

**CAMBRIDGE INTERNATIONAL EXAMINATIONS**

Cambridge International Advanced Subsidiary and Advanced Level

## **MARK SCHEME for the October/November 2014 series**

### **9702 PHYSICS**

**9702/41**

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

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### Section A

- 1 (a)  $g = GM/R^2$   
 $= (6.67 \times 10^{-11} \times 6.4 \times 10^{23}) / (3.4 \times 10^6)^2 = 3.7 \text{ N kg}^{-1}$  C1  
A1 [2]
- (b)  $\Delta E_P = mg\Delta h$   
because  $\Delta h \ll R$  (or  $1800 \text{ m} \ll 3.4 \times 10^6 \text{ m}$ )  $g$  is constant B1  
 $\Delta E_P = 2.4 \times 3.7 \times 1800$  C1  
 $= 1.6 \times 10^4 \text{ J}$  A1 [3]  
*(use of  $g = 9.8 \text{ m s}^{-2}$  max. 1 for explanation)*
- (c) gravitational potential energy  $= (-)GMm/x$  C1  
 $v^2 = 2GM/x$  C1  
 $x = 4D = 4 \times 6.8 \times 10^6$  C1  
 $v^2 = (2 \times 6.67 \times 10^{-11} \times 6.4 \times 10^{23}) / (4 \times 6.8 \times 10^6)$   
 $= 3.14 \times 10^6$   
 $v = 1.8 \times 10^3 \text{ m s}^{-1}$  A1 [4]  
*(use of 3.5D giving  $1.9 \times 10^3 \text{ m s}^{-1}$ , allow max. 3)*
- 2 (a) (i)  $F = R \cos \theta$  M1  
 $W = R \sin \theta$  M1  
dividing,  $W = F \tan \theta$  A0 [2]  
*(max. 1 if derivation to final line not shown)*
- (ii) provides the centripetal force B1 [1]
- (b) either  $F = mv^2/r$  and  $W = mg$   
or  $v^2 = rg/\tan \theta$  C1  
 $v^2 = (14 \times 10^{-2} \times 9.8) / \tan 28^\circ$  C1  
 $= 2.58$   
 $v = 1.6 \text{ m s}^{-1}$  A1 [3]
- 3 (a) obeys the equation  $pV/T = \text{constant}$  B1 [1]  
*(accept  $pV = nRT$ )*
- (b) (i)  $pV = nRT$  C1  
 $5.0 \times 10^7 \times 3.0 \times 10^{-4} = n \times 8.31 \times 296$  giving  $n = 6.1 \text{ mol}$  A1 [2]
- (ii) pressure  $\propto$  amount of substance  
loss  $= 0.40/100 \times 6.1 \text{ mol} = 0.0244 \text{ mol}$  C1  
 $= 0.0244 \times 6.02 \times 10^{23}$  (atoms) C1  
 $= 1.47 \times 10^{22}$  atoms C1  
rate  $= (1.47 \times 10^{22}) / (35 \times 24 \times 60 \times 60)$   
 $= 4.9 \times 10^{15} \text{ s}^{-1}$  A1 [4]

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- 4 (a) acceleration / force proportional to displacement (from a fixed point)  
*either* acceleration and displacement in opposite directions  
*or* acceleration always directed towards a fixed point
- M1  
A1 [2]
- (b) (i)  $g$  and  $r$  are constant so  $a$  is proportional to  $x$   
negative sign shows  $a$  and  $x$  are in opposite directions
- B1  
B1 [2]
- (ii)  $\omega^2 = g/r$  and  $\omega = 2\pi/T$   
 $\omega^2 = 9.8/0.28$   
 $= 35$   
 $T = 2\pi/\sqrt{35} = 1.06 \text{ s}$   
time interval  $\tau = 0.53 \text{ s}$
- C1  
C1  
A1 [3]
- (c) sketch: time period constant (or increases very slightly)  
drawn line always 'inside' given loops  
successive decrease in peak height
- M1  
A1  
A1 [3]
- 5 (a) work done in moving unit positive charge  
from infinity (to the point)
- M1  
A1 [2]
- (b) (i) inside the sphere, the potential would be constant
- B1 [1]
- (ii) for point charge,  $V_x$  is constant  
co-ordinates clear and determines two values of  $V_x$  at least 4 cm apart  
conclusion made clear
- B1  
M1  
A1 [3]
- (c)  $q = 4\pi\epsilon_0 V_x$   
 $q = 4\pi \times 8.85 \times 10^{-12} \times 180 \times 1.0 \times 10^{-2}$   
 $= 2.0 \times 10^{-10} \text{ C}$
- M1  
A1 [2]
- 6 (a)  $F = BIL \sin \theta$   
 $= 2.6 \times 10^{-3} \times 5.4 \times 4.7 \times 10^{-2} \times \sin 34^\circ$   
 $= 3.69 \times 10^{-4} \text{ N}$   
*(allow 1 mark for use of  $\cos 34^\circ$ )*
- C1  
A1 [2]
- (b) peak current  $= 1.7 \times \sqrt{2}$   
 $= 2.4 \text{ A}$
- C1
- max. force  $= 2.6 \times 10^{-3} \times 2.4 \times 4.7 \times 10^{-2} \times \sin 34^\circ$   
 $= 1.64 \times 10^{-4} \text{ N}$
- C1
- variation  $= 2 \times 1.64 \times 10^{-4}$   
 $= 3.3 \times 10^{-4} \text{ N}$
- A1 [3]

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- 7 (a) (i) *either* heating effect in a resistor  $\propto$  (current)<sup>2</sup> B1  
square of value of an alternating current is always positive B1  
so heating effect A0  
*or* current moves in opposite directions in resistor during half-cycles (B1)  
heating effect is independent of direction (B1) [2]
- (ii) that value of the direct current M1  
producing the same heating effect (as the alternating current) in a resistor A1 [2]
- (b) (i) induced e.m.f. proportional to the rate M1  
of change of (magnetic) flux (linkage) A1 [2]
- (ii) flux in core is in phase with current in the primary coil B1  
(induced) e.m.f. in secondary because coil cuts the flux B1  
flux and rate of change of flux are not in phase B1 [3]
- 8 (a) photon 'absorbed' by electron B1  
photon has energy equal to difference in energy of two energy levels B1  
electron de-excites emitting photon (of same energy) in any direction B1 [3]
- (b) (i)  $E = hc/\lambda$  C1  
 $= (6.63 \times 10^{-34} \times 3 \times 10^8)/(435 \times 10^{-9})$  C1  
 $= 4.57 \times 10^{-19} \text{ J (allow 2 s.f.)}$  C1  
 $= (4.57 \times 10^{-19})/(1.6 \times 10^{-19}) \text{ (eV)}$   
 $= 2.86 \text{ eV (allow 2 s.f.)}$  A1 [4]
- (ii) arrow pointing in either direction between  $-3.41 \text{ eV}$  and  $-0.55 \text{ eV}$  B1 [1]
- 9 (a) 'light' nuclei combine to form 'heavier' nuclei B1 [1]
- (b) (i) *either* energy =  $c^2\Delta m$   
*or* energy =  $(3.00 \times 10^8)^2 \times 1.66 \times 10^{-27}$  C1  
energy =  $1.494 \times 10^{-10} \text{ J}$  C1  
 $= (1.494 \times 10^{-10})/(1.60 \times 10^{-13})$   
 $= 934 \text{ MeV (3 s.f.)}$  A1 [3]
- (ii)  $\Delta m = (2.01356 + 3.01551) - (4.00151 + 1.00867)$   
 $= 5.02907 - 5.01018$   
 $= 0.01889 \text{ u}$  C1
- energy =  $0.01889 \times 934$   
 $= 17.6 \text{ MeV (allow 2 s.f.)}$  A1 [2]
- (iii) high temperature means high speeds/kinetic energy of nuclei B1  
D and T nuclei collide despite repelling one another B1 [2]

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### Section B

- 10 (a)** e.g. zero output resistance/impedance  
infinite bandwidth  
infinite slew rate  
1 mark each, max. 3 B3 [3]
- (b) (i)** at 1.0 °C, thermistor resistance is 3.7 kΩ  
amplifier gain =  $-R/740 = -3700/740$  (*negative sign essential*)  
= -5.0 B1  
C1  
C1
- potential =  $1.0/-5.0 = -0.20\text{ V}$  A1 [4]
- (ii)** at 15 °C,  $R = 2.15\text{ k}\Omega$  (*allow  $\pm 0.05\text{ k}\Omega$* )  
reading =  $(2150/740) \times 0.2$   
= 0.58 V (0.59 V → 0.57 V) C1  
A1 [2]
- (c) (i)** 0.68 V A1 [1]
- (ii)** resistance (of thermistor) does not change linearly with temperature B1 [1]
- 11 (a)** X-ray beam contains many wavelengths B1  
aluminium filter absorbs long wavelength X-ray radiation M1  
that would be absorbed by the body (and not contribute to the image) A1 [3]
- (b)** CT scan consists of (many) X-ray images of a slice M1  
and there are many slices A1  
X-ray image is a single exposure B1  
(so much) greater exposure with CT scan B1 [4]
- 12 (a) (i)** e.g. satellite communication, mobile phones, line of sight communication, wifi B1 [1]
- (ii)** e.g. connection of TV to aerial, loudspeaker, microphone (if clearly identified) B1 [1]
- (iii)** e.g. a.f. amplifier to loudspeaker, landline for phone B1 [1]
- (b) (i)** attenuation/dB =  $10 \lg (P_2/P_1)$  C1  
 $-190 = 10 \lg (P_2/3.1)$   
 $P_2 = 3.1 \times 10^{-19}\text{ kW}$  A1 [2]
- (ii)** signal is amplified M1  
frequency is changed M1  
to prevent swamping of up-link signal by down-link (signal) A1 [3]

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- 13 (a) *either* for transmission and reception of signal  
*or* switching between transmitted and received signals M1  
*either* so that one aerial may be used  
*or* so that transmission and reception can occur in quick succession A1 [2]
- (b) gives large signal for one (input) frequency M1  
(and) rejects/very small signal for all other frequencies A1 [2]