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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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]

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3 (a) (i) amplitude remains constant — B1 [1]

(ii) amplitude 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 into plane of paper — B1 [2]

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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]

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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* $6\ \text{dB} = 4 \times 3.7 \times 10^{-3}$
or $32 = 10 \lg(P/9.3 \times 10^{-6})$
input power = 1.5×10^{-2} W A1 [2]

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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]

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