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.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.
Section A

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

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

   (ii) change in grav. potential energy = change in kinetic energy  
        $\frac{1}{2} \times 4.5 \times v^2 = 1.27 \times 10^{7}$  
        $v = 2.4 \times 10^{3}$ 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  
   escape speed would be lower  
   M1  
   A1  [2]

2  (a) (i) $N$: (total) number of molecules  
   B1  [1]

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

(b) $pV = \frac{1}{3} N m <c^2> = N k T$
   (mean) kinetic energy = $\frac{1}{2} m <c^2>$  
   C1  
   algebra clear leading to $\frac{1}{2} m <c^2> = (3/2) k T$  
   A1  [2]

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

   or energy = $(3/2) \times 8.31 \times 1.0$
       $= 12.5$ J  
       (C1)  
       (A1)

(ii) energy is needed to push back atmosphere/do work against  
     atmosphere  
     so total energy required is greater  
     M1  
     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 $\omega = 2\pi / T$
       $v = (2\pi / 1.2) \times 1.5 \times 10^{-2}$  
       $= 0.079$ m s$^{-1}$  
       C1  
       M1  
       A0  [2]

   or gradient drawn clearly at a correct position  
   working clear  
   to give $(0.08 \pm 0.01)$ m s$^{-1}$  
   (C1)  
   (M1)  
   (A0)
(b) (i) sketch: curve from \((-1.5, 0)\) passing through \((0, 25)\) M1
reasonable shape \((\text{curved with both intersections between } y = 12.0 \rightarrow 13.0)\) 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) \(F = \frac{2 \times (1.6 \times 10^{-19})^2}{4 \pi \times 8.85 \times 10^{-12} \times (20 \times 10^{-6})^2}\) C1
\[= 1.15 \times 10^{-18} \text{ N}\] A1 [2]

(b) (i) force per unit charge M1
on \(\text{either a stationary charge or a positive charge}\) A1 [2]

(ii) 1. electric field is a vector quantity M1
electric fields are in opposite directions A1
charges repel
\(\text{Any two of the above, 1 each}\) B2 [2]

2. graph: line always between given lines M1
crosses x-axis between 11.0 \(\mu\text{m}\) and 12.3 \(\mu\text{m}\) 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 A1
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 of change of (magnetic) flux (linkage) M1
\(\text{(allow rate of cutting of flux)}\) A1 [2]

(ii) e.g. move coil towards/away from solenoid A1
rotate coil B3 [3]
vary current in solenoid
insert iron core into solenoid
\(\text{(any three sensible suggestions, 1 each)}\)
6 (a) force due to magnetic field is constant
force is (always) normal to direction of motion
this force provides the centripetal force

(b) \( \frac{mv^2}{r} = Bqv \)
hence \( \frac{q}{m} = \frac{v}{Br} \)

(c) (i) \( \frac{q}{m} = \frac{(2.0 \times 10^7)}{(2.5 \times 10^{-3} \times 4.5 \times 10^{-2})} \)
      \( = 1.8 \times 10^{11} \text{ C kg}^{-1} \)

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

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

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

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

8 (a) energy to separate nucleons (in a nucleus)
separate to infinity

(b) (i) fission

(ii) 1. U: near right-hand end of line

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

3. La: 0.4 → 0.6 of distance from peak to U
(iii) 1. right-hand side, mass = 235.922 u
   mass change = 0.210 u
   C1
   A1 [2]

2. energy = \( mc^2 \)
   = 0.210 \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2
   = 3.1374 \times 10^{-11} J
   C1
   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 \times 10^{-27} not 1.66 \times 10^{-27} scores max. 2/3)

Section B

9 (a) operates on / takes signal from sensing device
   (so that) it gives an voltage output
   B1
   B1 [2]

(b) thermistor and resistor in series between +4 V line and earth
   \( V_{OUT} \) 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)
    produced by quartz / piezo-electric crystal
    reflected from boundaries (between media)
    reflected pulse detected
    by the ultrasound transmitter
    signal processed and displayed
    intensity of reflected pulse gives information about the boundary
    time delay gives information about depth
    (four B marks plus any two from the four, max. 6)
    B2 [6]

(b) shorter wavelength
    smaller structures resolved / detected (not more sharpness)
    B1
    B1 [2]

(c) (i) \( I = I_0 e^{-\alpha x} \)
    ratio = \exp(-23 \times 6.4 \times 10^{-2})
    = 0.23
    C1
    A1 [3]

(ii) later signal has passed through greater thickness of medium
    so has greater attenuation / greater absorption / smaller intensity
    M1
    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
    so frequency too low  M1  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 $\log(P_2/P_1)$  C1
       = 10 $\log((6.5 \times 10^{-3})/(1.5 \times 10^{-15}))$  C1
       = 126

       length = 126 / 1.8
       = 70 km  A1  [3]