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

9702/41 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	
		$= 4.0 \times 10^5 \times 6 \times 10^{-4}$		
		$= 240\,\text{J}$ (*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	
		$= 0.454$ 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	
		$B = 0.499$ 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	
		$= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (4.57 \times 10^{-19})$		
		$= 4.4 \times 10^{-7}$ 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)	$^{1}_{0}n$		
		$^{4}_{2}He$ (*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 × 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)

(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 back to Earth		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]