CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2012 series

9702 PHYSICS

9702/43　　　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.

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

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CAMBRIDGE
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Section A

1 **(a)** **(i)** number of molecules   B1 [1]

     (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* $N = nN_A$
           $= 5.4 \times 6.02 \times 10^{23}$ C1
           $= 3.26 \times 10^{24}$ A1
           or
           $pV = NkT$
           $N = (6.1 \times 10^5 \times 2.1 \times 10^4 \times 10^{-6}) / (1.38 \times 10^{-23} \times 285)$ (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
         $c_{RMS} = 1.33 \times 10^3\,\text{m s}^{-1}$ 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)
         $c_{RMS} = 1.33 \times 10^3\,\text{m s}^{-1}$ (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 = $90°$ *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]

3 (a) (i) (tangent to line gives) direction of force on a (small test) mass   B1   [1]

    (ii) (tangent to line gives) direction of force on a (small test) charge   M1
           charge is positive   A1   [2]

    (b) similarity:
         e.g. radial fields
         lines normal to surface
         greater separation of lines with increased distance from sphere
         field strength $\propto 1 /$ (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 = $1.67 \times 10^{-27} \times 9.81$
                            = 1.6×10^{-26} N   A1
         electric force = $1.6 \times 10^{-19} \times 270 / (1.8 \times 10^{-2})$ C1
                         = 2.4×10^{-15} 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)
        θ 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]

(c) (i) (induced) e.m.f. proportional to   M1
      rate of change of (magnetic) flux (linkage)   A1   [2]

    (ii) short pulse on entering and on leaving region between poles   M1
         pulses approximately the same shape but opposite polarities   A1
         e.m.f. zero between poles and outside   A1   [3]

6 (a) (i) connection to 'top' of resistor labelled as positive   B1   [1]

    (ii) diode B and diode D   B1   [1]

(b) (i) $V_P = 4.0\,V$ C1
      mean power $= V_P^2/2R$ C1
      $= 4^2 / (2 × 2700)$
      $= 2.96 × 10^{-3}\,W$ A1   [3]

    (ii) capacitor, correct symbol, connected in parallel with R   B1   [1]

(c) graph: half-wave rectification   M1
    same period and same peak value   A1   [2]

7 (a) wavelength associated with a particle   M1
    that is moving   A1   [2]

(b) (i) kinetic energy $= 1.6 × 10^{-19} × 4700$ C1
               $= 7.52 × 10^{-16}\,J$
      either energy $= p^2/2m$ *or* $E_K = \frac{1}{2}mv^2$ *and* $p = mv$ C1
      $p = \sqrt{(7.52 × 10^{-16} × 2 × 9.1 × 10^{-31})}$ C1
        $= 3.7 × 10^{-23}\,N\,s$
      $\lambda = h/p$ C1
        $= (6.63 × 10^{-34}) / (3.7 × 10^{-23})$
        $= 1.8 × 10^{-11}\,m$ A1   [5]

    (ii) wavelength is about separation of atoms   B1
         can be used in (electron) diffraction   B1   [2]

8 (a) (i) $x = 2$ A1   [1]

    (ii) *either* beta particle *or* electron   B1   [1]

(b) (i) mass of separate nucleons $= \{(92 × 1.007) + (143 × 1.009)\}\,u$ C1
                        $= 236.931\,u$ C1
      binding energy $= 236.931\,u – 235.123\,u$
                    $= 1.808\,u$ A1   [3]

(ii) $E = mc^2$ C1
      energy = $1.808 \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$
            = 2.7×10^{-10} J   C1
      binding energy per nucleon = $(2.7 \times 10^{-10}) / (235 \times 1.6 \times 10^{-13})$ M1
                          = 7.18 MeV   A0 [3]

(c) energy released = (95 × 8.09) + (139 × 7.92) – (235 × 7.18)   C1
                    = 1869.43 – 1687.3
                    = 182 MeV   A1 [2]
     (*allow calculation using mass difference between products and reactants*)

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   M1
        dependent on which of the inputs is at a higher potential   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   B1
              diode with correct polarity in output from op-amp   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]

(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 = 2.1×40 (= 84 dB)   C1
$84 = 10\lg(\{450 \times 10^{-3}\} / P)$
$P = 1.8 \times 10^{-9}$ W   A1   [3]
(*answer 1.1×10^8 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]