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	
	$r^3\omega^2 = GM$ and 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 molecules/atoms/particles		
	no intermolecular forces of attraction/repulsion		
	volume of molecules/atoms/particles negligible compared to volume of container		
	time of collision negligible to time between collisions		
	(1 each, max 2)	B2	[2]
(b) (i) 1.	number of (gas) molecules	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 molecules/atoms/particles	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)	$\lambda = \ln 2/(24.8 \times 24 \times 3600)$	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 × 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 × 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 A1 [2]

11	**(a)**	**(i)**	switch	M1	
			so that one aerial can be used for transmission and reception	A1	[2]
		(ii)	tuning circuit	M1	
			to select (one) carrier frequency (and reject others)	A1	[2]
		(iii)	analogue-to-digital converter/ADC	M1	
			converts microphone output to a digital signal	A1	[2]
		(iv)	(a.f.) amplifier *(not r.f. amplifier)*	M1	
			to increase (power of) signal to drive the loudspeaker	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]