

**CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Level**

## **MARK SCHEME for the May/June 2014 series**

### **9702 PHYSICS**

**9702/42**

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

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### Section A

- 1 (a) gravitational force provides/is the centripetal force  
 $GMm/r^2 = mv^2/r$   
 $v = \sqrt{GM/r}$   
 allow gravitational field strength provides/is the centripetal acceleration  
 $GM/r^2 = v^2/r$
- (b) (i) kinetic energy increase/change = loss/change in (gravitational) potential energy  
 $\frac{1}{2}mV_0^2 = GMm/x$   
 $V_0^2 = 2GM/x$   
 $V_0 = \sqrt{2GM/x}$   
 (max. 2 for use of  $r$  not  $x$ )
- (ii)  $V_0$  is (always) greater than  $v$  (for  $x = r$ )  
 so stone could not enter into orbit
- (expressions in (a) and (b)(i) must be dimensionally correct)
- 2 (a) use of kelvin temperatures  
 both values of  $(V/T)$  correct (11.87),  $V/T$  is constant so pressure is constant  
 (allow use of  $n = 1$ . Do not allow other values of  $n$ .)
- (b) (i) work done =  $p\Delta V$   
 $= 4.2 \times 10^5 \times (3.87 - 3.49) \times 10^3 \times 10^{-6}$   
 $= 160 \text{ J}$
- (do not allow use of  $V$  instead of  $\Delta V$ )
- (ii) increase/change in internal energy = heating of system  
 + work done on system  
 $= 565 - 160$   
 $= 405 \text{ J}$
- (c) internal energy = sum of kinetic energy and potential energy /  $E_K + E_P$   
 no intermolecular forces  
 no potential energy (so  $\Delta U = \Delta E_K$ )
- 3 (a) resonance
- (b)  $Pt = mc \Delta\theta$   
 $750 \times 2 \times 60 = 0.28 \times c \times (98 - 25)$   
 $c = 4400 \text{ J kg}^{-1} \text{ K}^{-1}$   
 (use of  $\Delta\theta = 73 + 273$  max. 1/3)  
 (use of  $t = 2 \text{ s}$  not  $120 \text{ s}$  max. 2/3)

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- (c) e.g. some microwave leakage from the cooker  
e.g. container for the water is also heated  
(any sensible suggestion) B1 [1]
- 4 (a) (i)  $F_E = Q_1Q_2/4\pi\epsilon_0r^2$   
 $= 8.99 \times 10^9 \times (1.6 \times 10^{-19})^2 / (2.0 \times 10^{-15})^2$   
 $= 58 \text{ N}$  C1  
A1 [2]
- (ii)  $F_G = Gm_1m_2/r^2$   
 $= 6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2 / (2.0 \times 10^{-15})^2$   
 $= 4.7 \times 10^{-35} \text{ N}$  C1  
A1 [2]
- (b) (i) force of repulsion (much) greater than force of attraction  
must be some other force of attraction  
to hold nucleus together B1  
M1  
A1 [3]
- (Do not allow if  $F_G > F_E$  in (a) or one of the forces not calculated in (a))
- (ii) outside nucleus there is repulsion between protons B1  
*either* attractive force must act only in nucleus  
*or* if not short range, all nuclei would stick together B1 [2]
- 5 (a) only curve with decreasing gradient M1  
acceptable value near  $x = 0$  and does not reach zero A1 [2]
- (if graph line less than 4.0 cm do not allow A1 mark)  
(no credit if graph line has positive and negative values of  $V_H$ )
- (b) graph: from 0 to 2T, two cycles of a sinusoidal wave M1  
all peaks above 3.5 mV C1  
peaks at 4.95/5.0 mV (allow 4.8 mV to 5.2 mV) A1 [3]
- (c) e.m.f. induced in coil when magnetic field/flux is changing/cutting B1
- either* at each position, magnetic field does not vary  
so no e.m.f. is induced in the coil/no reading on the millivoltmeter  
*or* at each position, switch off current and take millivoltmeter reading  
*or* at each position, rapidly remove coil from field and take meter reading B1 [2]
- 6 (a) electric and magnetic fields normal to each other B1
- either* charged particle enters region normal to both fields  
*or* correct  $B$  direction w.r.t.  $E$  for zero deflection B1  
for no deflection,  $v = E/B$  B1 [3]
- (no credit if magnetic field region clearly not overlapping with electric field region)

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- (b) (i)  $m = Bqr/v$  C1  
 $= (640 \times 10^{-3} \times 1.6 \times 10^{-19} \times 6.2 \times 10^{-2}) / (9.6 \times 10^4)$  C1  
 $= 6.61 \times 10^{-26} \text{ kg}$  C1  
 $= (6.61 \times 10^{-26}) / (1.66 \times 10^{-27}) \text{ u}$   
 $= 40 \text{ u}$  A1 [4]
- (ii)  $q/m \propto 1/r$  or  $m$  constant and  $q \propto 1/r$  B1  
 $q/m$  for A is twice that for B B1  
ions in path A have (same mass but) twice the charge (of ions in path B) B1 [3]
- 7 (a) angle subtended at the centre of a circle B1  
by an arc equal in length to the radius B1 [2]
- (b) (i) arc = distance  $\times$  angle C1  
diameter =  $3.8 \times 10^5 \times 9.7 \times 10^{-6}$   
= 3.7 km A1 [2]
- (ii) Mars is (much) further from Earth/away (*answer must be comparative*) B1  
angle (at telescope is much) smaller B1 [2]
- 8 (a) photon energy =  $hc/\lambda$   
 $= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (590 \times 10^{-9})$  C1  
 $= 3.37 \times 10^{-19} \text{ J}$  C1
- number =  $(3.2 \times 10^{-3}) / (3.37 \times 10^{-19})$   
=  $9.5 \times 10^{15}$  (allow  $9.4 \times 10^{15}$ ) A1 [3]
- (b) (i)  $p = h/\lambda$  C1  
 $= (6.63 \times 10^{-34}) / (590 \times 10^{-9})$   
 $= 1.12 \times 10^{-27} \text{ kg ms}^{-1}$  C1
- total momentum =  $9.5 \times 10^{15} \times 1.12 \times 10^{-27}$   
=  $1.06 \times 10^{-11} \text{ kg ms}^{-1}$  A1 [3]
- (ii) force =  $1.06 \times 10^{-11} \text{ N}$  A1 [1]
- 9 (a) time for number of atoms/nuclei/activity (of the isotope) M1  
to be reduced to one half (of its initial value) A1 [2]
- (b) (i)  $A = \lambda N$  C1  
 $460 = N \times \ln 2 / (8.1 \times 24 \times 60 \times 60)$  C1  
 $N = 4.6 \times 10^8$  A1 [3]
- (ii) number of water molecules in 1.0 kg =  $(6.02 \times 10^{23}) / (18 \times 10^{-3})$  C1  
=  $3.3 \times 10^{25}$
- ratio =  $(3.3 \times 10^{25}) / (4.6 \times 10^8)$   
=  $7.2 (7.3) \times 10^{16}$  A1 [2]

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- (c)  $A = A_0 e^{-\lambda t}$  and  $\lambda t_{1/2} = \ln 2$  C1  
 $170 = 460 \exp(-\{\ln 2 t\}/8.1)$  C1  
 $t = 11.6$  days (allow 2 s.f.) A1 [3]

### Section B

- 10 (a) compares the potentials/voltages at the (inverting and non-inverting) inputs B1  
*either* output (potential) dependent on which input is the larger  
*or*  $V^+ > V^-$ , then  $V_{OUT}$  is positive B1  
states the other condition B1 [3]
- (b) (i) ring drawn around both the LEDs (and series resistors) B1 [1]
- (ii)  $V^- = (1.5 \times 2.4)/(1.2 + 2.4) = 1.0V$  B1 [1]  
(allow  $1.5 \times 2.4/3.6 = 1.0V$ )
- (iii) 1.  $V_{OUT}$  switches at  $+1.0V$  B1  
maximum  $V_{OUT}$  is  $5.0V$  B1  
when curve is above  $+1.0V$ ,  $V_{OUT}$  is negative (or v.v.) B1 [3]
2. at time  $t_1$ , diode R is emitting light, diode G is not emitting B1  
at time  $t_2$ , diode R is not emitting, diode G is emitting B1 [2]  
(must be consistent with graph line. If no graph line then 0/2)
- 11 (a) X-ray: flat/shadow/2D image B1  
regardless of depth of object/depth not indicated B1
- CT scan: built up from (many) images at different angles B1  
image is three-dimensional B1  
image can be rotated/viewed at different angles B1 [5]
- (b) (i)  $I = I_0 e^{-\mu x}$  C1  
 $0.25 = e^{-0.69x}$   
 $x = 2.0$  mm (allow 1 s.f.) A1 [2]
- (ii) for aluminium,  $I/I_0 = e^{-0.46 \times 2.4}$   
 $= 0.33$  C1  
fraction  $= 0.33 \times 0.25$   
 $= 0.083$  A1 [2]
- (iii) gain/dB  $= 10 \lg(I/I_0)$  C1  
 $= 10 \lg(0.083)$   
 $= (-) 10.8$  dB (allow 2 s.f.) A1  
with negative sign B1 [3]
- 12 (a) (i) satellite is in equatorial orbit B1  
travelling from west to east B1  
period of 24 hours/1 day B1 [3]

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- (ii) *either* uplink signal is highly attenuated  
*or* signal is highly amplified (before transmission) as downlink signal  
prevents downlink signal swamping the uplink signal B1 B1 [2]
- (b) speed of signal is same order of magnitude in both systems B1  
optic fibre link (much) shorter than via satellite M1  
time delay using optic fibre is less A1 [3]