

**MARK SCHEME for the October/November 2012 series**

**9702 PHYSICS**

**9702/43**

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

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Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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Section A

- 1 (a) (i) number of molecules B1
- (ii) mean square speed B1 [1]
- (b) (i) 1.  $pV = nRT$  C1  
 $n = (6.1 \times 10^5 \times 2.1 \times 10^4 \times 10^{-6}) / (8.31 \times 285)$  C1  
 $n = 5.4 \text{ mol}$  A1 [3]
2. either  $N = nN_A$  C1  
 $= 5.4 \times 6.02 \times 10^{23}$  A1  
 $= 3.26 \times 10^{24}$
- or  
 $pV = NkT$  C1  
 $N = (6.1 \times 10^5 \times 2.1 \times 10^4 \times 10^{-6}) / (1.38 \times 10^{-23} \times 285)$  (C1)  
 $N = 3.26 \times 10^{24}$  (A1) [2]
- (ii) either  $6.1 \times 10^5 \times 2.1 \times 10^{-2} = \frac{1}{3} \times 3.25 \times 10^{24} \times 4 \times 1.66 \times 10^{-27} \times \langle c^2 \rangle$  C1  
 $\langle c^2 \rangle = 1.78 \times 10^6$  C1  
 $c_{\text{RMS}} = 1.33 \times 10^3 \text{ m s}^{-1}$  A1
- or  
 $\frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times \langle c^2 \rangle = \frac{3}{2} \times 1.38 \times 10^{-23} \times 285$  (C1)  
 $\langle c^2 \rangle = 1.78 \times 10^6$  (C1)  
 $c_{\text{RMS}} = 1.33 \times 10^3 \text{ m s}^{-1}$  (A1) [3]
- 2 (a) (i) 1. 0.1 s, 0.3 s, 0.5 s, etc (any two) A1 [1]
2. either 0, 0.4 s, 0.8 s, 1.2 s  
or  
0.2 s, 0.6 s, 1.0 s (any two) A1 [1]
- (ii) period = 0.4 s C1  
frequency = (1/0.4 =) 2.5 Hz A1 [2]
- (iii) phase difference =  $90^\circ$  or  $\frac{1}{2} \pi$  rad B1 [1]
- (b) frequency = 2.4 – 2.5 Hz B1 [1]
- (c) e.g. attach sheet of card to trolley M1  
increases damping / frictional force A1  
e.g. reduce oscillator amplitude (M1)  
reduces power/energy input to system (A1) [2]

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- 3 (a) (i) (tangent to line gives) direction of force on a (small test) mass
- (ii) (tangent to line gives) direction of force on a (small test) charge  
charge is positive M1  
A1
- (b) similarity:  
e.g. radial fields  
lines normal to surface  
greater separation of lines with increased distance from sphere  
field strength  $\propto 1 / (\text{distance to centre of sphere})^2$   
(allow any sensible answer) B1
- difference:  
e.g. gravitational force (always) towards sphere B1  
electric force direction depends on sign of charge on sphere / towards or  
away from sphere B1  
e.g. gravitational field/force is attractive (B1)  
electric field/force is attractive or repulsive (B1)  
(allow any sensible comparison) [3]
- (c) gravitational force =  $1.67 \times 10^{-27} \times 9.81$   
 $= 1.6 \times 10^{-26} \text{ N}$  A1  
electric force =  $1.6 \times 10^{-19} \times 270 / (1.8 \times 10^{-2})$  C1  
 $= 2.4 \times 10^{-15} \text{ N}$  A1  
electric force very much greater than gravitational force B1 [4]
- 4 (a) force on proton is normal to velocity and field M1  
provides centripetal force (for circular motion) A1 [2]
- (b) magnetic force =  $Bqv$  B1  
centripetal force =  $mr\omega^2$  or  $mv^2/r$  B1  
 $v = r\omega$  B1  
 $Bqv = Bqr\omega = mr\omega^2$   
 $\omega = Bq/m$  A1 [4]
- 5 (a) either  $\phi = BA \sin \theta$  M1  
where  $A$  is the area (through which flux passes)  
 $\theta$  is the angle between  $B$  and (plane of)  $A$  A1  
or  
 $\phi = BA$  (M1)  
where  $A$  is area normal to  $B$  (A1) [2]
- (b) graph:  $V_H$  constant and non zero between the poles and zero outside M1  
sharp increase/decrease at ends of magnet A1 [2]

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- (c) (i) (induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage)
- (ii) short pulse on entering and on leaving region between poles  
pulses approximately the same shape but opposite polarities  
e.m.f. zero between poles and outside
- 6 (a) (i) connection to 'top' of resistor labelled as positive
- (ii) diode B and diode D
- (b) (i)  $V_P = 4.0\text{V}$   
mean power =  $V_P^2/2R$   
 $= 4^2 / (2 \times 2700)$   
 $= 2.96 \times 10^{-3}\text{W}$
- (ii) capacitor, correct symbol, connected in parallel with R
- (c) graph: half-wave rectification  
same period and same peak value
- 7 (a) wavelength associated with a particle that is moving
- (b) (i) kinetic energy =  $1.6 \times 10^{-19} \times 4700$   
 $= 7.52 \times 10^{-16}\text{J}$   
*either* energy =  $p^2/2m$  or  $E_K = \frac{1}{2}mv^2$  and  $p = mv$   
 $p = \sqrt{(7.52 \times 10^{-16} \times 2 \times 9.1 \times 10^{-31})}$   
 $= 3.7 \times 10^{-23}\text{Ns}$   
 $\lambda = h/p$   
 $= (6.63 \times 10^{-34}) / (3.7 \times 10^{-23})$   
 $= 1.8 \times 10^{-11}\text{m}$
- (ii) wavelength is about separation of atoms  
can be used in (electron) diffraction
- 8 (a) (i)  $x = 2$
- (ii) *either* beta particle or electron
- (b) (i) mass of separate nucleons =  $\{(92 \times 1.007) + (143 \times 1.009)\} \text{u}$   
 $= 236.931 \text{u}$   
binding energy =  $236.931 \text{u} - 235.123 \text{u}$   
 $= 1.808 \text{u}$

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(ii)  $E = mc^2$   
 energy =  $1.808 \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$   
 =  $2.7 \times 10^{-10} \text{ J}$   
 binding energy per nucleon =  $(2.7 \times 10^{-10}) / (235 \times 1.6 \times 10^{-13})$   
 = 7.18 MeV

C1  
M1  
A0 [3]

(c) energy released =  $(95 \times 8.09) + (139 \times 7.92) - (235 \times 7.18)$   
 = 1869.43 – 1687.3  
 = 182 MeV

(allow calculation using mass difference between products and reactants)

C1  
A1 [2]

### Section B

9 (a) light-emitting diode (allow LED) B1 [1]

(b) gives a high or a low output / +5 V or –5 V output  
 dependent on which of the inputs is at a higher potential M1  
A1 [2]

(c) (i) provides a reference/constant potential B1 [1]

(ii) determines temperature of ‘switch-over’ B1 [1]

(d) (i) relay A1 [1]

(ii) relay connected correctly for op-amp output and high-voltage circuit  
 diode with correct polarity in output from op-amp B1  
B1 [2]

10 (a) background reading = 19 B1 [1]

(b) A = 2 A1  
 B = 5 A1  
 C = 9 A1  
 D = 3 A1 [4]  
 (Allow 1 mark if only subtracts background reading)

(c) (i) either 5, 14 or 14, 5 (A+D, B+C or v.v.) B1 [1]

(ii) Three numbers and ‘inside’ number is 8 (B+D) B1  
 Three numbers and ‘outside’ numbers are either 2,9 or 9,2 (A,C or v.v.) B1 [2]

11 (a) high frequency wave B1  
 the amplitude or the frequency is varied M1  
 the variation represents the information signal /  
 in synchrony with (the displacement of) the information signal. A1 [3]

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- (b) e.g. shorter aerial required  
 longer transmission range / lower transmitter power / less attenuation  
 allows more than one station in a region  
 less distortion  
 (allow any three sensible suggestions, 1 mark each)

B3 [3]

12 (a) (i) e.g. linking a (land) telephone to the (local) exchange

B1 [1]

(ii) e.g. connecting an aerial to a television

B1 [1]

(iii) e.g. linking a ground station to a satellite

B1 [1]

(b) (i) attenuation =  $10 \lg (P_2 / P_1)$

C1

total attenuation =  $2.1 \times 40$  (= 84 dB)

C1

$84 = 10 \lg (\{450 \times 10^{-3}\} / P)$

$P = 1.8 \times 10^{-9} \text{ W}$

A1 [3]

(answer  $1.1 \times 10^8 \text{ W}$  scores 1 mark only)

(ii) maximum attenuation =  $10 \lg (\{450 \times 10^{-3}\} / \{7.2 \times 10^{-11}\})$   
 = 98 dB

C1

maximum length =  $98/2.1$

= 47 km

A1 [2]