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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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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]

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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)	

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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
$= 0.454\,\text{T}$ — 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
$B = 0.499\,\text{T}$ — 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) <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) ${}^{1}_{0}\text{n}$
${}^{4}_{2}\text{He}$ (*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]

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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 × 10^6)^2 / (3.1 × 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)

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(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]

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