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Cambridge International Advanced Subsidiary and Advanced Level

## **MARK SCHEME for the March 2016 series**

### **9702 PHYSICS**

**9702/42**

Paper 4 (A Level Structured Questions),  
maximum raw mark 100

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- 1 (a) force proportional to product of the (two) masses and inversely proportional to the square of their separation  
*either* reference to point masses *or* separation  $\ll$  'size' of masses M1  
A1 [2]
- (b) gravitational force provides/is the centripetal force B1  
 $GMm/r^2 = mv^2/r$  *or*  $GMm/r^2 = mr\omega^2$  *and*  $v = r\omega$   
and algebra leading to  $v = (GM/r)^{1/2}$  B1 [2]
- (c) (i) 1.  $v_A/v_B = (r_B/r_A)^{1/2}$   
 $= (2.2 \times 10^{10}/1.3 \times 10^8)^{1/2}$  C1  
 $= 13$  (13.0) A1 [2]
2.  $v = 2\pi r/T$  *or*  $v \propto r/T$  *or*  $vT/r = \text{constant}$  C1  
 $T_A/T_B = (r_A/r_B) \times (v_B/v_A)$   
 $= (1.3 \times 10^8/2.2 \times 10^{10}) \times (1/13)$  C1  
 $= 4.5$  (4.54)  $\times 10^{-4}$  A1
- or*
- $T^2 = 4\pi^2 r^3/GM$  *or*  $T^2 \propto r^3$  *or*  $T^2/r^3 = \text{constant}$  (C1)  
 $T_A/T_B = (r_A^3/r_B^3)^{1/2}$   
 $= [(1.3 \times 10^8)^3/(2.2 \times 10^{10})^3]^{1/2}$  (C1)  
 $= 4.5$  (4.54)  $\times 10^{-4}$  (A1) [3]
- (ii)  $T = 2\pi/1.7 \times 10^{-4}$   
 $= 3.70 \times 10^4$  s C1  
 $T_B = 3.70 \times 10^4/4.54 \times 10^{-4}$   
 $= 8.1 \times 10^7$  s A1 [2]  
If identifies  $T_A$  as  $T_B$  then 0/2
- 2 (a) (i) sum of kinetic and potential energy of atoms/molecules M1  
reference to random (distribution) A1 [2]
- (ii) no forces (of attraction or repulsion) between molecules B1 [1]
- (b)  $pV = NkT$  *or*  $pV = nRT$  *and*  $R = kN_A$ ,  $n = N/N_A$  B1  
 $\frac{1}{3} Nm\langle c^2 \rangle = NkT$  *or*  $\frac{1}{3} m\langle c^2 \rangle = kT$  B1  
 $\langle E_K \rangle = \frac{1}{2} m\langle c^2 \rangle$  so  $\langle E_K \rangle = \frac{3}{2} kT$  B1 [3]
- (c) (i)  $\langle E_K \rangle = \frac{3}{2} \times 1.38 \times 10^{-23} \times (273 + 12)$  C1  
 $= 5.9$  (5.90)  $\times 10^{-21}$  J A1 [2]
- (use of  $T = 12$  K *not*  $T = 285$  K scores 0/2)
- (ii) number =  $(17/32) \times 6.02 \times 10^{23}$  C1  
 $= 3.2$  (3.20)  $\times 10^{23}$  A1 [2]

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- (iii) internal energy =  $5.9 \times 10^{-21} \times 3.2 \times 10^{23}$   
= 1900 (1890)J A1 [1]
- 3 (a) the (thermal) energy per unit mass to raise the temperature of a substance by one degree M1  
A1 [2]
- (If ratio not clear for M1 mark, allow 1/2 marks for an otherwise correct answer)*
- (b) (i) to allow for/determine/cancel heat transfer to/from tube/surroundings B1 [1]
- (do not allow 'to stop/prevent' heat loss)*
- (ii) either  $P = mc\Delta\theta \pm h$   
or  $44.9 = 1.58 \times 10^{-3} \times c \times (25.5 - 19.5) \pm h$   
or  $33.3 = 1.11 \times 10^{-3} \times c \times (25.5 - 19.5) \pm h$  B1  
 $(44.9 - 33.3) = (1.58 - 1.11) \times 10^{-3} \times c \times (25.5 - 19.5)$  C1  
 $c = 4100$  (4110)  $\text{J kg}^{-1} \text{K}^{-1}$  A1 [3]
- (allow 1/3 for use of only 33.3 W, 1.11 g s<sup>-1</sup> leading to 5000 J kg<sup>-1</sup> K<sup>-1</sup>)*  
*(allow 1/3 for use of only 44.9 W, 1.58 g s<sup>-1</sup> leading to 4740 J kg<sup>-1</sup> K<sup>-1</sup>)*
- (c)  $V_0 = 27$  or  $V_{\text{rms}} = 19.1$  C1  
 $33.3 = 27^2/2R$  or  $33.3 = 19.1^2/R$  C1  
 $R = 11 \Omega$  A1 [3]
- 4 (a) amplitude = 1.8 cm and period = 0.30 s A1 [1]
- (b)  $E_K = \frac{1}{2}m \omega^2 (x_0^2 - x^2)$  or  $E_K = \frac{1}{2}mv^2$  and  $v = \pm \omega \sqrt{(x_0^2 - x^2)}$  C1  
=  $\frac{1}{2} \times 0.080 \times (2\pi/0.30)^2 \times [(1.8 \times 10^{-2})^2 - (1.2 \times 10^{-2})^2]$  C1  
=  $3.2 \times 10^{-3} \text{ J}$  A1 [3]
- 5 (a) (i) (series of) 'highs' and 'lows' / 'on' and 'off' / 1's and 0's / two values with no intermediate values / the values are discrete M1  
A1 [2]
- (ii) either use higher sampling frequency / rate  
or use more bits in each sample / each digital number  
or use more levels in each sample B1 [1]
- (b) voltage = 30 mV A1 [1]
- 6 (a) speed =  $Z/\rho$   
=  $1.4 \times 10^6/940$  (=1490) C1  
time =  $(1.1 \times 10^{-2} \times 2)/1490$  C1  
=  $1.5 \times 10^{-5} \text{ s}$  A1 [3]  
(time of  $7.4 \times 10^{-6} \text{ s}$  is one way only and scores 2/3 marks)  
(use of speed of light is wrong physics and scores 0/3 marks)

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- (b)  $I = I_0 \exp(-\mu x)$  or  $I_2 = I_1 \exp(-\mu x)$  C1  
ratio =  $\exp(-48 \times 1.1 \times 10^{-2})$   
= 0.59 A1 [2]
- (c)  $0.33/100 = 0.59 \times (I_3/I_2) \times 0.59$  C1  
ratio =  $9.5 \times 10^{-3}$  A1  
or  
 $0.33/100 = \exp(-48 \times 2.2 \times 10^{-2}) \times (I_3/I_2)$  (C1)  
ratio =  $9.5 \times 10^{-3}$  (A1) [2]
- (d) ratio  $I_3/I_2$  increases B1 [1]  
(accept: "there is an increase in the proportion of the intensity that is reflected")
- 7 (a) (capacitance =) charge/potential (difference) B1 [1]
- (b)  $V = V_1 + V_2 + V_3$  B1  
either  $Q/C = Q/C_1 + Q/C_2 + Q/C_3$  or  $V/Q = V_1/Q + V_2/Q + V_3/Q$   
and so  $1/C = 1/C_1 + 1/C_2 + 1/C_3$  B1 [2]
- (c) (i) 1.  $1/C_T = (1/200) + (1/600)$   
 $C_T = 150 \mu\text{F}$  A1 [1]
2.  $Q = CV$   
=  $150 \times 10^{-6} \times 12$  or  $600 \times 10^{-6} \times 3.0$  or  $200 \times 10^{-6} \times 9.0$   
=  $1.8 \times 10^{-3} \text{ C}$  A1 [1]
3.  $V = Q/C = 1.8 \times 10^{-3} / 600 \times 10^{-6}$  or  $V = [200 / (200 + 600)] \times 12$   
= 3(.0) V A1 [1]
- (ii) energy =  $\frac{1}{2}CV^2$  or energy =  $\frac{1}{2}QV$  and  $C = Q/V$  C1  
 $\frac{1}{2} \times C \times 3^2 = 2 \times \frac{1}{2} \times C \times V^2$  C1  
 $V = 2.1 \text{ V}$  A1 [3]
- 8 (a) decreases gain B1  
increases bandwidth/decreases distortion/increases (operating) stability B1 [2]
- (b) (i) additional resistor connected between 7.2 k $\Omega$  resistor and earth B1  
 $V^-$  joined to lower end of 7.2 k $\Omega$  resistor and  $V^+$  joined to  $V_{IN}$  B1 [2]
- (ii) either  $5 = 1 + (7.2/R)$  or  $5 = 1 + (7200/R)$  C1  
 $R = 1.8 \text{ k}\Omega$  A1 [2]
- (iii) horizontal line from (0, 8.0) to (1.8, 8.0) B1  
straight line from (1.8, 8.0) to (5.0, 0) B1 [2]
- (allow a tolerance of  $\pm \frac{1}{2}$  small square when marking the graph)

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- 9 (a) direction of force due to electric field opposite to force due to magnetic field  
electric field is up the page  
B1  
B1 [2]
- (b) force due to electric field = force due to magnetic field or  $Eq = Bqv$   
 $E = Bv$   
 $= 9.7 \times 10^{-2} \times 1.6 \times 10^5$   
 $= 1.6 (1.55) \times 10^4 \text{ V m}^{-1}$   
B1  
C1  
A1 [3]
- (c)  $q/m = v/Br$   
 $= 1.6 \times 10^5 / (9.7 \times 10^{-2} \times 4.0 \times 10^{-2})$   
 $= 4.1 (4.12) \times 10^7 \text{ C kg}^{-1}$   
C1  
C1  
A1 [3]
- (d) (i)  $m = (3 \times 1.60 \times 10^{-19}) / (4.12 \times 10^7)$   
 $m = 1.16 \times 10^{-26} / 1.66 \times 10^{-27}$   
 $= 7(.0) \text{ u (allow 7.1 u)}$   
C1  
A1 [2]
- (ii) 3 protons, 4 neutrons  
A1 [1]
- 10 (a) (i) change in flux linkage  $= 40 \times (5.0 - 3.0) \times 10^{-6}$   
 $= 8(.0) \times 10^{-5} \text{ Wb}$   
A1 [1]
- (ii) time taken  $= 8.0 \times 10^{-5} / 5.0 \times 10^{-4}$   
 $= 0.16 \text{ (s)}$   
C1  
speed  $= 3.0 \times 10^{-2} / 0.16$   
 $= 0.19 (0.188) \text{ m s}^{-1}$   
A1
- or
- $E = (\Delta\Phi / \Delta x) \times \text{speed}$   
speed  $= 5.0 \times 10^{-4} / (8.0 \times 10^{-5} / 3.0 \times 10^{-2})$   
 $= 0.19 (0.188) \text{ m s}^{-1}$   
(C1)  
(A1) [2]
- (b) a constant non-zero value of  $E$  from 0 to 3 cm and  
a different constant non-zero value of  $E$  from 3 to 6 cm  
 $E$  from 3–6 cm has the opposite sign to and larger value than  $E$  from 0–3 cm  
M1  
A1 [2]
- 11 (a) minimum frequency for electron(s) to be emitted (from surface)  
reference to frequency of electromagnetic radiation / photon  
M1  
A1
- or
- frequency causing emission of electron(s)  
from surface with zero kinetic energy  
reference to frequency of electromagnetic radiation / photon  
(M1)  
(A1) [2]

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- (b) (i) positive intercept on  $(1/\lambda)$ -axis (when extrapolated)  
straight line with positive gradient B1 [2]  
B1
- (ii) gradient =  $hc$  where  $c$  is the speed of light B1 [1]
- (iii) maximum kinetic energy when electron emitted from surface  
energy is required to bring an electron to the surface B1 [2]  
B1
- (iv) each photon has more energy M1  
fewer photons per unit time M1  
fewer electrons per unit time / less current A1 [3]
- 12 (a) (i) the penetration of the beam B1 [1]
- (ii) *either* decrease the accelerating voltage  
*or* decrease voltage between cathode and anode B1 [1]
- (b) advantage: image gives depth / image is 3D / final image can be  
viewed from any angle B1  
disadvantage: greater exposure / more risk to health / more expensive /  
person must remain stationary B1 [2]
- 13 (a)  $\lambda = \ln 2 / T_{1/2}$   
 $= \ln 2 / (53.3 \times 24 \times 60 \times 60) = 1.5 \times 10^{-7} \text{ s}^{-1}$  A1 [1]
- (b)  $A = \lambda N$  C1  
 $N = 39 \times 10^{-3} / 1.5 \times 10^{-7} = 2.6 \times 10^5$   
 $m = (2.6 \times 10^5 / 6.0 \times 10^{23}) \times 7 \times 10^{-3}$  *or*  $2.6 \times 10^5 \times 1.66 \times 10^{-27} \times 7$  C1  
 $= 3.0 \times 10^{-21} \text{ kg}$  A1 [3]
- (c)  $2/39 = \exp(-1.5 \times 10^{-7} \times t)$  *or*  $2/39 = (1/2)^{[t/(53.3 \times 24 \times 3600)]}$  C1  
 $t = 2.0 \times 10^7 \text{ s}$  A1 [2]