7}})	(C1)	
			= 5.3 dB		
			length = 5.3 / 12 km		
			= 440 m	(A1)	

(ii) use an amplifier			M1	
coupled to the microphone			A1	[2]
(*repeater amplifiers scores no mark*)				

12	**(a)** (carrier wave) transmitted from Earth to satellite	(1)		
	satellite receives greatly attenuated signal	(1)		
	signal amplified and transmitted <u>back to Earth</u>		B1	
	at a different (carrier) frequency		B1	
	different frequencies prevent swamping of uplink signal	(1)		
	e.g. of frequencies used (6/4 GHz, 14/11 GHz, 30/20 GHz)	(1)		
	(*two B1 marks plus any two other for additional physics*)		B2	[4]

(b) advantage:	e.g.	much shorter time delay	M1	
		because orbits are much lower	A1	
	e.g.	whole Earth may be covered	(M1)	
		in several orbits / with network	(A1)	
disadvantage:	e.g.	*either* must be tracked		
		or limited use in any one orbit	M1	
		more satellites required for continuous operation	A1	[4]