

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

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

### **9702 PHYSICS**

**9702/41**

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

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### Section A

- 1 (a) region of space area / volume where a mass experiences a force B1 B1 [2]
- (b) (i) force proportional to product of two masses M1  
force inversely proportional to the square of their separation M1  
*either* reference to point masses *or* separation  $\gg$  'size' of masses A1 [3]
- (ii) field strength =  $GM / x^2$  **or** field strength  $\propto 1 / x^2$  C1  
ratio =  $(7.78 \times 10^8)^2 / (1.5 \times 10^8)^2$  C1  
= 27 A1 [3]
- (c) (i) *either* centripetal force =  $mR\omega^2$  and  $\omega = 2\pi / T$  B1  
*or* centripetal force =  $mv^2 / R$  and  $v = 2\pi R / T$  B1  
gravitational force provides the centripetal force M1  
*either*  $GMm / R^2 = mR\omega^2$  *or*  $GMm / R^2 = mv^2 / R$  A0 [3]  
 $M = 4\pi^2 R^3 / GT^2$   
(allow working to be given in terms of acceleration)
- (ii)  $M = \{4\pi^2 \times (1.5 \times 10^{11})^3\} / \{6.67 \times 10^{-11} \times (3.16 \times 10^7)^2\}$  C1  
=  $2.0 \times 10^{30}$  kg A1 [2]
- 2 (a) obeys the equation  $pV = \text{constant} \times T$  *or*  $pV = nRT$  M1  
 $p$ ,  $V$  and  $T$  explained A1  
at all values of  $p$ ,  $V$  and  $T$ /fixed mass/ $n$  is constant A1 [3]
- (b) (i)  $3.4 \times 10^5 \times 2.5 \times 10^3 \times 10^{-6} = n \times 8.31 \times 300$  M1  
 $n = 0.34$  mol A0 [1]
- (ii) for total mass/amount of gas  
 $3.9 \times 10^5 \times (2.5 + 1.6) \times 10^3 \times 10^{-6} = (0.34 + 0.20) \times 8.31 \times T$  C1  
 $T = 360$  K A1 [2]
- (c) when tap opened B1  
gas passed (from cylinder B) to cylinder A M1  
work done on gas in cylinder A (and no heating) A1 [3]  
so internal energy and hence temperature increase

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- 3 (a) (i) 1. amplitude = 1.7 cm A1 [1]
2. period = 0.36 cm C1  
frequency = 1/0.36 A1 [2]  
= 2.8 Hz
- (ii)  $a = (-)\omega^2 x$  and  $\omega = 2\pi/T$  C1  
acceleration =  $(2\pi/0.36)^2 \times 1.7 \times 10^{-2}$  M1  
=  $5.2 \text{ m s}^{-2}$  A0 [2]
- (b) graph: straight line, through origin, with negative gradient M1  
from  $(-1.7 \times 10^{-2}, 5.2)$  to  $(1.7 \times 10^{-2}, -5.2)$  A1 [2]  
*(if scale not reasonable, do not allow second mark)*
- (c) either kinetic energy =  $\frac{1}{2}m\omega^2(x_0^2 - x^2)$  B1  
or potential energy =  $\frac{1}{2}m\omega^2 x^2$  and potential energy = kinetic energy C1  
 $\frac{1}{2}m\omega^2(x_0^2 - x^2) = \frac{1}{2} \times \frac{1}{2}m\omega^2 x_0^2$  or  $\frac{1}{2}m\omega^2 x^2 = \frac{1}{2} \times \frac{1}{2}m\omega^2 x_0^2$   
 $x_0^2 = 2x^2$   
 $x = x_0 / \sqrt{2} = 1.7 / \sqrt{2}$   
= 1.2 cm A1 [3]
- 4 (a) work done moving unit positive charge M1  
from infinity (to the point) A1 [2]
- (b) (gain in) kinetic energy = change in potential energy B1  
 $\frac{1}{2}mv^2 = qV$  leading to  $v = (2Vq/m)^{1/2}$  B1 [2]
- (c) either  $(2.5 \times 10^5)^2 = 2 \times V \times 9.58 \times 10^7$  C1  
 $V = 330 \text{ V}$  M1  
this is less than 470 V and so 'no' A1 [3]
- or  $v = (2 \times 470 \times 9.58 \times 10^7)^{1/2}$  (C1)  
 $v = 3.0 \times 10^5 \text{ m s}^{-1}$  (M1)  
this is greater than  $2.5 \times 10^5 \text{ m s}^{-1}$  and so 'no' (A1)
- or  $(2.5 \times 10^5)^2 = 2 \times 470 \times (q/m)$  (C1)  
 $(q/m) = 6.6 \times 10^7 \text{ C kg}^{-1}$  (M1)  
this is less than  $9.58 \times 10^7 \text{ C kg}^{-1}$  and so 'no' (A1)

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- 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) flux density  $= 4\pi \times 10^{-7} \times 1.5 \times 10^3 \times 3.5$   
 $= 6.6 \times 10^{-3} \text{ T}$  C1  
A1 [2]
- (ii) flux linkage  $= 6.6 \times 10^{-3} \times 28 \times 10^{-4} \times 160$   
 $= 3.0 \times 10^{-3} \text{ Wb}$  C1  
A1 [2]
- (c) (i) (induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) M1  
A1 [2]
- (ii) e.m.f.  $= (2 \times 3.0 \times 10^{-3}) / 0.80$   
 $= 7.4 \times 10^{-3} \text{ V}$  C1  
A1 [2]
- 6 (a) (i) to reduce power loss in the core due to eddy currents/induced currents B1  
B1 [2]
- (ii) *either* no power loss in transformer  
*or* input power = output power B1 [1]
- (b) *either* r.m.s. voltage across load  $= 9.0 \times (8100 / 300)$   
peak voltage across load  $= \sqrt{2} \times 243$   
 $= 340 \text{ V}$  C1  
A1 [2]
- or* peak voltage across primary coil  $= 9.0 \times \sqrt{2}$   
peak voltage across load  $= 12.7 \times (8100/300)$   
 $= 340 \text{ V}$  (C1)  
(A1)
- 7 (a) (i) lowest frequency of e.m. radiation giving rise to emission of electrons (from the surface) M1  
A1 [2]
- (ii)  $E = hf$  C1  
threshold frequency  $= (9.0 \times 10^{-19}) / (6.63 \times 10^{-34})$   
 $= 1.4 \times 10^{15} \text{ Hz}$  A1 [2]
- (b) *either*  $300 \text{ nm} \equiv 10 \times 10^{15} \text{ Hz}$  (and  $600 \text{ nm} \equiv 5.0 \times 10^{14} \text{ Hz}$ )  
*or*  $300 \text{ nm} \equiv 6.6 \times 10^{-19} \text{ J}$  (and  $600 \text{ nm} \equiv 3.3 \times 10^{-19} \text{ J}$ )  
*or* zinc  $\lambda_0 = 340 \text{ nm}$ , platinum  $\lambda_0 = 220 \text{ nm}$  (and sodium  $\lambda_0 = 520 \text{ nm}$ )  
emission from sodium and zinc M1  
A1 [2]
- (c) each photon has larger energy M1  
fewer photons per unit time M1  
fewer electrons emitted per unit time A1 [3]

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- 8 (a) two (light) nuclei combine to form a more massive nucleus M1  
A1 [2]
- (b) (i)  $\Delta m = (2.01410 \text{ u} + 1.00728 \text{ u}) - 3.01605 \text{ u}$   
 $= 5.33 \times 10^{-3} \text{ u}$   
energy  $= c^2 \times \Delta m$  C1  
 $= 5.33 \times 10^{-3} \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$  C1  
 $= 8.0 \times 10^{-13} \text{ J}$  A1 [3]
- (ii) speed/kinetic energy of proton and deuterium must be very large so that the nuclei can overcome electrostatic repulsion B1  
B1 [2]

### Section B

- 9 (a) (i) light-dependent resistor/LDR B1 [1]
- (ii) strain gauge B1 [1]
- (iii) quartz/piezo-electric crystal B1 [1]
- (b) (i) resistance of thermistor decreases as temperature increases M1  
*either*  $V_{\text{OUT}} = V \times R / (R + R_T)$   
or current increases and  $V_{\text{OUT}} = IR$  A1  
 $V_{\text{OUT}}$  increases A1 [3]
- (ii) *either* change in  $R_T$  with temperature is non-linear  
or  $V_{\text{OUT}}$  is not proportional to  $R_T$ / change in  $V_{\text{OUT}}$  with  $R_T$  is non-linear so change is non-linear M1  
A1 [2]
- 10 (a) sharpness: how well the edges (of structures) are defined B1  
contrast: difference in (degree of) blackening between structures B1 [2]
- (b) e.g. scattering of photos in tissue/no use of a collimator/no use of lead grid  
large penumbra on shadow/large area anode/wide beam  
large pixel size  
(any two sensible suggestions, 1 each) B2 [2]
- (c) (i)  $I = I_0 e^{-\mu x}$  C1  
ratio  $= \exp(-2.85 \times 3.5) / \exp(-0.95 \times 8.0)$  C1  
 $= (4.65 \times 10^{-5}) / (5.00 \times 10^{-4})$   
 $= 0.093$  A1 [3]
- (ii) *either* large difference (in intensities)  
or ratio much less than 1.0  
so good contrast M1  
A1 [2]
- (answer given in (c)(ii) must be consistent with ratio given in (c)(i))

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- 11 (a) (i) amplitude of the carrier wave varies  
(in synchrony) with the displacement of the information signal M1  
A1 [2]
- (ii) e.g. more than one radio station can operate in same region/less interference  
enables shorter aerial  
increased range/less power required/less attenuation  
less distortion  
(any two sensible answers, 1 each) B2 [2]
- (b) (i) frequency = 909 kHz C1  
wavelength =  $(3.0 \times 10^8) / (909 \times 10^3)$   
= 330 m A1 [2]
- (ii) bandwidth = 18 kHz A1 [1]
- (iii) frequency = 9000 Hz A1 [1]
- 12 (a) for received signal,  $28 = 10 \lg(P / \{0.36 \times 10^{-6}\})$  C1  
 $P = 2.3 \times 10^{-4} \text{ W}$  A1 [2]
- (b) loss in fibre =  $10 \lg(\{9.8 \times 10^{-3}\} / \{2.27 \times 10^{-4}\})$  C1  
= 16 dB A1 [2]
- (c) attenuation per unit length = 16 / 85  
= 0.19 dB km<sup>-1</sup> A1 [1]