INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

MARKSCHEME

May 2000

PHYSICS

Higher Level

Paper 2

SECTION A

A1. (a) Work done $= Fd = \Delta(\text{KE}) = \frac{1}{2}mv^2$ ***[1]***

to give $F = \dfrac{mv^2}{d}$ ***[1]***

[2 max]

(b)

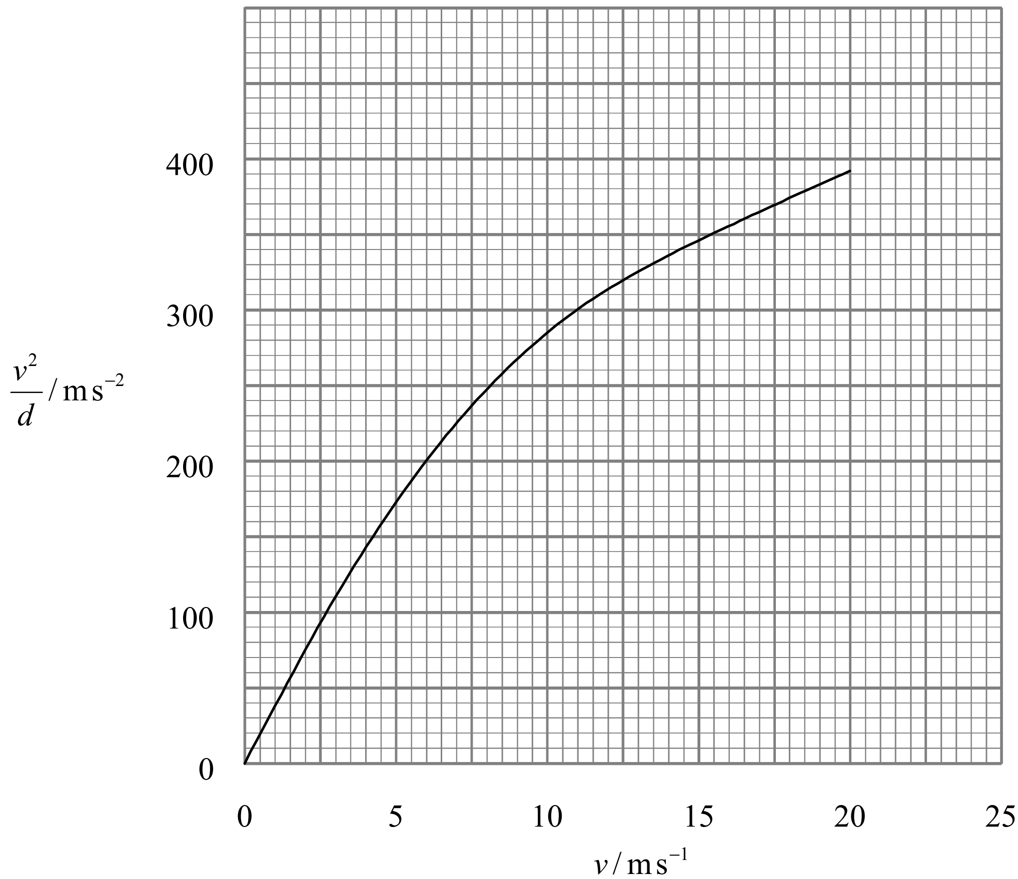
$v\,/\,\text{m s}^{-1}$	$d\,/\,\text{m}$	$\dfrac{v^2}{d}\,/\,\text{m s}^{-2}$
0	0	0
3.0	0.08	**113**
10.0	0.35	**286**
15.0	0.65	**346**
20.0	1.02	**392**

$\dfrac{v^2}{d}$ column *(All or nothing here!)* ***[1]***

[1 max]

Question A1 continued

(c)



correctly labelled axes **[1]**
appropriate scales **[1]**
data points **[1]**
line of best fit **[1]**
(If the point (0 , 0) is not shown deduct ***[1]****.*
If a straight line is drawn deduct ***[1]****.)* ***[4 max]***

(Do not penalise for plotting v against $\frac{v^2}{d}$*.)*

(d) from the graph $\frac{v^2}{d} = 330\ (\pm 20)$ **[1]**

to give $F = 2\times10^5$ N $(1.9 \rightarrow 2.1\times10^5$ N) **[1]**

[2 max]

(e) Using $F\Delta t = m\Delta v$
to give $\Delta t = 0.07$ s (0.06–0.08 s) **[1]**
[1 max]

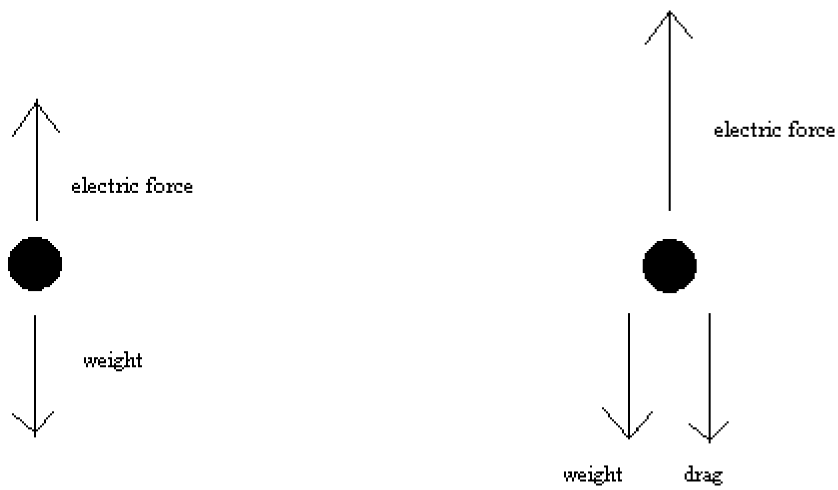
A2. (a) anticlockwise *[1]*
[1 max]

(b) Force $= BIl = 10^{-3}$ N *[1]*
Torque $= BIld = 10^{-4}$ N m *[1]*
[2 max]

(c) Initially there is no back emf *[1]*
As the coil rotates the magnetic flux linking the coil is changing *[1]*
this will induce an emf in the coil *[1]*
which is in a direction such as to oppose the current *[1]*
(Essentially the answer should show evidence of the understanding of induced emf's and the effect they will have on the current in the coil.) *[4 max]*

A3. (a) positive *[1]*
[1 max]

(b) V_1 V_2



[1] for each labelled force.
*(Deduct a mark if they are not nearly equal in magnitude **[2]**.)*

[1] for each labelled force.
*(Deduct **[1]** if the sum of the magnitudes of the drag force and the weight do not look closely equal to the electric force **[3]**.)*

[5 max]

(c) Electric force $= \dfrac{qV_2}{d}$ *[1]*

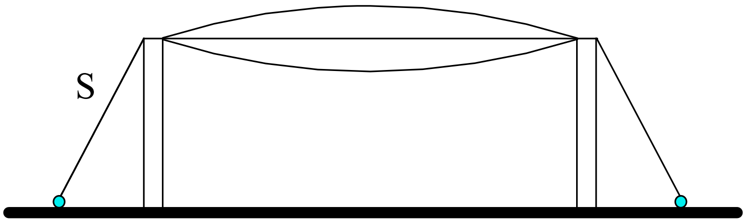
Electric force = weight + drag force *[1]*

weight $= \dfrac{qV_1}{d}$ *[1]*

Correct substitution to give $v = \dfrac{q}{kd}(V_2 - V_1)$ *[1]*

[4 max]

A4. (a)



[1]

(b) Tension in the string *[1]*
mass per unit length of the string *[1]*
distance between the supports A and B *[1]*
[3 max]

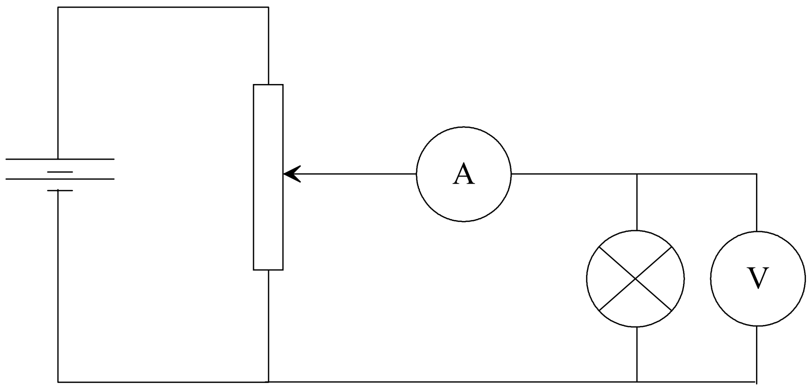
(c) Tension must increase by a factor of 4 *[1]*
mass per unit length decreased by a factor of 4 *[1]*
distance between A and B is halved *[1]*
[3 max]

(d) $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$
correct substitution to give $f = 50$ Hz *[1]*
[1 max]

SECTION B

B1. Part 1

(a)



Correct connection of rheostat to battery ***[1]***
Correct connection of lamp to rheostat ***[1]***
Correct position of ammeter ***[1]***
Correct position of voltmeter ***[1]***

(The essential thing here is that the rheostat is connected as a potential divider. If candidates connect it as a variable resistance then the maximum mark is ***[2]*** *and zero marks if connected as a variable resistor and the meters are connected incorrectly.)* ***[4 max]***

(b) (i) No ***[1]***
[1 max]

(ii) Resistance is the initial slope of the graph ***[1]***
$= \frac{1}{0.04} = 25\ \Omega \pm 2\ \Omega$ ***[1]***
[2 max]

(iii) power $= VI$ ***[1]***
$= 12 \times 0.2 = 2.4$ W ***[1]***
[2 max]

(c) (i) The battery has an internal resistance ***[1]***
of value comparable to the lamp resistance ***[1]***
(Essentially internal resistance must be mentioned and for the ***[1]*** *and for the other mark some idea of how it will affect the external p.d.)* ***[2 max]***

(ii) voltage drop across battery $= 1.2$ V ***[1]***
therefore pd "across" internal resistance $= 1.2$ V ***[1]***

therefore internal resistance $= \frac{1.2}{0.18} = 6.7\ \Omega$ ***[1]***

[3 max]

continued...

Question B1 Part 1 continued

(d) (i) $I_{\text{RMS}} = 0.25 \text{ A}$ ***[1]***

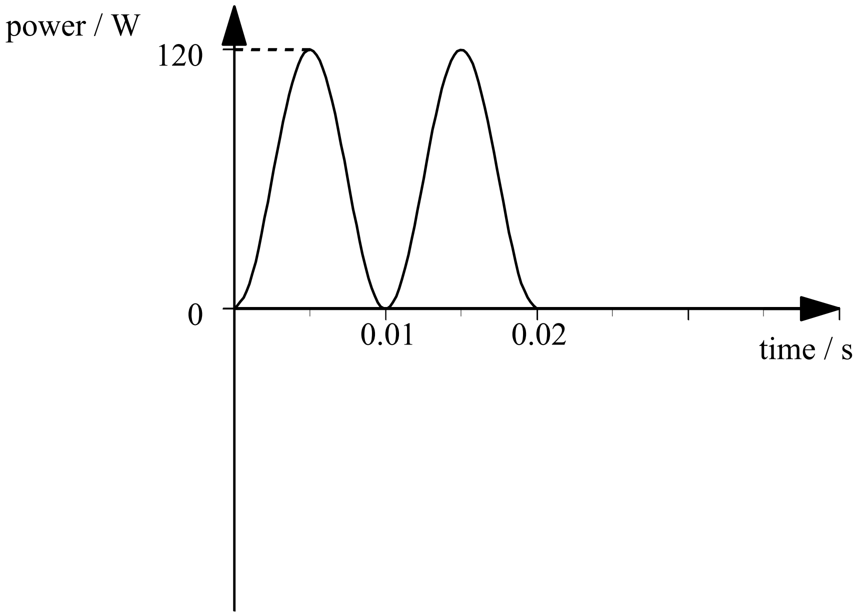
$I_{\max} = \sqrt{2} I_{\text{RMS}} = 0.35 \text{ A}$ ***[1]***

[2 max]

(ii) $P_{\max} = 2 \times P_{\text{average}} = 120 \text{ W}$ ***[1]***

[1 max]

(iii)



*(If a sine curve is drawn, then maximum mark is **[1]**.)*

$\sin^2$ graph ***[1]***

labelled axes ***[1]***

With correct position on time axis (1 cycle $= \frac{1}{50\text{th}}$ s) + max power ***[1]***

[3 max]

continued…

Question B1 continued

B1. Part 2

(a) (i) $B \to C$, ***[1]***
$C \to D$ ***[1]***
[2 max]

(ii) $A \to B$, ***[1]***
$D \to A$ ***[1]***
[2 max]

(b) From the area bounded by the graph ***[1]***
[1 max]

(c) $Eff = \dfrac{T_{\text{hot}} - T_{\text{cold}}}{T_{\text{hot}}}$

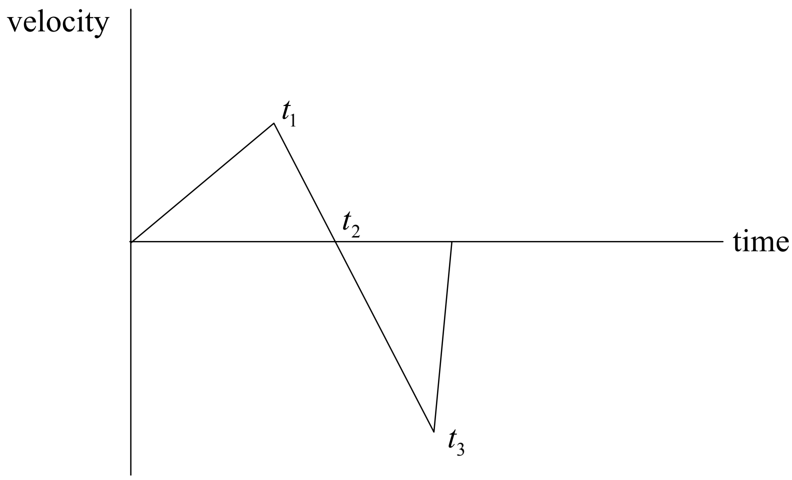
$= 50\,\%$ ***[1]***
[1 max]

(d) (i) increase in energy of the molecules of air in the ball and friction at the point of contact increases molecular motion ***[1]***
and thereby increasing disorder (entropy). ***[1]***
[2 max]

(ii) air molecules from inside balloon mix with outside air molecules ***[1]***
increasing the overall disorder (entropy). ***[1]***

(Accept that disorder implies entropy but 'disorder' needs to be mentioned somewhere.) ***[2 max]***

B2. (a) (i)



correctly labelled axes *[1]*
correct different slopes *[1]*
(steeper going down)
t_1 fuel out *[1]*
t_2 maximum height *[1]*
t_3 hits the ground *[1]*
velocity less at t_1 than at ground *[1]*
[6 max]

(ii) areas are equal to the distance travelled up and travelled down *[1]*
the areas are equal *[1]*
[2 max]

(b) (i) $v = at$ *[1]*
$= 40 \text{ m s}^{-1}$ *[1]*
[2 max]

(ii) height when fuel runs out $= \frac{1}{2}at^2$ *[1]*
$= 100 \text{ m}$ *[1]*
[2 max]

(iii) height reached after fuel runs out given by $v^2 = 2gs$ *[1]*
$= 80 \text{ m}$ *[1]*
maximum height $= 180$ m *[1]*
[3 max]

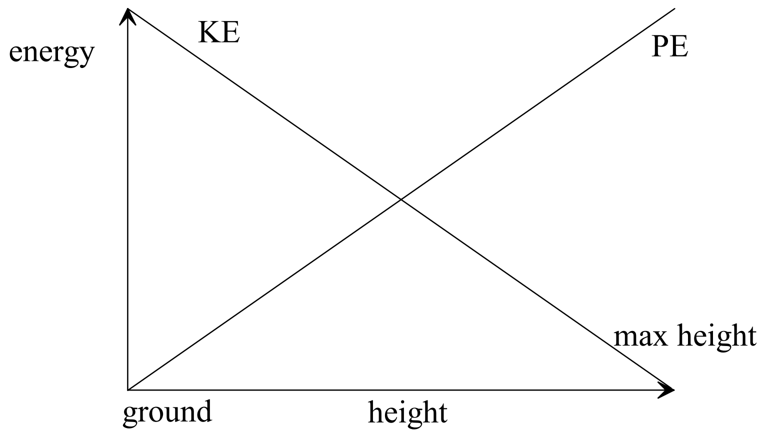
(iv) time to reach maximum height from time that fuel runs out
$\frac{40}{10} = 4.0$ s *[1]*
total time $= 5.0 + 4.0 = 9.0$ s *[1]*
[2 max]

(v) use $s = ut + \frac{1}{2}gt^2$ *[1]*
to give 6.0 s *[1]*
[2 max]

continued…

Question B2 continued

(c) (i)



labelled axes **[1]**
correct sketch for KE **[1]**
correct sketch for PE **[1]**
showing same slopes and max PE = max KE **[1]**
[4 max]

(ii) that the mass of the rocket does not change **[1]**
[1 max]

(d) when fuel runs out $m = 0.14$ kg **[1]**
$\text{KE} = \frac{1}{2}mv^2 = 112$ J **[1]**
[2 max]

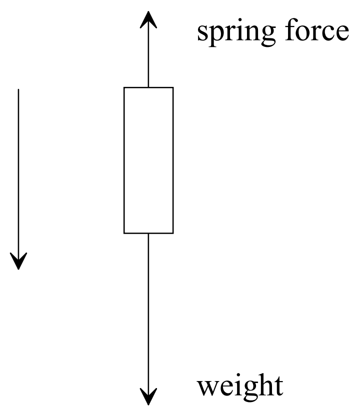
(e) max energy at 100 m = KE + PE = 252 J (or allow 272 J) **[1]**
therefore average power $= \frac{252}{5.0} = 50$ W (56 W) **[1]**
[2 max]

(f) Any sensible two effects *e.g.*
maximum height smaller, maximum velocity smaller, acceleration smaller
possibility of reaching terminal velocity when falling *etc.*
smaller acceleration when falling ***[2 max]***

B3. (a) The acceleration of the system is proportional to the displacement of the system from its equilibrium position ***[1]***
And is directed towards the equilibrium position. ***[1]***
(These are the two essential conditions for which to look.)

[2 max]

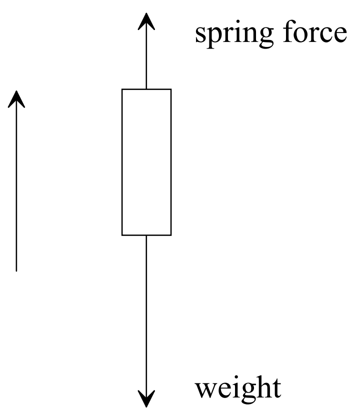
(b) (i)



spring force ***[1]***
weight ***[1]***
appropriate magnitudes and directions ***[1]***

[3 max]

(ii)



spring force and weight ***[1]***
appropriate magnitudes and directions ***[1]***

[2 max]

continued...

Question B3 continued

(c) (i) from the graph period $T = 0.5$ s **[1]**

$T = 2\pi\sqrt{\frac{m}{k}}$ **[1]**

To give $k = 47.3\ \mathrm{N\,m^{-1}}$ **[1]**

[3 max]

(ii) From the graph amplitude $a = 4$ cm **[1]**

$\omega = \frac{2\pi}{T}$ **[1]**

$\mathrm{KE_{max}} = \frac{1}{2} m a \omega^2$ **[1]**

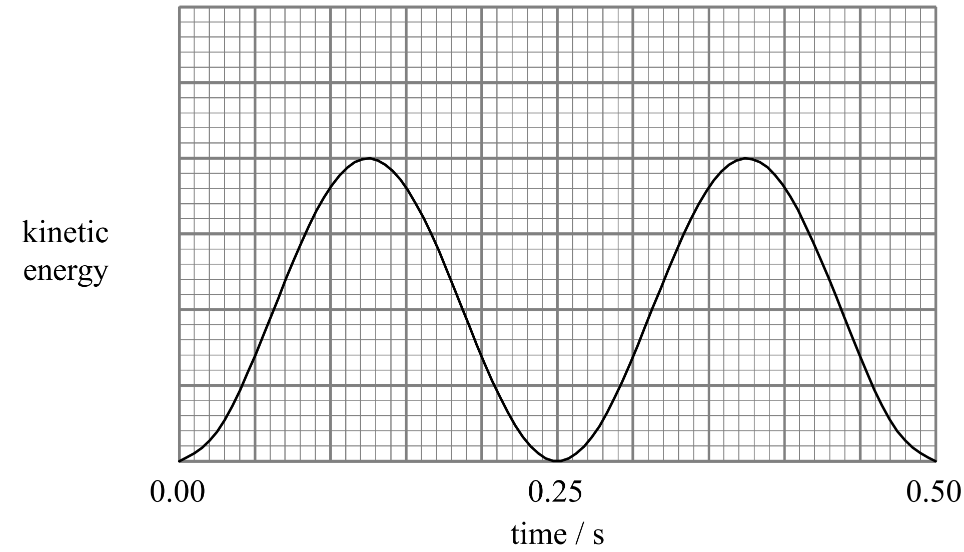
$= 0.038$ J **[1]**

or from $\mathrm{PE_{max}} = \mathrm{KE_{max}} = \frac{1}{2} k a^2$

or from finding the maximum velocity from the graph by measuring the gradient. **[4 max]**

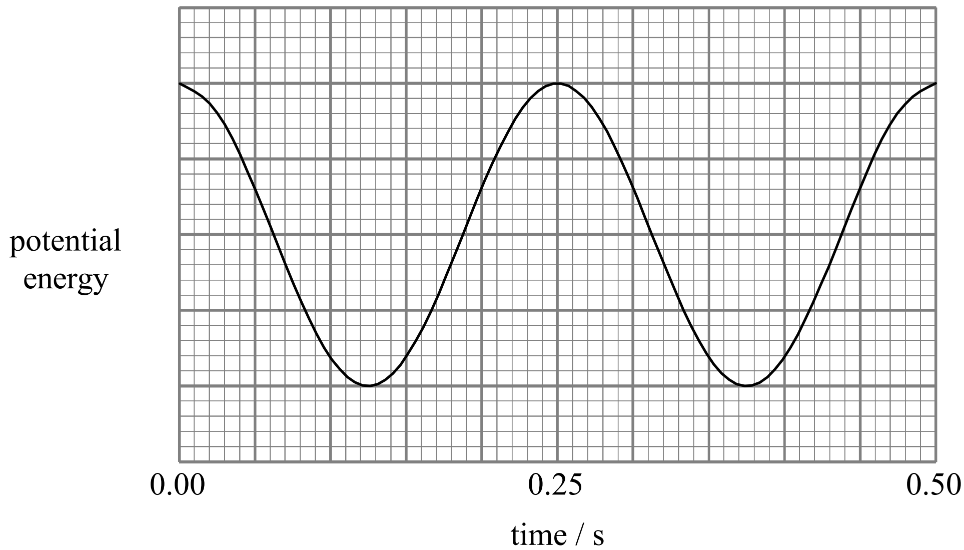
Question B3 continued

(d) (i)



One cycle of a $\sin^2$ graph or $\cos^2$ graph with zero for KE marked ***[1]***
correct position with respect to the x-axis scale ***[1]***
(No scale need to be shown on the y-axis.) ***[2 max]***

(ii)

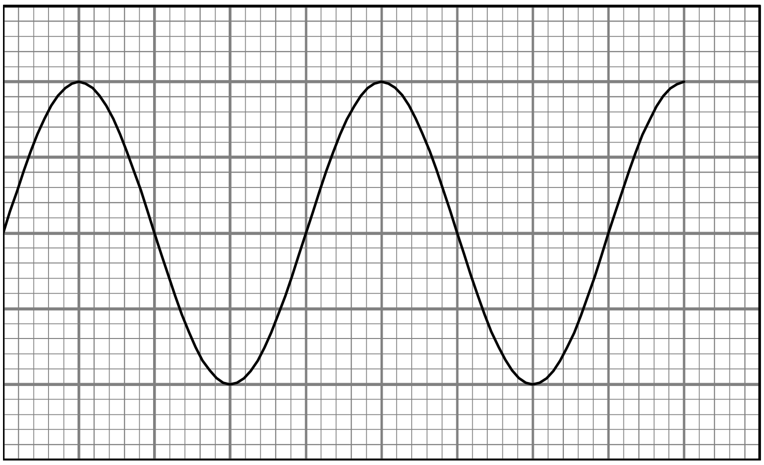


One cycle of a $\cos^2$ graph or $\sin^2$ graph (or $\cos^2/\sin^2$ drawn in (i)) ***[1]***
correct position with respect to the x-axis scale ***[1]***
shifted up the y-axis ***[1]***
[3 max]

continued…

Question B3 continued

(e) (i)



Sine or cosine graph (values need not be given on the axes) ***[1]***

[1 max]

(ii) stationary – zero points ***[1]***

maximum velocity – at a maximum or minimum point ***[1]***

[2 max]

(iii) Any three of:

the period of oscillation of the magnet

the amplitude of oscillation of the magnet

the strength of the magnet

the number of turns per unit length of the coil

the area of cross-section of the coil

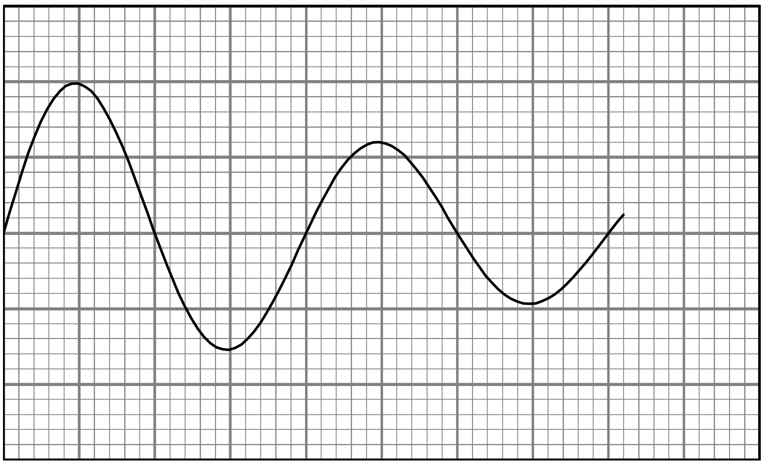
spring constant

mass of magnet ***[3 max]***

continued...

Question B3 continued

(f) (i)



sine or cosine graph ***[1]***
with decaying amplitude *(again values need not be shown on the axes. Be generous. This graph need not tie in with (e) (i).)* ***[1]***
[2 max]

(ii) A current now flows in the resistor ***[1]***
so energy is being dissipated ***[1]***
therefore the amplitude of oscillation of the magnet decays ***[1]***
[3 max]

B4. Part 1

(a) $^{4}\text{He} + {}^{9}\text{Be} = {}^{12}\text{C} + {}^{1}\text{n}$
correct balanced equation *[1]*
carbon *[1]*
[2 max]

(b) (i) The energy of the protons is measured by determining the thickness of aluminium required to just stop them reaching a detector. *[1]*
The mass of the proton is known *[1]*
therefore the velocity can be computed *[1]*
(Generally look for an answer that mentions absorption but accept deflection by an electric or magnetic field. (However, this is not the way that Chadwick did it.)) *[3 max]*

(ii) from the length of the tracks they leave *[1]*
the track length can be compared with track lengths left by ions of known speed *[2]*
i.e. track length and some idea of a control
[3 max]

(c) (i) $mv = MV - mv'$
momentum before *[1]*
momentum after *[1]*
(Watch out for correct sign.) *[2 max]*

(ii) $\frac{1}{2}mv^2 = \frac{1}{2}MV^2 + \frac{1}{2}mv'^2$
KE before *[1]*
KE after *[1]*
[2 max]

(d) for the proton $33 = \dfrac{2m_n v}{(m_n + m_p)}$ *[1]*

for the nitrogen $4.7 = \dfrac{2m_n v}{(m_n + 14m_p)}$ *[1]*

Division of the equations to eliminate v *[2]*

to give $m_n = 1.16\, m_p$ *[1]*

[5 max]

continued...

Question B4 continued

B4. Part 2.

(a) All particles have an associated wavelength ***[1]***

the value of which is given by $\lambda = \frac{h}{p}$ ***[1]***

where h is Planck's constant and p is the momentum of the particle
(*i.e.* look for the statement and the relationship and definition of terms.) ***[2 max]***

(b)

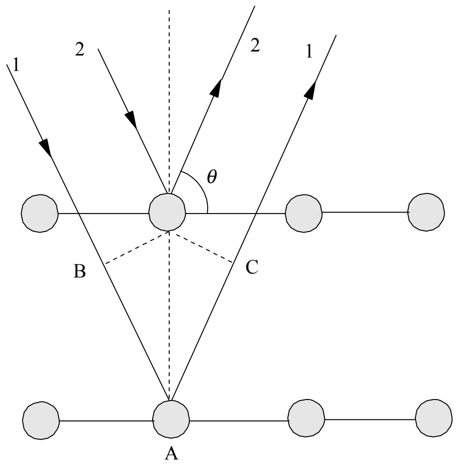


diagram should show two rays one scattered from one plane ***[1]***
one from the other ***[1]***
some indication of the path difference $(\mathrm{BA} + \mathrm{AC})$ ***[1]***
In the explanation look for
the two scattered waves have travelled different distances to the collector ***[1]***
If path difference is an integral number of λ then
the waves will reinforce ***[1]***
this will only occur for certain scattering angles θ ***[1]***
[6 max]

continued…

Question B4 Part 2 continued

(c) (i) Use $E = Ve = 150$ e **[1]**

$$E = \frac{p^2}{2m}$$ **[1]**

$$= \frac{h^2}{2m\lambda^2}$$ **[1]**

to give $\lambda \approx 10^{-10}$ m **[1]**

(or alternative method of calculation i.e. finding v then p.) ***[4 max]***

(ii) This wavelength is comparable to the lattice spacing. ***[1]***
[1 max]