UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 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)** gravitational force provides the centripetal force — B1
$GMm/r^2 = mr\omega^2$ (*must be in terms of* ω) — B1
$r^3\omega^2 = GM$ <u>and</u> GM is a constant — B1 [3]

(b) **(i)** **1.** for Phobos, $\omega = 2\pi/(7.65 \times 3600)$ — C1
$= 2.28 \times 10^{-4}\ \text{rad s}^{-1}$
$(9.39 \times 10^6)^3 \times (2.28 \times 10^{-4})^2 = 6.67 \times 10^{-11} \times M$ — C1
$M = 6.46 \times 10^{23}$ kg — A1 [3]

2. $(9.39 \times 10^6)^3 \times (2.28 \times 10^{-4})^2 = (1.99 \times 10^7)^3 \times \omega^2$ — C1
$\omega = 7.30 \times 10^{-5}\ \text{rad s}^{-1}$ — C1
$T = 2\pi/\omega = 2\pi/(7.30 \times 10^{-5})$
$= 8.6 \times 10^4$ s
$= 23.6$ hours — A1 [3]

(ii) *either* almost 'geostationary'
or satellite would take a long time to cross the sky — B1 [1]

2 **(a)** e.g. moving in random (rapid) motion of <u>molecules/atoms/particles</u>
no intermolecular forces of attraction/repulsion
volume of <u>molecules/atoms/particles</u> negligible <u>compared</u> to volume of container
time of collision negligible to time between collisions
(1 each, max 2) — B2 [2]

(b) **(i)** **1.** number of (gas) <u>molecules</u> — B1 [1]

2. mean square speed/velocity (of gas molecules) — B1 [1]

(ii) either $pV = NkT$ *or* $pV = nRT$ and links n and k
and $\langle E_K \rangle = \frac{1}{2}m\langle c^2 \rangle$ — M1
clear algebra leading to $\langle E_K \rangle = \frac{3}{2}kT$ — A1 [2]

(c) **(i)** sum of potential energy and kinetic energy of <u>molecules/atoms/particles</u> — M1
reference to random (distribution) — A1 [2]

(ii) no intermolecular forces so no potential energy — B1
(change in) internal energy is (change in) kinetic energy and this is proportional to (change in) T — B1 [2]

3	**(a)**	**(i)**	<u>amplitude</u> remains constant	B1	[1]
		(ii)	<u>amplitude</u> decreases gradually	M1	
			light damping	A1	[2]
		(iii)	period = 0.80 s	C1	
			frequency = 1.25 Hz *(period not 0.8 s, then 0/2)*	A1	[2]
	(b)	**(i)**	(induced) e.m.f. is proportional to	M1	
			rate of change/cutting of (magnetic) flux (linkage)	A1	[2]
		(ii)	a current is induced in the coil	M1	
			as magnet moves in coil	A1	
			current in resistor gives rise to a heating effect	M1	
			thermal energy is derived from energy of oscillation of the magnet	A1	[4]
4	**(a)**	**(i)**	zero field (strength) inside spheres	B1	[1]
		(ii)	*either* field strength is zero		
			or the fields are in opposite directions	M1	
			at a point between the spheres	A1	[2]
	(b)	**(i)**	field strength is (–) potential gradient *(not V/x)*	B1	[1]
		(ii)	**1.** field strength has maximum value	B1	
			at x = 11.4 cm	B1	[2]
			2. field strength is zero	B1	
			either at x = 7.9 cm *(allow ±0.3 cm)*		
			or at 0 to 1.4 cm *or* 11.4 cm to 12 cm	B1	[2]
5	**(a)**	**(i)**	$Bqv(\sin\theta)$ or $Bqv(\cos\theta)$	B1	[1]
		(ii)	qE	B1	[1]
	(b)		F_B must be opposite in direction to F_E	B1	
			so magnetic field <u>into</u> plane of paper	B1	[2]

6	(a)	(i)	period = 1/50	C1	
			t_1 = 0.03 s	A1	[2]
		(ii)	peak voltage = 17.0 V	A1	[1]
		(iii)	r.m.s. voltage = 17.0/√2		
			= 12.0 V	A1	[1]
		(iv)	mean voltage = 0	A1	[1]
	(b)		power = V^2/R	C1	
			= $12^2/2.4$		
			= 60 W	A1	[2]
7	(a)		each line represents photon of specific energy	M1	
			photon emitted as a result of energy change of electron	M1	
			specific energy changes so discrete levels	A1	[3]
	(b)	(i)	arrow from –0.85 eV level to –1.5 eV level	B1	[1]
		(ii)	$\Delta E = hc/\lambda$	C1	
			$= (1.5 - 0.85) \times 1.6 \times 10^{-19}$	C1	
			$= 1.04 \times 10^{-19}$ J		
			$\lambda = (6.63 \times 10^{-34} \times 3.0 \times 10^{8})/(1.04 \times 10^{-19})$		
			$= 1.9 \times 10^{-6}$ m	A1	[3]
	(c)		spectrum appears as continuous spectrum crossed by dark lines	B1	
			two dark lines	B1	
			electrons in gas absorb photons with energies equal to the excitation energies	M1	
			light photons re-emitted in all directions	A1	[4]
8	(a)	(i)	time for initial number of nuclei/activity	M1	
			to reduce to one half of its initial value	A1	[2]
		(ii)	λ = ln 2/(24.8 × 24 × 3600)	M1	
			$= 3.23 \times 10^{-7}$ s^{-1}	A0	[1]
	(b)	(i)	$A = \lambda N$	C1	
			$3.76 \times 10^{6} = 3.23 \times 10^{-7} \times N$		
			$N = 1.15 \times 10^{13}$	A1	[2]
		(ii)	$N = N_0 e^{-\lambda t}$		
			$= 1.15 \times 10^{13} \times \exp(-\{\ln 2 \times 30\}/24.8)$	C1	
			$= 4.97 \times 10^{12}$	A1	[2]
	(c)		ratio $= (4.97 \times 10^{12})/(1.15 \times 10^{13} - 4.97 \times 10^{12})$	C1	
			= 0.76	A1	[2]

Section B

9	**(a)**	e.g. reduced gain increased stability greater bandwidth or less distortion *(allow any two sensible suggestions, 1 each, max 2)*	B2	[2]
	(b) (i)	V^- connected to midpoint between resistors	B1	
		V_{OUT} clear and input to V^+ clear	B1	[2]
	(ii)	gain = 1 + R_F/R		
		15 = 1 + 12000/R	C1	
		R = 860 Ω	A1	[2]
	(c)	graph: straight line from (0,0) to (0.6,9.0)	B1	
		straight line from (0.6,9.0) to (1.0,9.0)	B1	[2]
	(d)	*either* relay can be used to switch a large current/voltage	M1	
		output current of op-amp is a few mA/very small	A1	[2]
		or relay can be used as a remote switch	(M1)	
		for inhospitable region/avoids using long heavy cables	(A1)	
10	**(a)**	e.g. large bandwidth/carries more information low attenuation of signal low cost smaller diameter, easier handling, easier storage, less weight high security/no crosstalk low noise/no EM interference *(allow any four sensible suggestions, 1 each, max 4)*	B4	[4]
	(b) (i)	infra-red	B1	[1]
	(ii)	lower attenuation than for visible light	B1	[1]
	(c) (i)	gain/dB = 10 lg(P_2/P_1)	C1	
		26 = 10 lg($P_2/9.3 \times 10^{-6}$)		
		P_2 = 3.7×10^{-3} W	A1	[2]
	(ii)	power loss along fibre = 30 × 0.2 = 6.0 dB	C1	
		either 6 = 10 lg($P/3.7 \times 10^{-3}$) *or* 6 dB = 4 × 3.7×10^{-3}		
		or 32 = 10 lg($P/9.3 \times 10^{-6}$)		
		input power = 1.5×10^{-2} W	A1	[2]

11	**(a)**	**(i)**	switch so that one aerial can be used for transmission and reception	M1 A1	[2]
		(ii)	tuning circuit to select (one) carrier frequency (and reject others)	M1 A1	[2]
		(iii)	analogue-to-digital converter/ADC converts microphone output to a digital signal	M1 A1	[2]
		(iv)	(a.f.) amplifier *(not r.f. amplifier)* to increase (power of) signal to drive the loudspeaker	M1 A1	[2]
	(b)		e.g. short aerial so easy to handle short range so less interference between base stations larger waveband so more carrier frequencies *(any two sensible suggestions, 1 each, max 2)*	B2	[2]