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 May/June 2014 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.
Section A

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

(b) \( E_p = -m\phi \) B1 [1]

(c) \( \phi \propto \frac{1}{x} \) C1

 either at 6R from centre, potential is \((6.3 \times 10^7)/6\) \((= 1.05 \times 10^7 \text{ J kg}^{-1})\) C1
   and at 5R from centre, potential is \((6.3 \times 10^7)/5\) \((= 1.26 \times 10^7 \text{ J kg}^{-1})\) C1
   change in energy = \((1.26 - 1.05) \times 10^7 \times 1.3\) C1
   = \(2.7 \times 10^6 \text{ J} \) A1

 or change in potential = \((1/5 - 1/6) \times (6.3 \times 10^7)\) \((= 1.26 \times 10^7 \text{ J kg}^{-1})\) \(\phi \propto \frac{1}{x} \) C1
   change in energy = \((1/5 - 1/6) \times (6.3 \times 10^7) \times 1.3\) A1
   = \(2.7 \times 10^6 \text{ J} \) \(\phi \propto \frac{1}{x} \) A1 [4]

2 (a) the number of atoms M1
    in 12 g of carbon-12 A1 [2]

(b) (i) amount = \(3.2/40\) = 0.080 mol A1 [1]

(ii) \( pV = nRT \) C1
    \( p \times 210 \times 10^{-6} = 0.080 \times 8.31 \times 310 \) C1
    \( p = 9.8 \times 10^5 \text{ Pa} \) A1 [2]
    \((do \ not \ credit \ if \ T \ in \ °C \ not \ K)\)

(iii) either \( pV = 1/3 \times Nm <c^2> \) C1
    \( N = 0.080 \times 6.02 \times 10^{23} (= 4.82 \times 10^{22}) \) C1
    and \( m = 40 \times 1.66 \times 10^{-27} (= 6.64 \times 10^{-26}) \) C1
    \( 9.8 \times 10^5 \times 210 \times 10^{-6} = 1/3 \times 4.82 \times 10^{22} \times 6.64 \times 10^{-26} \times <c^2> \) C1
    \( <c^2> = 1.93 \times 10^5 \) A1
    \( \sigma_{\text{RMS}} = 440 \text{ m s}^{-1} \) A1 [3]

 or \( Nm = 3.2 \times 10^{-3} \) \((C1)\)
    \( 9.8 \times 10^5 \times 210 \times 10^{-6} = 1/3 \times 3.2 \times 10^{-3} \times <c^2> \) \((C1)\)
    \( <c^2> = 1.93 \times 10^5 \) \((C1)\)
    \( \sigma_{\text{RMS}} = 440 \text{ m s}^{-1} \) \((A1)\)

 or \( 1/2 m <c^2> = 3/2 kT \) \((C1)\)
    \( 1/2 \times 40 \times 1.66 \times 10^{-27} <c^2> = 3/2 \times 1.38 \times 10^{-23} \times 310 \) \((C1)\)
    \( <c^2> = 1.93 \times 10^5 \) \((C1)\)
    \( \sigma_{\text{RMS}} = 440 \text{ m s}^{-1} \) \((A1)\)

(if T in °C not K award max 1/3, unless already penalised in (b)(ii))
3 (a) either change in volume = \((1.69 - 1.00 \times 10^{-3})\)  
or liquid volume \(<\text{volume of vapour}\)  
work done = \(1.01 \times 10^5 \times 1.69 = 1.71 \times 10^5\) (J)  

A1 [2]

(b) (i) 1. heating of system/thermal energy supplied to the system  
B1 [1]

2. work done on the system  
B1 [1]

(ii) \(\Delta U = (2.26 \times 10^6) - (1.71 \times 10^5)\)  
\(= 2.09 \times 10^5\) J (3 s.f. needed)  
A1 [2]

4 (a) kinetic (energy)/KE/\(E_k\)  
B1 [1]

(b) either change in energy = 0.60 mJ  
or \(\text{max } E \propto (\text{amplitude})^2/\text{equivalent numerical working}\)  
new amplitude is 1.3 cm  
B1 [1]

change in amplitude = 0.2 cm  
B1 [3]

5 (a) graph: straight line at constant potential = \(V_0\) from \(x = 0\) to \(x = r\)  
B1

curve with decreasing gradient  
M1

passing through \((2r, 0.50V_0)\) and \((4r, 0.25V_0)\)  
A1 [3]

(b) graph: straight line at \(E = 0\) from \(x = 0\) to \(x = r\)  
B1

curve with decreasing gradient from \((r, E_0)\)  
M1

passing through \((2r, \frac{1}{4}E_0)\)  
A1 [3]

(for 3rd mark line must be drawn to \(x = 4r\) and must not touch x-axis)

6 (a) (i) energy = \(EQ\)  
C1

= \(9.0 \times 22 \times 10^{-3}\)  
= 0.20 J  
A1 [2]

(ii) 1. \(C = \frac{Q}{V}\)  
\(V = (22 \times 10^{-3})/(4700 \times 10^{-6})\)  
\(= 4.7 V\)  
C1

A1 [2]

2. either \(E = \frac{1}{2}CV^2\)  
\(= \frac{1}{2} \times 4700 \times 10^{-6} \times 4.7^2\)  
\(= 5.1 \times 10^{-2}\) J  
A1 [2]

or \(E = \frac{1}{2}QV\)  
\(= \frac{1}{2} \times 22 \times 10^{-3} \times 4.7\)  
\(= 5.1 \times 10^{-2}\) J  
(A1)

or \(E = \frac{1}{2}Q^2/C\)  
\(= \frac{1}{2} \times (22 \times 10^{-3})^2/4700 \times 10^{-6}\)  
\(= 5.1 \times 10^{-2}\) J  
(C1)

(A1)
(b) energy lost (as thermal energy) in resistance/wires/battery/resistor  
(award only if answer in (a)(i) > answer in (a)(ii))  

7 (a) graph:  
- $V_H$ increases from zero when current switched on  
- $V_H$ then non-zero constant  
- $V_H$ returns to zero when current switched off  

(b) (i) (induced) e.m.f. proportional to rate  
of change of (magnetic) flux (linkage)  

(ii) pulse as current is being switched on  
- zero e.m.f. when current in coil  
- pulse in opposite direction when switching off  

8 (a) discrete and equal amounts (of charge)  
- allow: discrete amounts of $1.6 \times 10^{-19}$ C/elementary charge/e  
- integral multiples of $1.6 \times 10^{-19}$ C/elementary charge/e  

(b) weight = $qV/d$  
- $4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$  
- $q = 4.9 \times 10^{-19}$ C  

(c) elementary charge = $1.6 \times 10^{-19}$ C  
- (allow 1.6 $\times 10^{-19}$ C to 1.7 $\times 10^{-19}$ C)  
- either the values are (approximately) multiples of this  
- or it is a common factor  
- it is the highest common factor  

9 (a) e.g. no time delay between illumination and emission  
- max. (kinetic) energy of electron dependent on frequency  
- max. (kinetic) energy of electron independent of intensity  
- rate of emission of electrons dependent on/proportional to intensity  
(any three separate statements, one mark each, maximum 3)  

(b) (i) (photon) interaction with electron may be below surface  
- energy required to bring electron to surface
(ii) 1. threshold frequency \( = 5.8 \times 10^{14} \text{ Hz} \) A1

2. \( \Phi = hf_0 \)
\( = 6.63 \times 10^{-34} \times 5.8 \times 10^{14} \)
\( = 3.84 \times 10^{-19} \text{ (J)} \) C1
\( = (3.84 \times 10^{-19})/(1.6 \times 10^{-19}) \)
\( = 2.4 \text{ eV} \) A1 [3]

or

\( hf = \Phi + E_{\text{MAX}} \)
chooses point on line and substitutes values \( E_{\text{MAX}}, f \) and \( h \) into equation with the units of the \( hf \) term converted from J to eV C1

\( \Phi = 2.4 \text{ eV} \) (A1)

10 (a) energy required to separate the nucleons (in a nucleus) to infinity M1
(allow reverse statement) A1 [2]

(b) (i) \( \Delta m = (2 \times 1.00867) + 1.00728 – 3.01551 \)
\( = 9.11 \times 10^{-3} \text{ u} \) C1
binding energy \( = 9.11 \times 10^{-3} \times 930 \)
\( = 8.47 \text{ MeV} \) A1 [3]
(allow 930 to 934 MeV so answer could be in range 8.47 to 8.51 MeV)
(allow 2 s.f.)

(ii) \( \Delta m = 211.70394 – 209.93722 \)
\( = 1.76672 \text{ u} \) C1
binding energy per nucleon \( = (1.76672 \times 930)/210 \)
\( = 7.82 \text{ MeV} \) A1 [3]
(allow 930 to 934 MeV so answer could be in range 7.82 to 7.86 MeV)
(allow 2 s.f.)

(c) total binding energy of barium and krypton is greater than binding energy of uranium M1
A1 [2]

Section B

11 (a) (i) inverting amplifier B1 [1]

(ii) gain is very large/infinite B1
\( V^* \) is earthed/zero B1
for amplifier not to saturate, P must be (almost) earth/zero B1 [3]

(b) (i) \( R_A = 100 \text{ k}\Omega \) A1
\( R_B = 10 \text{ k}\Omega \) A1
\( V_{\text{IN}} = 1000 \text{ mV} \) A1 [3]

(ii) variable range meter B1 [1]
12 (a) series of X-ray images (for one section/slice) taken from different angles to give image of the section/slice repeated for many slices to build up three-dimensional image (of whole object) M1 A1 M1 M1 A1 [5]

(b) deduction of background from readings division by three

\[ P = 5 \quad Q = 9 \quad R = 7 \quad S = 13 \]

(four correct 2/2, three correct 1/2) C1 C1 A2 [4]

13 (a) e.g. noise can be eliminated/waveform can be regenerated extra bits of data can be added to check for errors cheaper/more reliable greater rate of transfer of data (1 each, max 2) B2 [2]

(b) receives bits all at one time transmits the bits one after another B1 B1 [2]

(c) sampling frequency must be higher than/(at least) twice frequency to be sampled either higher (range of) frequencies reproduced on the disc or lower (range of) frequencies on phone either higher quality (of sound) on disc or high quality (of sound) not required for phone B1 B1 [3]

14 (a) reduction in power (allow intensity/amplitude) B1 [1]

(b) (i) attenuation = \( 2.4 \times 30 \) = 72 dB A1 [1]

(ii) gain/attenuation/dB = \( 10 \log \left( \frac{P_2}{P_1} \right) \)

\[ 72 = 10 \log \left( \frac{P_{\text{IN}}}{P_{\text{OUT}}} \right) \quad \text{or} \quad -72 = 10 \log \left( \frac{P_{\text{OUT}}}{P_{\text{IN}}} \right) \]

ratio = \( 1.6 \times 10^{-7} \) C1 C1 A1 [3]

(c) e.g. enables smaller/more manageable numbers to be used e.g. gains in dB for series amplifiers are added, not multiplied B1 [1]