

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**  
GCE Advanced Subsidiary Level and GCE Advanced Level

**MARK SCHEME for the October/November 2010 question paper  
for the guidance of teachers**

**9702 PHYSICS**

**9702/43**

Paper 4 (A2 Structured Questions), maximum raw mark 100

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## Section A

- 1 (a) (i) rate of change of angle / angular displacement swept out by radius M1  
A1 [2]
- (ii)  $\omega \times T = 2\pi$  B1 [1]
- (b) centripetal force is provided by the gravitational force B1  
either  $mr(2\pi/T)^2 = GMm/r^2$  or  $mr\omega^2 = GMm/r^2$  M1  
 $r^3 \times 4\pi^2 = GM \times T^2$  A1  
 $GM/4\pi^2$  is a constant (c) A1  
 $T^2 = cr^3$  A0 [4]
- (c) (i) either  $T^2 = (45/1.08)^3 \times 0.615^2$  or  $T^2 = 0.30 \times 45^3$  C1  
 $T = 165$  years A1 [2]
- (ii) speed =  $(2\pi \times 1.08 \times 10^8) / (0.615 \times 365 \times 24 \times 3600)$  C1  
=  $35 \text{ km s}^{-1}$  A1 [2]
- 2 (a) atoms / molecules / particles behave as elastic (identical) spheres (1)  
volume of atoms / molecules negligible compared to volume of containing vessel (1)  
time of collision negligible to time between collisions (1)  
no forces of attraction or repulsion between atoms / molecules (1)  
atoms / molecules / particles are in (continuous) random motion (1)  
(any four, 1 each) B4 [4]
- (b)  $pV = \frac{1}{3} Nm\langle c^2 \rangle$  and  $pV = nRT$  or  $pV = NkT$  B1  
 $\frac{1}{3} Nm\langle c^2 \rangle = nRT$  or  $= NkT$  and  $\langle E_K \rangle = \frac{1}{2} m\langle c^2 \rangle$  B1  
 $n = N/N_A$  or  $k = R/N_A$  B1  
 $\langle E_K \rangle = \frac{3}{2} \times R/N_A \times T$  A0 [3]
- (c) (i) reaction represents either build-up of nucleus from light nuclei M1  
or build-up of heavy nucleus from nuclei A1 [2]  
so fusion reaction
- (ii) proton and deuterium nucleus will have equal kinetic energies B1  
 $1.2 \times 10^{-14} = \frac{3}{2} \times 8.31 / (6.02 \times 10^{23}) \times T$  C1  
 $T = 5.8 \times 10^8 \text{ K}$  A1 [3]  
(use of  $E = 2.4 \times 10^{-14}$  giving  $1.16 \times 10^9 \text{ K}$  scores 1 mark)
- (iii) either inter-molecular / atomic / nuclear forces exist B1  
or proton and deuterium nucleus are positively charged / repel A1 [1]

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- 3 (a) (i) 8.0 cm A1 [1]
- (ii)  $2\pi f = 220$  C1  
 $f = 35$  (condone unit) A1 [2]
- (iii) line drawn mid-way between AB and CD (allow  $\pm 2$  mm) B1 [1]
- (iv)  $v = \omega a$  C1  
 $= 220 \times 4.0$   
 $= 880 \text{ cm s}^{-1}$  A1 [2]
- (b) (i) 1. line drawn 3 cm above AB (allow  $\pm 2$  mm) B1 [1]  
2. arrow pointing upwards B1 [1]
- (ii) 1. line drawn 3 cm above AB (allow  $\pm 2$  mm) B1 [1]  
2. arrow pointing downwards B1 [1]
- (iii)  $v = \omega\sqrt{a^2 - x^2}$   
 $= 220 \times \sqrt{4.0^2 - 2.0^2}$  C1  
 $= 760 \text{ cm s}^{-1}$  A1 [2]  
(incorrect value for  $x$ , 0/2 marks)
- 4 (a) (i) work done moving unit positive charge M1  
from infinity to the point A1 [2]
- (ii) charge / potential (difference) (ratio must be clear) B1 [1]
- (b) (i) capacitance =  $(2.7 \times 10^{-6}) / (150 \times 10^3)$  C1  
(allow any appropriate values)  
capacitance =  $1.8 \times 10^{-11}$  (allow  $1.8 \pm 0.05$ ) A1 [2]
- (ii) either energy =  $\frac{1}{2}CV^2$  or energy =  $\frac{1}{2}QV$  and  $Q = CV$  C1  
energy =  $\frac{1}{2} \times 1.8 \times 10^{-11} \times (150 \times 10^3)^2$  or  $\frac{1}{2} \times 2.7 \times 10^{-6} \times 150 \times 10^3$   
= 0.20 J A1 [2]
- (c) either since energy  $\propto V^2$ , capacitor has  $(\frac{1}{2})^2$  of its energy left  
or full formula treatment C1  
energy lost = 0.15 J A1 [2]

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- 5 (a) magnetic flux =  $BA$   
 $= 89 \times 10^{-3} \times 5.0 \times 10^{-2} \times 2.4 \times 10^{-2}$   
 $= 1.07 \times 10^{-4} \text{ Wb}$  C1  
A1 [2]
- (b) (i) e.m.f. =  $\Delta\phi / \Delta t$  C1  
(for  $\Delta\phi = 1.07 \times 10^{-4} \text{ Wb}$ ),  $\Delta t = 2.4 \times 10^{-2} / 1.8 = 1.33 \times 10^{-2} \text{ s}$  C1  
e.m.f. =  $(1.07 \times 10^{-4}) / (1.33 \times 10^{-2})$   
 $= 8.0 \times 10^{-3} \text{ V}$  A1 [3]
- (ii) current =  $8.0 \times 10^{-3} / 0.12$  M1  
 $\approx 70 \text{ mA}$  A0 [1]
- (c) force on wire =  $BIL$   
 $= 89 \times 10^{-3} \times 70 \times 10^{-3} \times 5.0 \times 10^{-2}$  C1  
 $\approx 3 \times 10^{-4} \text{ (N)}$  M1  
suitable comment e.g. this force is too / very small (to be felt) A1 [3]
- 6 (a) power / heating depends on  $I^2$  M1  
so independent of current direction A1 [2]
- (b) *either* maximum power =  $I_0^2 R$  or average power =  $I_{\text{RMS}}^2 R$  M1  
 $I_0 = \sqrt{2} \times I_{\text{RMS}}$  M1  
maximum power =  $2 \times$  average power  
ratio = 0.5 A1 [3]
- 7 (a) force due to  $E$ -field is equal and opposite to force due to  $B$ -field B1  
 $Eq = Bqv$  B1  
 $v = E/B$  B1 [3]
- (b) *either* charge and mass are not involved in the equation in (a)  
or  $F_E$  and  $F_B$  are both doubled  
or  $E$ ,  $B$  and  $v$  do not change M1  
so no deviation A1 [2]
- 8 (a) minimum frequency for electron to be emitted (from surface) M1  
of electromagnetic radiation / light / photons A1 [2]
- (b)  $E = hc / \lambda$  or  $E = hf$  and  $c = f\lambda$  C1  
*either* threshold wavelength =  $(6.63 \times 10^{-34} \times 3.0 \times 10^8) / (5.8 \times 10^{-19})$   
 $= 340 \text{ nm}$   
or energy of 340 nm photon =  $4.4 \times 10^{-19} \text{ J}$   
or threshold frequency =  $8.7 \times 10^{14} \text{ Hz}$   
or 450 nm  $\rightarrow 6.7 \times 10^{14} \text{ Hz}$  A1  
appropriate comment comparing wavelengths / energies / frequencies B1  
so no effect on photo-electric current B1 [4]

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## Section B

- 9 (a) (i) edges can be (clearly) distinguished B1 [1]
- (ii) e.g. size of X-ray source / anode / target / aperture  
scattering of X-ray beam  
pixel size  
(any two, 1 each) B2  
further detail e.g. use of lead grid B1 [3]
- (b) X-ray image involves a single exposure B1  
CT scan: exposure of a slice from many different angles M1  
repeated for different slices A1  
CT scan involves a (much) greater exposure B1 [4]
- 10 (a) e.g. infinite input impedance / resistance  
zero output impedance / resistance  
infinite gain  
infinite bandwidth  
infinite slew rate  
(any three, 1 each) B3 [3]
- (b) (i) with switch open,  $V^-$  is less (positive) than  $V^+$  M1  
output is positive A1  
with switch closed,  $V^-$  is more (positive) than  $V^+$  so output is negative A1 [3]  
(allow similar scheme if  $V^-$  more positive than  $V^+$  treated first)
- (ii) 1. diodes connected correctly between output and earth M1  
2. green identified correctly A1 [2]  
(do not allow this mark if not argued in (i))
- 11 (a) (i)  $I / I_0 = \exp(-1.5 \times 2.9)$  C1  
 $= 0.013$  A1 [2]
- (ii)  $I / I_0 = \exp(-4.6 \times 0.95)$   
 $= 0.013$  A1 [1]
- (b) attenuation (coefficients) in muscle and in fat are similar B1  
attenuation (coefficients) in bone and muscle / fat are different B1  
contrast depends on difference in attenuation B1 [3]

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- 12 (a) (i) 1. signal has same variation (with time) as the data B1  
 2. consists of (a series of) 'highs' and 'lows' B1  
*either* analogue is continuously variable (between limits)  
*or* digital has no intermediate values B1 [3]
- (ii) e.g. can be regenerated / noise can be eliminated  
 extra data can be added to check / correct transmitted signal  
*(any two reasonable suggestions, 1 each)* B2 [2]
- (b) (i) analogue signal is sampled at (regular time) intervals B1  
 sampled signal is converted into a binary number B1 [2]
- (ii) one channel is required for each bit (of the digital number) B1 [1]