CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9702 PHYSICS

9702/41   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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Section A

1 **(a)** work done in moving unit mass   M1
     from infinity (to the point)   A1   [2]

    (b) **(i)** gravitational potential energy = GMm / x
           energy = $(6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 4.5) / (1.74 \times 10^{6})$ M1
           energy = 1.27×10^{7} J   A0   [1]

        (ii) <u>change in</u> grav. potential energy = <u>change in</u> kinetic energy   B1
            ½ $\times 4.5 \times v^{2}$ = 1.27×10^{7}
            $v = 2.4 \times 10^{3}$ m s^{-1} A1   [2]

    (c) Earth would attract the rock / potential at Earth('s surface) not zero / <0
      / at Earth, potential due to Moon not zero   M1
      escape speed would be lower   A1   [2]

2 **(a)** **(i)** N: (total) number of <u>molecules</u>   B1   [1]

        (ii) $<c^{2}>$: mean square speed/velocity   B1   [1]

    (b) $pV = ⅓Nm<c^{2}> = NkT$
      (mean) kinetic energy = ½ $m<c^{2}>$ C1
      algebra clear leading to ½ $m<c^{2}>$ = $(3/2)kT$ A1   [2]

    (c) **(i)** *either*   energy required = $(3/2) \times 1.38 \times 10^{-23} \times 1.0 \times 6.02 \times 10^{23}$ C1
                          = 12.5 J (*12J if 2 s.f.*)   A1   [2]
         or   energy = $(3/2) \times 8.31 \times 1.0$ (C1)
                   = 12.5 J   (A1)

        (ii) energy is needed to push back atmosphere/do work against
          atmosphere   M1
          so total energy required is greater   A1   [2]

3 **(a)** **(i)** any two from 0.3(0) s, 0.9(0) s, 1.50 s (*allow 2.1 s etc.*)   B1   [1]

        (ii) *either* $v = \omega x$ and $\omega = 2\pi/T$ C1
             $v = (2\pi/1.2) \times 1.5 \times 10^{-2}$ M1
               = 0.079 m s^{-1} A0   [2]
         or   gradient drawn clearly at a correct position   (C1)
             working clear   (M1)
             to give (0.08 ± 0.01) m s^{-1} (A0)

(b) (i) sketch: <u>curve</u> from ($\pm$1.5, 0) passing through (0, 25)   M1
         reasonable shape (*curved with both intersections between*
         y = 12.0→13.0)   A1   [2]

     (ii) at max. amplitude potential energy is total energy   B1
           total energy = 4.0 mJ   B1   [2]

4 (a) (i) force proportional to product of (two) charges and inversely
         proportional to square of separation   M1
         reference to point charges   A1   [2]

     (ii) $F = 2 \times (1.6 \times 10^{-19})^2 / \{4\pi \times 8.85 \times 10^{-12} \times (20 \times 10^{-6})^2\}$ C1
           $= 1.15 \times 10^{-18}$ N   A1   [2]

(b) (i) force per unit charge   M1
         on *either* a stationary charge
         or a positive charge   A1   [2]

     (ii) 1. electric field is a vector quantity
           electric fields are in opposite directions
           charges repel
           Any two of the above, 1 each   B2   [2]

         2. graph: line always between given lines   M1
           crosses *x*-axis between 11.0 μm and 12.3 μm   A1
           reasonable shape for curve   A1   [3]

5 (a) (i) field shown as right to left   B1   [1]

     (ii) lines are more spaced out at ends   B1   [1]

(b) Hall voltage depends on angle   M1
     either between field and plane of probe
     or maximum when field normal to plane of probe
     or zero when field parallel to plane of probe   A1   [2]

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

     (ii) e.g. move coil towards/away from solenoid
            rotate coil
            vary current in solenoid
            insert iron core into solenoid
         (*any three sensible suggestions, 1 each*)   B3   [3]

6 **(a)** force due to magnetic field is constant   B1
force is (always) normal to direction of motion
this force provides the centripetal force   A1   [3]

    (b) $mv^2 / r = Bqv$ M1
hence $q / m = v / Br$ A0   [1]

    (c) **(i)** $q / m = (2.0 \times 10^7) / (2.5 \times 10^{-3} \times 4.5 \times 10^{-2})$ C1
           $= 1.8 \times 10^{11}$ C kg^{-1} A1   [2]

        (ii) sketch: curved path, constant radius, in direction towards bottom of
page   M1
tangent to curved path on entering and on leaving the field   A1   [2]

7 **(a)** *either* if light passes through suitable film / cork dust etc.   M1
         diffraction occurs and similar pattern observed   A1
or concentric circles are evidence of diffraction   (M1)
      diffraction is a wave property   (A1)   [2]

    (b) (speed increases so) momentum increases   M1
$\lambda = h/p$ so λ decreases   M1
hence radii decrease   A1   [3]
(*special case: wavelength decreases so radii decreases – scores 1/3*)
or
(speed increases so) energy increases   (B1)
$\lambda = h / \sqrt{(2Em)}$ so λ decreases   (M1)
hence radii decrease   (A1)

    (c) electron and proton have same (kinetic) energy   C1
either $E = p^2 / 2m$ *or* $p = \sqrt{(2Em)}$ C1
ratio $= p_e / p_p = \sqrt{(m_e / m_p)}$ C1
      $= \sqrt{\{(9.1 \times 10^{-31}) / (1.67 \times 10^{-27})\}}$
      $= 2.3 \times 10^{-2}$ A1   [4]

8 **(a)** energy to separate nucleons (in a nucleus)   M1
separate to infinity   A1   [2]

    (b) **(i)** fission   B1   [1]

        (ii) **1.** U: near right-hand end of line   B1   [1]

               2. Mo: to right of peak, less than 1/3 distance from peak to U   B1   [1]

               3. La: 0.4 → 0.6 of distance from peak to U   B1   [1]

(iii) 1.   right-hand side, mass = 235.922 u   C1

                mass change = 0.210 u   A1   [2]

           2.   energy = mc^2 C1

                    = $0.210 \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$

                    = 3.1374×10^{-11} J   C1

                    = 196 MeV (*need 3 s.f.*)   A1   [3]

               (*use of 1 u = 934 MeV, allow 3/3; use of 1 u = 930 MeV or 932 MeV, allow 2/3*)

               (*use of 1.67×10^{-27} not 1.66×10^{-27} scores max. 2/3*)

Section B

9   (a) operates on / takes signal from sensing device   B1

           (so that) it gives an voltage output   B1   [2]

     (b) thermistor and resistor in series between +4 V line and earth   M1

           V_{OUT} shown clearly across *either* thermistor *or* resistor   A1

           V_{OUT} shown clearly across thermistor   A1   [3]

     (c) e.g. remote switching

              switching large current by means of a small current

              isolating circuit from high voltage

              switching high voltage by means of a small voltage/current

           (*any two sensible suggestions, 1 each to max. 2*)   B2   [2]

10 (a) pulse (of ultrasound)   B1

           produced by quartz / piezo-electric crystal   (1)

           reflected from boundaries (between media)   B1

           reflected pulse detected   B1

           by the ultrasound transmitter   (1)

           signal processed and displayed   B1

           intensity of reflected pulse gives information about the boundary   (1)

           time delay gives information about depth   (1)

           (*four B marks plus any two from the four, max. 6*)   B2   [6]

     (b) shorter wavelength   B1

           smaller structures resolved / detected (*not more sharpness*)   B1   [2]

     (c) (i) $I = I_0 e^{-\mu x}$ C1

               ratio = $\exp(-23 \times 6.4 \times 10^{-2})$ C1

                   = 0.23   A1   [3]

        (ii) later signal has passed through greater thickness of medium   M1

             so has greater attenuation / greater absorption / smaller intensity   A1   [2]

11 (a) left-hand bit underlined   B1   [1]

(b) 1010, 1110, 1111, 1010, 1001
(*5 correct scores 2, 4 correct scores 1*)   A2   [2]

(c) significant changes in detail of *V* between samplings   M1
so frequency too low   A1   [2]

12 (a) e.g. logarithm provides a smaller number
     gain of amplifiers is series found by addition, (not multiplication)
(*any sensible suggestion*)   B1   [1]

(b) (i) optic fibre   B1   [1]

     (ii) attenuation/dB = $10 \lg(P_2/P_1)$ C1
         = $10 \lg(\{6.5 \times 10^{-3}\}/\{1.5 \times 10^{-15}\})$ C1
         = 126
     length = 126 / 1.8
         = 70 km   A1   [3]