

**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  $\omega$ )  
 $r^3\omega^2 = GM$  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  $\pm 0.3$  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 =  $17.0 \text{ V}$  A1 [1]
- (iii) r.m.s. voltage =  $17.0/\sqrt{2}$   
=  $12.0 \text{ V}$  A1 [1]
- (iv) mean voltage =  $0$  A1 [1]
- (b) power =  $V^2/R$  C1  
=  $12^2/2.4$   
=  $60 \text{ W}$  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  $-0.85 \text{ eV}$  level to  $-1.5 \text{ eV}$  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  
=  $4.97 \times 10^{12}$  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  
 $V_{OUT}$  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]