

## **MARK SCHEME for the May/June 2013 series**

### **9702 PHYSICS**

**9702/42**

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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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### Section A

- 1 (a) equatorial orbit / above equator B1  
 satellite moves from west to east / same direction as Earth spins B1  
 period is 24 hours / same period as spinning of Earth B1 [3]  
*(allow 1 mark for 'appears to be stationary/overhead' if none of above marks scored)*
- (b) gravitational force provides/is the centripetal force B1  
 $GMm/R^2 = mR\omega^2$  or  $GMm/R^2 = mv^2/R$  M1  
 $\omega = 2\pi/T$  or  $v = 2\pi R/T$  or clear substitution M1  
 clear working to give  $R^3 = (GMT^2/4\pi^2)$  A1 [4]
- (c)  $R^3 = 6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times (24 \times 3600)^2 / 4\pi^2$  C1  
 $= 7.57 \times 10^{22}$  C1  
 $R = 4.2 \times 10^7$  m A1 [3]  
*(missing out 3600 gives  $1.8 \times 10^5$  m and scores 2/3 marks)*
- 2 (a) (i) 1.  $pV = nRT$   
 $1.80 \times 10^{-3} \times 2.60 \times 10^5 = n \times 8.31 \times 297$  C1  
 $n = 0.19$  mol A1 [2]
2.  $\Delta q = mc\Delta T$   
 $95.0 = 0.190 \times 12.5 \times \Delta T$  B1  
 $\Delta T = 40$  K A1 [2]  
*(allow 2 marks for correct answer with clear logic shown)*
- (ii)  $p/T = \text{constant}$   
 $(2.6 \times 10^5) / 297 = p / (297 + 40)$  M1  
 $p = 2.95 \times 10^5$  Pa A0 [1]
- (b) change in internal energy is 120 J / 25 J B1  
 internal energy decreases /  $\Delta U$  is negative / kinetic energy of molecules decreases M1  
 so temperature lower A1 [3]

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- 3 (a) (i)  $\omega = 2\pi / T$   
 $= 2\pi / 0.69$   
 $= 9.1 \text{ rad s}^{-1}$   
 (allow use of  $f = 1.5 \text{ Hz}$  to give  $\omega = 9.4 \text{ rad s}^{-1}$ )  
 C1  
 A1 [2]
- (ii) 1.  $x = 2.1 \cos 9.1t$   
 2.1 and 9.1 numerical values  
 use of cos  
 B1  
 B1 [2]
2.  $v_0 = 2.1 \times 10^{-2} \times 9.1$  (allow ecf of value of  $x_0$  from (ii)1.)  
 $= 0.19 \text{ m s}^{-1}$   
 $v = v_0 \sin 9.1t$  (allow  $\cos 9.1t$  if  $\sin$  used in (ii)1.)  
 B1  
 B1 [2]
- (b) energy = either  $\frac{1}{2} mv_0^2$  or  $\frac{1}{2} m\omega^2 x_0^2$   
 $= \text{either } \frac{1}{2} \times 0.078 \times 0.19^2 \text{ or } \frac{1}{2} \times 0.078 \times 9.1^2 \times (2.1 \times 10^{-2})^2$   
 $= 1.4 \times 10^{-3} \text{ J}$   
 C1  
 A1 [2]
- 4 (a) (i)  $V = q / 4\pi\epsilon_0 R$   
 B1 [1]
- (ii) (capacitance is) ratio of charge and potential or  $q/V$   
 $C = q/V = 4\pi\epsilon_0 R$   
 M1  
 A0 [1]
- (b) (i)  $C = 4\pi \times 8.85 \times 10^{-12} \times 0.45$   
 $= 50 \text{ pF}$   
 C1  
 A1 [2]
- (ii) either energy =  $\frac{1}{2} CV^2$  or energy =  $\frac{1}{2} QV$  and  $Q = CV$   
 energy of spark =  $\frac{1}{2} \times 50 \times 10^{-12} \{(9.0 \times 10^5)^2 - (3.6 \times 10^5)^2\}$   
 $= 17 \text{ J}$   
 C1  
 C1  
 A1 [3]
- 5 (a) (uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A  
 (creates) force per unit length of  $1 \text{ N m}^{-1}$   
 M1  
 A1 [2]
- (b) (i) sketch: concentric circles  
 increasing separation (*must show more than 3 circles*)  
 correct direction (anticlockwise, looking down)  
 M1  
 A1  
 B1 [3]
- (ii)  $B = (4\pi \times 10^{-7} \times 6.3) / (2\pi \times 4.5 \times 10^{-2})$   
 $= 2.8 \times 10^{-5} \text{ T}$   
 C1  
 A1 [2]
- (iii)  $F = BIL (\sin\theta)$   
 $= 2.8 \times 10^{-5} \times 9.3 \times 1$   
 $F/L = 2.6 \times 10^{-4} \text{ N m}^{-1}$   
 C1  
 A1 [2]
- (c) force per unit length depends on product  $I_x I_y$  / by Newton's third law / action and reaction are equal and opposite  
 so same for both  
 M1  
 A1 [2]

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- 6 (a) (induced) e.m.f. proportional to rate  
of change of (magnetic) flux (linkage) M1  
A1 [2]
- (b) (i) positive terminal identified (upper connection to load) B1 [1]
- (ii)  $V_P = \sqrt{2} \times V_{RMS}$   
ratio =  $240 \sqrt{2} / 9$   
= 38 C1  
C1  
A1 [3]  
( $V_P = V_{RMS} / \sqrt{2}$  gives ratio = 18.9 and scores 1/3)  
(ratio =  $240 / 9 = 26.7$  scores 1/3)  
(ratio =  $9 / (240 / \sqrt{2}) = 0.0265$  is inverted ratio and scores 1/3)
- (c) (i) e.g. (output) p.d. / voltage / current does not fall to zero  
e.g. range of (output) p.d. / voltage / current is reduced (*any sensible answer*) B1 [1]
- (ii) sketch: same peak value at start of discharge M1  
correct shape between one peak and the next A1 [2]
- 7 (a) each wavelength is associated with a discrete change in energy M1  
discrete energy change / difference implies discrete levels A1 [2]
- (b) (i) 1. arrow from  $-0.54$  eV to  $-0.85$  eV, labelled L B1 [1]
2. arrow from  $-0.54$  eV to  $-3.4$  eV, labelled S B1 [1]  
(two correct arrows, but only one label – allow 2 marks)  
(two correct arrows, but no labels – allow 1 mark)
- (ii)  $E = hc / \lambda$  C1  
 $(3.4 - 0.54) \times 1.6 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.0 \times 10^8) / \lambda$  C1  
 $\lambda = 4.35 \times 10^{-7}$  m A1 [3]
- (c)  $-1.50 \rightarrow -3.4 = 1.9$  eV  
 $-0.85 \rightarrow -3.4 = 2.55$  eV (allow 2.6 eV)  
 $-0.54 \rightarrow -3.4 = 2.86$  eV (allow 2.9 eV)  
3 correct, 2 marks with –1 mark for each additional energy  
2 correct, 1 mark but no marks if any additional energy differences B2 [2]

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- 8 (a) energy is given out / released on formation of the  $\alpha$ -particle (or reverse argument) M1  
either  $E = mc^2$  so mass is less  
or reference to mass-energy equivalence A1 [2]
- (b) (i) mass change =  $18.00567 \text{ u} - 18.00641 \text{ u}$  C1  
=  $7.4 \times 10^{-4} \text{ u}$  (*sign not required*) A1 [2]
- (ii) energy =  $c^2 \Delta m$   
=  $(3.0 \times 10^8)^2 \times 7.4 \times 10^{-4} \times 1.66 \times 10^{-27}$  C1  
=  $1.1 \times 10^{-13} \text{ J}$  A1 [2]  
(*allow use of u =  $1.67 \times 10^{-27} \text{ kg}$* )  
(*allow method based on 1u equivalent to 930 MeV to 933 MeV*)
- (iii) *either* mass of products greater than mass of reactants M1  
this mass/energy provided as kinetic energy of the helium-4 nucleus A1  
*or* both nuclei positively charged (M1)  
energy required to overcome electrostatic repulsion (A1) [2]

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### Section B

- 9 (a) 30 litres → 54 litres (*allow ± 4 litres on both limits*) A1 [1]
- (b) (i) only 0.1 V change in reading for 10 litre consumption (*or similar numbers*) B1  
above about 60 litres gradient is small compared to the gradient at about 40 litres B1 [2]
- (ii) voltmeter reading (nearly) zero when fuel is left C1  
voltmeter reads only about 0.1 V when 10 litres of fuel left in tank A1 [2]  
(*“voltmeter reads zero when about 4 litres of fuel left in tank” scores 2 marks*)
- 10 (a) product of density and speed of sound / wave M1  
(density of medium and) speed of sound / wave in medium A1 [2]
- (b) if  $(Z_1 - Z_2)$  is small, mostly transmission M1  
if  $(Z_1 - Z_2)$  is large, mostly reflection M1  
(*if ‘mostly’ not stated allow 1/2 marks for these first two marks*)  
either reflection / transmission also depends on  $(Z_1 + Z_2)$   
or intensity reflection coefficient =  $(Z_1 - Z_2)^2 / (Z_1 + Z_2)^2$  A1 [3]
- (c) e.g. smaller structures can be distinguished B1  
because better resolution at shorter wavelength / higher frequency B1 [2]
- 11 (a) changing voltage changes energy / speed of electrons M1  
changing electron energy changes maximum X-ray photon energy A1 [2]
- (b) (i) 1. loss of power / energy / intensity B1 [1]  
2. intensity changes when beam not parallel C1  
decreases when beam is divergent A1 [2]
- (ii) ratio =  $(\exp \{-2.9 \times 2.5\}) / (\exp \{-0.95 \times 6.0\})$  C1  
= 0.21 (*min. 2 sig. fig.*) A1 [2]  
(*values of both lengths incorrect by factor of  $10^{-2}$  to give ratio of 0.985 scores 1 mark*)

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**12 (a)** takes all the simultaneous digits for one number  
and ‘sends’ them one after another (along the transmission line) B1  
B1 [2]

**(b) (i)** 0111 A1 [1]

**(ii)** 0110 A1 [1]

**(c)** levels shown

<i>t</i>	0	0.2	0.4	0.6	0.8	1.0	1.2
	0	8	7	15	6	5	8

*(–1 for each error or omission)*

correct basic shape of graph i.e. series of steps  
with levels staying constant during correct time intervals  
*(vertical lines in steps do not need to be shown)*

A2  
M1  
A1 [4]

**(d)** increasing number of bits reduces step height M1  
increasing sampling frequency reduces step depth / width M1  
reproduction of signal is more exact A1 [3]