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

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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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 provides 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	
		$= 0.454\,\text{T}$	A0	[3]
	(c) (i)	semicircle with diameter greater than 12.8 cm	B1	[1]
	(ii)	new flux density = $\frac{22}{20} \times 0.454$	C1	
		$B = 0.499\,\text{T}$	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) in core	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	
		$= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (4.57 \times 10^{-19})$		
		$= 4.4 \times 10^{-7}\,\text{m}$	A1	[2]
8	**(a)**	splitting of a heavy nucleus (*not atom/nuclide*)	M1	
		into two (lighter) nuclei of approximately same mass	A1	[2]
	(b)	${}^{1}_{0}\text{n}$		
		${}^{4}_{2}\text{He}$ (*allow* ${}^{4}_{2}\alpha$)	M2	
		${}^{7}_{3}\text{Li}$	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 × 10^6) / 4100		
			= 1700 kg m^{-3}	A1	[1]
	(b)	**(i)**	$I = I_T + I_R$	B1	[1]
		(ii)	**1.** α = $(0.1 \times 10^6)^2 / (3.1 \times 10^6)^2$	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 × 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]