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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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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
$= 2.28 \times 10^{-4}\ \text{rad s}^{-1}$
$(9.39 \times 10^6)^3 \times (2.28 \times 10^{-4})^2 = 6.67 \times 10^{-11} \times M$ — 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 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 $\langle E_K \rangle = ½m\langle c^2 \rangle$ — 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		
(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
t_1 = 0.03 s — A

(ii) peak voltage = 17.0 V — A1 [

(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
$R = 860\ \Omega$ 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
$26 = 10\ \lg(P_2/9.3 \times 10^{-6})$
$P_2 = 3.7 \times 10^{-3}$ W A1 [2]

(ii) power loss along fibre = $30 \times 0.2 = 6.0$ dB C1
either $6 = 10\ \lg(P/3.7 \times 10^{-3})$ *or* 6 dB = $4 \times 3.7 \times 10^{-3}$
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 A

(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]