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 = \( GMm / r \)
   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 B1
   \( \frac{1}{2} \times 4.5 \times v^2 = 1.27 \times 10^7 \)
   \( v = 2.4 \times 10^3 \) 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) \( pV = \frac{1}{3}Nm<c^2> = NkT \)
   (mean) kinetic energy = \( \frac{1}{2} m<c^2> \)
   algebra clear leading to \( \frac{1}{2} m<c^2> = (3/2)kT \) C1 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 = \( (3/2) \times 8.31 \times 1.0 \)
   = 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 \( \omega = 2\pi/T \) C1
   \( v = (2\pi/1.2) \times 1.5 \times 10^{-2} \)
   = 0.079 m s\(^{-1} \) M1
   A0 [2]
   or gradient drawn clearly at a correct position working clear (C1)
   (M1)
   to give \((0.08 \pm 0.01)\) m s\(^{-1} \) (A0)
(b) (i) sketch: curve from (±1.5, 0) passing through (0, 25) 
reasonable shape (curved with both intersections between
y = 12.0→13.0)  
M1
A1 [2]

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

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

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

(b) (i) force per unit charge 
on either a stationary charge 
or a positive charge  
M1
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 
crosses x-axis between 11.0 \( \mu \)m and 12.3 \( \mu \)m 
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 
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  
M1
A1 [2]

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

(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
   force is (always) normal to direction of motion
   this force provides the centripetal force
   B1

   A1 [3]

(b) \( \frac{mv^2}{r} = Bqv \)
   hence \( \frac{q}{m} = \frac{v}{Br} \)
   M1

   A0 [1]

(c) (i) \( \frac{q}{m} = \frac{(2.0 \times 10^7)}{(2.5 \times 10^{-3} \times 4.5 \times 10^{-2})} \)
   \( = 1.8 \times 10^{11} \text{ C kg}^{-1} \)
   C1

   A1 [2]

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

   A1 [2]

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
   or diffraction is a wave property
   M1

   A1 [2]

(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
   B1

   M1

   A1 [3]

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


8 (a) energy to separate nucleons (in a nucleus)
   separate to infinity
   M1

   A1 [2]

(b) (i) fission
   B1 [1]

   (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
   B1 [1]
(iii) 1. right-hand side, mass = 235.922 u  
   mass change = 0.210 u  
   energy = \( mc^2 \)  
   \[ = 0.210 \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2 \]  
   \[ = 3.1374 \times 10^{-11} \text{ J} \]  
   \[ = 196 \text{ MeV} \text{ (need 3 s.f.)} \]  
   (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 [2]

(b) thermistor and resistor in series between +4 V line and earth  
   \( V_{\text{OUT}} \) shown clearly across either thermistor or resistor  
   \( V_{\text{OUT}} \) shown clearly across thermistor  
   M1 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)  
   B1 [6]

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

(c) (i) \( I = I_0 e^{-\mu x} \)  
   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 \( = 10 \log(P_2/P_1) \)  
        \( = 10 \log((6.5 \times 10^{-3})/(1.5 \times 10^{-15})) \)  
        \( = 126 \)  
        length \( = 126 / 1.8 \)  
        \( = 70 \text{ km} \)  
   A1 [3]