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	
			$= 2.28 \times 10^{4}$ 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	
			$\omega = 7.30 \times 10^{5}$ 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 light damping	M1 A1	[2]
		(iii)	period = 0.80 s frequency = 1.25 Hz *(period not 0.8 s, then 0/2)*	C1 A1	[2]
	(b)	**(i)**	(induced) e.m.f. is proportional to rate of change/cutting of (magnetic) flux (linkage)	M1 A1	[2]
		(ii)	a current is induced in the coil as magnet moves in coil current in resistor gives rise to a heating effect thermal energy is derived from energy of oscillation of the magnet	M1 A1 M1 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 at a point between the spheres	 M1 A1	[2]
	(b)	**(i)**	field strength is (–) potential gradient *(not V/x)*	B1	[1]
		(ii)	**1.** field strength has maximum value at x = 11.4 cm	B1 B1	[2]
			2. field strength is zero *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 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 so magnetic field <u>into</u> plane of paper	B1 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	
			= 1.04×10^{19} J		
			λ = $(6.63 \times 10^{34} \times 3.0 \times 10^8)/(1.04 \times 10^{19})$		
			= 1.9×10^{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	
			= 3.23×10^{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	
			= 4.97×10^{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 V_{OUT} clear and input to V^+ clear	B1 B1	[2]
	(ii)	gain = 1 + R_F/R 15 = 1 + 12000/*R* *R* = 860 Ω	 C1 A1	[2]
	(c)	graph: straight line from (0,0) to (0.6,9.0) straight line from (0.6,9.0) to (1.0,9.0)	B1 B1	[2]
	(d)	*either* relay can be used to switch a large current/voltage output current of op-amp is a few mA/very small *or* relay can be used as a remote switch for inhospitable region/avoids using long heavy cables	M1 A1 (M1) (A1)	[2]
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) 26 = 10 lg(P_2/9.3 × 10^{6}) P_2 = 3.7 × 10^{3} W	C1 A1	[2]
	(ii)	power loss along fibre = 30 × 0.2 = 6.0 dB *either* 6 = 10 lg(*P*/3.7 × 10^{3}) *or* 6 dB = 4 × 3.7 × 10^{3} *or* 32 = 10 lg(*P*/9.3 × 10^{6}) input power = 1.5 × 10^{2} W	C1 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]