

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

**MARK SCHEME for the May/June 2012 question paper  
for the guidance of teachers**

**9702 PHYSICS**

**9702/42**

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

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## Section A

- 1 (a) force proportional to product of masses and inversely proportional to square of separation (*do not allow square of distance/radius*)  
*either* point masses *or* separation @ size of masses
- M1  
A1 [2]
- (b) (i)  $\omega = 2\pi / (27.3 \times 24 \times 3600)$  or  $2\pi / (2.36 \times 10^6)$   
 $= 2.66 \times 10^{-6} \text{ rad s}^{-1}$
- M1  
A0 [1]
- (ii)  $GM = r^3 \omega^2$  or  $GM = v^2 r$   
 $M = (3.84 \times 10^5 \times 10^3)^3 \times (2.66 \times 10^{-6})^2 / (6.67 \times 10^{-11})$   
 $= 6.0 \times 10^{24} \text{ kg}$   
 (special case: uses  $g = GM/r^2$  with  $g = 9.81$ ,  $r = 6.4 \times 10^6$  scores max 1 mark)
- C1  
M1  
A0 [2]
- (c) (i) grav. force  $= (6.0 \times 10^{24}) \times (7.4 \times 10^{22}) \times (6.67 \times 10^{-11}) / (3.84 \times 10^8)^2$   
 $= 2.0 \times 10^{20} \text{ N}$  (*allow 1 SF*)
- C1  
A1 [2]
- (ii) *either*  $\Delta E_p = Fx$  because  $F$  constant as  $x \ll$  radius of orbit  
 $\Delta E_p = 2.0 \times 10^{20} \times 4.0 \times 10^{-2}$   
 $= 8.0 \times 10^{18} \text{ J}$  (*allow 1 SF*)
- B1  
C1  
A1 [3]
- or*  $\Delta E_p = GMm/r_1 - GMm/r_2$   
 Correct substitution  
 $8.0 \times 10^{18} \text{ J}$   
 ( $\Delta E_p = GMm/r_1 + GMm/r_2$  is incorrect physics so 0/3)
- C1  
B1  
A1
- 2 (a) energy  $= \frac{1}{2} m \omega^2 a^2$  and  $\omega = 2\pi f$   
 $= \frac{1}{2} \times 37 \times 10^{-3} \times (2\pi \times 3.5)^2 \times (2.8 \times 10^{-2})^2$   
 $= 7.0 \times 10^{-3} \text{ J}$   
 (allow  $2\pi \times 3.5$  shown as  $7\pi$ )
- C1  
M1  
A0 [2]
- Energy  $= \frac{1}{2} m v^2$  and  $v = r\omega$   
 Correct substitution  
 Energy  $= 7.0 \times 10^{-3} \text{ J}$
- (C1)  
(M1)  
(A0)
- (b)  $E_K = E_p$   
 $\frac{1}{2} m \omega^2 (a^2 - x^2) = \frac{1}{2} m \omega^2 x^2$  or  $E_K$  or  $E_p = 3.5 \text{ mJ}$   
 $x = a/\sqrt{2} = 2.8/\sqrt{2}$  or  $E_K = \frac{1}{2} m \omega^2 (a^2 - x^2)$  or  $E_p = \frac{1}{2} m \omega^2 x^2$   
 $= 2.0 \text{ cm}$   
 ( $E_K$  or  $E_p = 7.0 \text{ mJ}$  scores 0/3)
- C1  
C1  
A1 [3]
- Allow:  $k = 17.9$   
 $E = \frac{1}{2} kx^2$   
 $x = 2.0 \text{ cm}$
- (C1)  
(C1)  
(A1)

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	(c) (i) graph: horizontal line, y-intercept = 7.0 mJ with end-points of line at +2.8 cm and –2.8 cm	B1	[1]
	(ii) graph: reasonable curve with maximum at (0,7.0) end-points of line at (–2.8, 0) and (+2.8, 0)	B1 B1	[2]
	(iii) graph: inverted version of (ii) with intersections at (–2.0, 3.5) and (+2.0, 3.5) (Allow marks in (iii), but not in (ii), if graphs K & P are not labelled)	M1 A1	[2]
	(d) <u>gravitational potential</u> energy	B1	[1]
3	(a) sum of potential energy and kinetic energy of atoms/molecules/particles reference to random (distribution)	M1 A1	[2]
	(b) (i) as lattice structure is 'broken'/bonds broken/forces between molecules reduced (not molecules separate) no change in kinetic energy, potential energy increases internal energy increases	B1 M1 A1	[3]
	(ii) <i>either</i> molecules/atoms/particles move faster/ $\langle c^2 \rangle$ is increasing <i>or</i> kinetic energy increases with temperature (increases) no change in potential energy, kinetic energy increases internal energy increases	B1 M1 A1	[3]
4	(a) (i) as $r$ decreases, energy decreases/work got out (due to <u>attraction</u> ) so point mass is negatively charged	M1 A1	[2]
	(ii) electric potential energy = charge $\times$ electric potential electric field strength is potential gradient field strength = gradient of potential energy graph/charge	B1 B1 A0	[2]
	(b) tangent drawn at (4.0, 14.5) gradient = $3.6 \times 10^{-24}$ (for $\langle \pm 0.3$ allow 2 marks, for $\langle \pm 0.6$ allow 1 mark) field strength = $(3.6 \times 10^{-24}) / (1.6 \times 10^{-19})$ = $2.3 \times 10^{-5} \text{ V m}^{-1}$ (allow ecf from gradient value) (one point solution for gradient leading to $2.3 \times 10^{-5} \text{ V m}^{-1}$ scores 1 mark only)	B1 A2 A1	[4]

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- 5 (a) (long) straight conductor carrying current of 1 A  
current/wire normal to magnetic field  
(for flux density 1 T,) force per unit length is  $1 \text{ N m}^{-1}$
- (b) (i) (originally) downward force on magnet (due to current)  
by Newton's third law (allow "N3")  
upward force on wire
- (ii)  $F = BIL$   
 $2.4 \times 10^{-3} \times 9.8 = B \times 5.6 \times 6.4 \times 10^{-2}$   
 $B = 0.066 \text{ T}$  (need 2 SF)  
(g missing scores 0/2, but g = 10 leading to 0.067 T scores 1/2)
- (c) new reading is  $2.4\sqrt{2} \text{ g}$   
either changes between +3.4 g and -3.4 g  
or total change is 6.8 g
- 6 (a) oil drop charged by friction/beta source  
between parallel metal plates  
plates are horizontal  
adjustable potential difference/field between plates  
until oil drop is stationary  
 $mg = q \times V/d$   
symbols explained  
oil drop viewed through microscope  
m determined from terminal speed of drop (when p.d. is zero)  
(any two extras, 1 each)
- (b)  $3.2 \times 10^{-19} \text{ C}$
- 7 (a) minimum energy to remove an electron from the metal/surface
- (b) gradient =  $4.17 \times 10^{-15}$  (allow 4.1 → 4.3)  
 $h = 4.15 \times 10^{-15} \times 1.6 \times 10^{-19}$  or  $h = 4.1 \text{ to } 4.3 \times 10^{-15} \text{ eVs}$   
 $= 6.6 \times 10^{-34} \text{ Js}$
- (c) graph: straight line parallel to given line  
with intercept at any higher frequency  
intercept at between  $6.9 \times 10^{14} \text{ Hz}$  and  $7.1 \times 10^{14} \text{ Hz}$

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- 8 (a) nuclei having same number of protons/proton (atomic) number  
different numbers of neutrons/neutron number  
(allow second mark for nucleons/nucleon number/mass number/atomic  
mass if made clear that same number of protons/proton number)
- B1  
B1 [2]
- (b) probability of decay per unit time is the decay constant  
 $\lambda = \ln 2 / t_{1/2}$   
 $= 0.693 / (52 \times 24 \times 3600)$   
 $= 1.54 \times 10^{-7} \text{ s}^{-1}$
- C1  
C1  
A1 [3]
- (c) (i)  $A = A_0 \exp(-\lambda t)$   
 $7.4 \times 10^6 = A_0 \exp(-1.54 \times 10^{-7} \times 21 \times 24 \times 3600)$   
 $A_0 = 9.8 \times 10^6 \text{ Bq}$   
(alternative method uses 21 days as 0.404 half-lives)
- C1  
A1 [2]
- (ii)  $A = \lambda N$  and  $\text{mass} = N \times 89 / N_A$   
 $\text{mass} = (9.8 \times 10^6 \times 89) / (1.54 \times 10^{-7} \times 6.02 \times 10^{23})$   
 $= 9.4 \times 10^{-9} \text{ g}$
- C1  
A1 [2]

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## Section B

- 9 (a) e.g. infinite input impedance/resistance  
zero output impedance/resistance  
infinite (open loop) gain  
infinite bandwidth  
infinite slew rate  
(any four, one mark each) B4 [4]
- (b) graph: square wave M1  
180° phase change A1  
amplitude 5.0 V A1 [3]
- (c) correct symbol for LED M1  
diodes connected correctly between  $V_{OUT}$  and earth A1  
diodes identified correctly A1 [3]  
(special case: if diode symbol, not LED symbol, allow 2<sup>nd</sup> and 3<sup>rd</sup> marks to be scored)
- 10 (a) e.g. beam is divergent/obeys inverse square law  
absorption (in block)  
scattering (of beam in block)  
reflection (at boundaries)  
(any two sensible suggestions, 1 each) B2 [2]
- (b) (i)  $I = I_0 \exp(-\mu x)$  C1  
 $I_0/I = \exp(0.27 \times 2.4)$   
 $= 1.9$  A1 [2]
- (ii)  $I_0/I = \exp(0.27 \times 1.3) \times \exp(3.0 \times 1.1)$  C1  
 $= 1.42 \times 27.1$   
 $= 38.5$  A1 [2]
- (c) either much greater absorption in bone than in soft tissue  
or  $I_0/I$  much greater for bone than soft tissue B1 [1]
- 11 (a) (i) loss of (signal) power B1 [1]
- (ii) unwanted power (on signal)  
that is random M1  
A1 [2]
- (b) for digital, only the 'high' and the 'low' / 1 and 0 are necessary M1  
variation between 'highs' and 'lows' caused by noise not required A1 [2]
- (c) attenuation =  $10 \lg(P_2 / P_1)$  C1  
either  $195 = 10 \lg\{2.4 \times 10^3 / P\}$   
or  $-195 = 10 \lg(P / 2.4 \times 10^3)$  C1  
 $P = 7.6 \times 10^{-17} \text{ W}$  A1 [3]

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12 (a) (i)	modulator	B1	[1]
(ii)	serial-to-parallel converter ( <i>accept series-to-parallel converter</i> )	B1	[1]
(b) (i)	enables one aerial to be used for transmission and receipt of signals	A1	[1]
(ii)	all bits for one number arrive at one time	B1	
	bits are sent out one after another	B1	[2]