MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

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 must be read in conjunction with the question papers and the report on the
examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2012 question papers for most IGCSE,
GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level
syllabuses.
Section A

1  

(a)  work done in bringing unit mass from infinity (to the point)  

\[ \text{B1} \] \[1\]

(b)  gravitational force is (always) attractive  

either  

as \( r \) decreases, object/mass/body does work  

or  

work is done by masses as they come together  

\[ \text{B1} \] \[2\]

(c)  

either \( \text{force on mass } = mg \) (where \( g \) is the acceleration of free fall /gravitational field strength)  

\[ g = \frac{GM}{r^2} \]  

if \( r \to h \), \( g \) is constant  

\[ \Delta E_p = \text{force} \times \text{distance moved} \]  

\[ = mgh \]  

or \[ \Delta E_p = m\Delta \phi \]  

\[ = \frac{GMMm}{r_2} \left( \frac{1}{r_1} - \frac{1}{r_2} \right) = \frac{GMM(r_2 - r_1)/r_1r_2}{r_2 - r_1} \]  

if \( r_2 \approx r_1 \), then \( r_2 - r_1 = h \) and \( r_1r_2 = r_2^2 \)  

\[ g = \frac{GM}{r^2} \]  

\[ \Delta E_p = mgh \]  

\[ \text{B1} \] \[A0\] \[4\]

(d)  \[ \frac{1}{2}mv^2 = m\Delta \phi \]  

\[ v^2 = 2 \times \frac{GM}{r} \]  

\[ = (2 \times 4.3 \times 10^{13}) / (3.4 \times 10^6) \]  

\[ v = 5.0 \times 10^3 \text{ m s}^{-1} \]  

(Use of diameter instead of radius to give \( v = 3.6 \times 10^3 \text{ m s}^{-1} \) scores 2 marks)

2  

(a)  

(i)  

either  

random motion  

or  

constant velocity until hits wall/other molecule  

\[ \text{B1} \] \[1\]

(ii)  

(total) volume of molecules is negligible  

compared to volume of containing vessel  

\[ \text{M1} \]  

or  

radius/diameter of a molecule is negligible  

compared to the average intermolecular distance  

\[ \text{A1} \]  

or \[ \text{(A1)} \] \[2\]

(b)  

either  

molecule has component of velocity in three directions  

or  

\( c^2 = c_x^2 + c_y^2 + c_z^2 \)  

random motion and averaging, so \( <c_x^2> = <c_y^2> = <c_z^2> \)  

\[ <c^2> = 3<c_x^2> \]  

so, \( pV = \frac{1}{2}Nm<c^2> \)  

\[ \text{M1} \]  

\[ \text{M1} \]  

\[ \text{A1} \]  

\[ \text{A0} \] \[3\]

(c)  

\( <c^2> \propto T \)  

or \( c_{\text{rms}} \propto \sqrt{T} \)  

temperatures are 300K and 373K  

\[ c_{\text{rms}} = 580 \text{ m s}^{-1} \]  

(Do not allow any marks for use of temperature in units of °C instead of K)  

\[ \text{C1} \]  

\[ \text{C1} \]  

\[ \text{A1} \] \[3\]
<table>
<thead>
<tr>
<th>Page 3</th>
<th>Mark Scheme: Teachers’ version</th>
<th>Syllabus</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCE AS/A LEVEL – May/June 2012</td>
<td>9702</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

3 (a) (numerically equal to) quantity of (thermal) energy required to change the state of unit mass of a substance without any change of temperature

′′Allow 1 mark for definition of specific latent heat of fusion/vaporisation′′

(b) either energy supplied  =  2400 × 2 × 60  =  288000 J
energy required for evaporation = 106 × 2260  =  240000 J

difference  =  48000 J
rate of loss  =  48000 / 120  =  400 W

or energy required for evaporation = 106 × 2260  =  240000 J
power required for evaporation = 240000 / (2 × 60) = 2000 W
rate of loss  =  2400 – 2000 = 400 W

4 (a)  
\[ a = (-\omega^2)x \] and \[ \omega = \frac{2\pi}{T} \]

\[ T = 0.60 \text{ s} \]
\[ a = \left(4\pi^2 \times 2.0 \times 10^{-2}\right) / (0.6)^2 \]
\[ a = 2.2 \text{ m s}^{-2} \]

(b) sinusoidal wave with all values positive

all values positive, all peaks at \( E_k \) and energy = 0 at \( t = 0 \)

period  =  0.30 s

5 (a) force per unit positive charge acting on a stationary charge

(b) (i) \[ E = \frac{Q}{4\pi\varepsilon_0 r^2} \]
\[ Q = 1.8 \times 10^4 \times 10^2 \times 4\pi \times 8.85 \times 10^{-12} \times (25 \times 10^{-2})^2 \]
\[ Q = 1.25 \times 10^{-5} \text{ C} = 12.5 \mu\text{C} \]

(ii) \[ V = \frac{Q}{4\pi\varepsilon_0 r} \]
\[ = \left(1.25 \times 10^{-5}\right) / (4\pi \times 8.85 \times 10^{-12} \times 25 \times 10^{-2}) \]
\[ = 4.5 \times 10^5 \text{V} \]

′′Do not allow use of \( V = Er \) unless explained′′
### 6 (a) (i) peak voltage = 4.0 V  
   A1 [1]

   (ii) r.m.s. voltage \((= 4.0/\sqrt{2})\) = 2.8 V  
   A1 [1]

   (iii) period \(T = 20 \text{ ms}\)  
   frequency = \(1 / (20 \times 10^{-3})\)  
   frequency = 50 Hz  
   A0 [2]

(b) (i) change = 4.0 – 2.4 = 1.6 V  
   A1 [1]

   (ii) \(\Delta Q = CV\)  
   \(Q = CV\)  
   = \(5.0 \times 10^{-6} \times 1.6 = 8.0 \times 10^{-6} \text{ C}\)  
   A1 [2]

   (iii) discharge time = 7 ms  
   current = \((8.0 \times 10^{-6}) / (7.0 \times 10^{-3})\)  
   = \(1.1(4) \times 10^{-3} \text{ A}\)  
   A0 [2]

(c) average p.d. = 3.2 V  
   resistance = \(3.2 / (1.1 \times 10^{-3})\)  
   = 2900 \(\Omega\) (allow 2800 \(\Omega\))  
   A1 [2]

### 7 (a) sketch: concentric circles (minimum of 3 circles)  
   separation increasing with distance from wire  
   correct direction  
   M1 A1 [3]

(b) (i) arrow direction from wire B towards wire A  
   B1 [1]

   (ii) either reference to Newton’s third law  
   or force on each wire proportional to product of the two currents  
   so forces are equal  
   M1 A1 [2]

(c) force always towards wire A/always in same direction  
   varies from zero (to a maximum value) (1)  
   variation is sinusoidal / \(\sin^2\) (1)  
   (at) twice frequency of current (1)  
   (any two, one each)  
   B2 [3]

### 8 (a) packet/quantum/discrete amount of energy  
   of electromagnetic radiation  
   M1 A1 [3]

   (allow 1 mark for ‘packet of electromagnetic radiation’)  
   energy = Planck constant \(\times\) frequency  
   (seen here or in b)  
   B1 [3]

(b) each (coloured) line corresponds to one wavelength/frequency  
   energy = Planck constant \(\times\) frequency  
   implies specific energy change between energy levels  
   so discrete levels  
   B1 A0 [2]
9 (a) (i) either probability of decay (of a nucleus) per unit time
or \( \lambda = (-)(dN/dt) / N \)

(ii) in time \( t_{\frac{1}{2}} \), number of nuclei changes from \( N_0 \) to \( \frac{1}{2}N_0 \)

\[
\frac{1}{2} = \exp(-\lambda t_{\frac{1}{2}}) \quad \text{or} \quad 2 = \exp(\lambda t_{\frac{1}{2}})
\]
\[
\ln \left( \frac{1}{2} \right) = -\lambda t_{\frac{1}{2}} \quad \text{and} \quad \ln \left( \frac{1}{2} \right) = -0.693 \quad \text{or} \quad \ln 2 = \lambda t_{\frac{1}{2}} \quad \text{and} \quad \ln 2 = 0.693
\]
\[
0.693 = \lambda t_{\frac{1}{2}}
\]

(b) \( 228 = 538 \exp(-8\lambda) \)
\( \lambda = 0.107 \text{ (hours}^{-1} \) \)
\( t_{\frac{1}{2}} = 6.5 \text{ hours (do not allow 3 or more SF)} \)

(c) e.g. random nature of decay
   background radiation
   daughter product is radioactive
   (any two sensible suggestions, 1 each)
Section B

10 (a) light-dependent resistor (allow LDR) B1 [1]

(b) (i) two resistors in series between +5 V line and earth M1
midpoint connected to inverting input of op-amp A1 [2]

(ii) relay coil between diode and earth M1
switch between lamp and earth A1 [2]

(c) (i) switch on/off mains supply using a low voltage/current output B1 [1]
(allow ‘isolates circuit from mains supply’)

(ii) relay will switch on for one polarity of output (voltage) C1
switches on when output (voltage) is negative A1 [2]

11 (a) (i) e.m. radiation produced whenever charged particle is accelerated M1
electrons hitting target have distribution of accelerations A1 [2]

(ii) either wavelength shorter/shortest for greater/greatest acceleration
or \[ \lambda_{\text{min}} = \frac{hc}{E_{\text{max}}} \]
or minimum wavelength for maximum energy B1
all electron energy given up in one collision/converted to single photon B1 [2]

(b) (i) hardness measures the penetration of the beam C1
greater hardness, greater penetration A1 [2]

(ii) controlled by changing the anode voltage C1
higher anode voltage, greater penetration/hardness A1 [2]

(c) (i) long-wavelength radiation more likely to be absorbed in the body/less B1 [1]
likely to penetrate through body

(ii) (aluminium) filter/metal foil placed in the X-ray beam B1 [1]

12 (a) strong uniform (magnetic) field M1
either aligns nuclei A1
or gives rise to Larmor/resonant frequency in r.f. region
non-uniform (magnetic) field M1
either enables nuclei to be located A1
or changes the Larmor/resonant frequency

(b) (i) difference in flux density = \( 2.0 \times 10^{-2} \times 3.0 \times 10^{-3} = 6.0 \times 10^{-5} \) T A1 [1]

(ii) \[ \Delta f = 2 \times c \times \Delta B \]
\[ = 2 \times 1.34 \times 10^8 \times 6.0 \times 10^{-5} \]
\[ = 1.6 \times 10^4 \) Hz A1 [2]
13 (a) (i) no interference (between signals) near boundaries (of cells)  

(ii) for large area, signal strength would have to be greater and this could be hazardous to health

(b) mobile phone is sending out an (identifying) signal

computer/cellular exchange continuously selects cell/base station with strongest signal

computer/cellular exchange allocates (carrier) frequency (and slot)