MARK SCHEME for the October/November 2011 question paper

for the guidance of teachers

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.

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Section A

1 **(a) (i)** weight = GMm/r^2 C1
    = $(6.67 \times 10^{-11} \times 6.42 \times 10^{23} \times 1.40)/(½ \times 6.79 \times 10^6)^2$ C1
    = 5.20 N   A1 [3]

    (ii) potential energy = $-GMm/r$ C1
        = $-(6.67 \times 10^{-11} \times 6.42 \times 10^{23} \times 1.40)/(½ \times 6.79 \times 10^6)$ M1
        = -1.77×10^7 J   A0 [2]

  (b) *either* $½mv^2 = 1.77 \times 10^7$ C1
         $v^2 = (1.77 \times 10^7 \times 2)/1.40$ C1
         $v = 5.03 \times 10^3$ m s^{-1} A1
     or $½mv^2 = GMm/r$ (C1)
         $v^2 = (2 \times 6.67 \times 10^{-11} \times 6.42 \times 10^{23})/(6.79 \times 10^6/2)$ (C1)
         $v = 5.02 \times 10^3$ m s^{-1} (A1) [3]

  (c) (i) $½ \times 2 \times 1.66 \times 10^{-27} \times (5.03 \times 10^3)^2 = \dfrac{3}{2} \times 1.38 \times 10^{-23} \times T$ C1

       $T = 2030$ K   A1 [2]

    (ii) *either*   because there is a range of speeds   M1
             some molecules have a higher speed   A1
       or   some escape from point above planet surface   (M1)
            so initial potential energy is higher   (A1) [2]

2 **(a)** temperature scale calibrated assuming linear change of property with
temperature   B1
neither property varies linearly with temperature   B1 [2]

  (b) (i) does not depend on the property of a substance   B1 [1]

    (ii) temperature at which atoms have minimum/zero energy   B1 [1]

  (c) (i) 323.15 K   A1 [1]

    (ii) 30.00 K   A1 [1]

3 (a) acceleration proportional to displacement/distance from fixed point   M1
and in opposite directions/directed towards fixed point   A1   [2]

(b) energy $= \frac{1}{2}m\omega^2 x_0^2$ and $\omega = 2\pi f$ C1
$= \frac{1}{2} \times 5.8 \times 10^{-3} \times (2\pi \times 4.5)^2 \times (3.0 \times 10^{-3})^2$ C1
$= 2.1 \times 10^{-5}$ J   A1   [3]

(c) (i) at maximum displacement   M1
above rest position   A1   [2]

(ii) acceleration $= (-)\omega^2 x_0$ and acceleration $= 9.81$ or g C1
$9.81 = (2\pi \times 4.5)^2 \times x_0$
$x_0 = 1.2 \times 10^{-2}$ m   A1   [2]

4 (a) e.g. storing energy
separating charge
blocking d.c.
producing electrical oscillations
tuning circuits
smoothing
preventing sparks
timing circuits
(any two sensible suggestions, 1 each, max 2)   B2   [2]

(b) (i) $-Q$ (induced) on opposite plate of C_1 B1
by <u>charge conservation</u>, charges are $-Q$, $+Q$, $-Q$, $+Q$, $-Q$ B1   [2]

(ii) total p.d. $V = V_1 + V_2 + V_3$ B1
$Q/C = Q/C_1 + Q/C_2 + Q/C_3$ B1
$1/C = 1/C_1 + 1/C_2 + 1/C_3$ A0   [2]

(c) (i) energy $= \frac{1}{2}CV^2$ or energy $= \frac{1}{2} QV$ and $C = Q/V$ C1
$= \frac{1}{2} \times 12 \times 10^{-6} \times 9.0^2$
$= 4.9 \times 10^{-4}$ J   A1   [2]

(ii) energy dissipated in (resistance of) wire/as a spark   B1   [1]

5 **(a)** supply connected correctly (to left & right)   B1
　　　　load connected correctly (to top & bottom)   B1 　[2]

　　(b) e.g. power supplied on every half-cycle
　　　　　　greater <u>average/mean</u> power
　　　　　　(any sensible suggestion, 1 mark)   B1 　[1]

　　(c) **(i)** reduction in the variation of the output voltage/current   B1 　[1]

　　　　(ii) larger capacitance produces more smoothing   M1
　　　　　　　either product RC larger
　　　　　　　or 　　for the same load   A1 　[2]

6 **(a)** unit of magnetic flux density   B1
　　　　field normal to (straight) conductor carrying current of 1 A   M1
　　　　force per unit length is $1\,\mathrm{N\,m^{-1}}$ A1 　[3]

　　(b) **(i)** force on particle always normal to direction of motion   M1
　　　　　　　(and speed of particle is constant)
　　　　　　　magnetic force provides the centripetal force   A1 　[2]

　　　　(ii) $mv^2/r = Bqv$ M1
　　　　　　　$r = mv/Bq$ A0 　[1]

　　(c) **(i)** the momentum/speed is becoming less   M1
　　　　　　　so the radius is becoming smaller   A1 　[2]

　　　　(ii) **1.** spirals are in opposite directions   M1
　　　　　　　　　so oppositely charged   A1 　[2]

　　　　　　　2. equal <u>initial</u> radii   M1
　　　　　　　　　so equal (initial) speeds   A1 　[2]

7 (a) (i) packet/quantum of energy   M1
of electromagnetic radiation   A1   [2]

    (ii) <u>minimum</u> energy to cause emission of an electron (from surface)   B1   [1]

(b) (i) $hc/\lambda = \Phi + E_{max}$ M1
c and h explained   A1   [2]

    (ii) 1. *either*   when $1/\lambda = 0$, $\Phi = -E_{max}$
            or   evidence of use of *x*-axis intercept from graph
            or   chooses point close to the line and substitutes values of $1/\lambda$ and
                      E_{max} into $hc/\lambda = \Phi + E_{max}$ C1
         $\Phi = 4.0 \times 10^{-19}$ J (allow $\pm 0.2 \times 10^{-19}$ J)   A1   [2]

          2. *either*   gradient of graph is $1/hc$ C1
                     gradient $= 4.80 \times 10^{24} \rightarrow 5.06 \times 10^{24}$ M1
                     $h = 1/(\text{gradient} \times 3.0 \times 10^8)$
                         $= 6.6 \times 10^{-34}$ J s $\rightarrow 6.9 \times 10^{-34}$ J s   A1
            or   chooses point close to the line and substitutes values of $1/\lambda$ and
                      E_{max} into $hc/\lambda = \Phi + E_{max}$ (C1)
                      values of $1/\lambda$ and E_{max} are correct within half a square   (M1)
                      $h = 6.6 \times 10^{-34}$ J s $\rightarrow 6.9 \times 10^{-34}$ J s   (A1)   [3]
         (Allow full credit for the correct use of any appropriate method)
         (Do not allow 'circular' calculations in **part 2** *that lead to the same value of*
         Planck constant that was substituted in **part 1**)

8 (a) (i) probability of decay (of a nucleus)   M1
<u>per</u> unit time   A1   [2]

    (ii) $\lambda t_{1/2} = \ln 2$
         $\lambda = \ln 2/(3.82 \times 24 \times 3600)$ M1
         $= 2.1 \times 10^{-6}$ s^{-1} A0   [1]

(b) $A = \lambda N$ C1
     $200 = 2.1 \times 10^{-6} \times N$ C1
     $N = 9.5 \times 10^7$
     ratio $= (2.5 \times 10^{25})/(9.5 \times 10^7)$
              $= 2.6 \times 10^{17}$ A1   [3]

Section B

9   (a)   any value greater than, or equal to, $5\,k\Omega$ B1   [1]

  (b)   (i)   'positive' shown in correct position   B1   [1]

    (ii) $V^+ = (500/2200) \times 4.5$
           $\approx 1\,V$ B1
          $V^- > V^+$ so output is negative   M1
          green LED on, (red LED off)   A1   [3]
          (allow full ecf of incorrect value of V^+)

    (iii)   *either* V^+ increases *or* $V^+ > V^-$ M1
           green LED off, red LED on   A1   [2]

10   quartz/piezo-electric crystal   B1
    p.d. across crystal causes   *either* centres of (+) and (−) charge to move
                                 or   crystal to change shape   B1
    alternating p.d. (in ultrasound frequency range) causes crystal to vibrate   B1
    crystal cut to produce resonance   B1
    when crystal made to vibrate by ultrasound wave   M1
    alternating p.d. produced across the crystal   A1   [6]

11   (a)   sharpness: ease with which edges of structures can be seen   B1
          contrast: <u>difference</u> in degree of blackening between structures   B1   [2]

  (b)   (i) $I = I_0\,e^{-\mu x}$ C1
          $I/I_0 = \exp(-0.20 \times 8)$
               $= 0.20$ A1   [2]

    (ii) $I/I_0 = \exp(-\mu_1 \times x_1) \times \exp(-\mu_2 \times x_2)$ *(could be three terms)*   C1
          $I/I_0 = \exp(-0.20 \times 4) \times \exp(-12 \times 4)$ C1
          $I/I_0 = 6.4 \times 10^{-22}$ or $I/I_0 \approx 0$ A1   [3]

  (c)   (i)   sharpness unknown/no   B1   [1]

    (ii)   contrast good/yes *(ecf from (b))*   B1   [1]

12 (a) e.g. <u>carrier</u> frequencies can be re-used (without interference)   (M1)
   so increased number of handsets can be used   (A1)
  e.g. lower power transmitters   (M1)
   so less interference   (A1)
  e.g. UHF used   (M1)
   so must be line-of-sight/short handset aerial   (A1)
  (any two sensible suggestions with explanation, max 4)   B4   [4]

 (b) computer at cellular exchange   B1
  monitors the signal power   B1
  relayed from several base stations   B1
  switches call to base station with strongest signal   B1   [4]