

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
 $GMm/r^2 = mr\omega^2$ (must be in terms of ω)
 $r^3\omega^2 = GM$ and GM is a constant
- B1
B1
B1 [3]
- (b) (i) 1. for Phobos, $\omega = 2\pi/(7.65 \times 3600)$
 $= 2.28 \times 10^{-4} \text{ rad s}^{-1}$
 $(9.39 \times 10^6)^3 \times (2.28 \times 10^{-4})^2 = 6.67 \times 10^{-11} \times M$
 $M = 6.46 \times 10^{23} \text{ kg}$
- C1
C1
A1 [3]
2. $(9.39 \times 10^6)^3 \times (2.28 \times 10^{-4})^2 = (1.99 \times 10^7)^3 \times \omega^2$
 $\omega = 7.30 \times 10^{-5} \text{ rad s}^{-1}$
 $T = 2\pi/\omega = 2\pi/(7.30 \times 10^{-5})$
 $= 8.6 \times 10^4 \text{ s}$
 $= 23.6 \text{ hours}$
- C1
C1
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
reference to random (distribution)
- M1
A1 [2]
- (ii) no intermolecular forces so no potential energy
(change in) internal energy is (change in) kinetic energy and this is
proportional to (change in) T
- B1
B1 [2]

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- 3 (a) (i) amplitude remains constant B1 [1]
- (ii) amplitude decreases gradually
light damping M1
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 M1
or the fields are in opposite directions A1 [2]
at a point between the spheres
- (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 = $1/50$
 $t_1 = 0.03 \text{ s}$ C1
A1 [2]
- (ii) peak voltage = 17.0 V A1 [1]
- (iii) r.m.s. voltage = $17.0/\sqrt{2}$
= 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
= $1.04 \times 10^{-19} \text{ J}$
 $\lambda = (6.63 \times 10^{-34} \times 3.0 \times 10^8)/(1.04 \times 10^{-19})$
= $1.9 \times 10^{-6} \text{ m}$ 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
= $3.23 \times 10^{-7} \text{ s}^{-1}$ 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]

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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
 V_{OUT} clear and input to V^+ clear B1
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
output current of op-amp is a few mA/very small M1
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
 $26 = 10 \lg(P_2/9.3 \times 10^{-6})$
 $P_2 = 3.7 \times 10^{-3} \text{ W}$ A1 [2]
- (ii) power loss along fibre = $30 \times 0.2 = 6.0 \text{ dB}$ 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 = $1.5 \times 10^{-2} \text{ W}$ A1 [2]

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- 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]