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IBO

M02/430/H(2)M+

MARKSCHEME

May 2002

PHYSICS

Higher Level

Paper 2

17 pages

Subject Details: Physics HL Paper 2 Markscheme

General

A markscheme often has more specific points worthy of a mark than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

When deciding upon alternative answers by candidates to those given in the markscheme, consider the following points:

- Each marking point has a separate line and the end is signified by means of a semicolon (;).
- An alternative answer or wording is indicated in the markscheme by a "/"; either wording can be accepted.
- Words in (…) in the markscheme are not necessary to gain the mark.
- The order of points does not have to be as written (unless stated otherwise).
- If the candidate's answer has the same 'meaning' or can be clearly interpreted as being the same as that in the markscheme then award the mark.
- Mark positively. Give candidates credit for what they have achieved, and for what they have got correct, rather than penalising them for what they have not achieved or what they have got wrong.
- Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
- Occasionally, a part of a question may require a calculation whose answer is required for subsequent parts. If an error is made in the first part then it should be penalised. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded. Indicate this with **"ECF"**, error carried forward.
- Units should always be given where appropriate. Omission of units should only be penalised once. Indicate this by **"U-1"** at the first point it occurs. Ignore this, if marks for units are already specified in the markscheme.
- Deduct **1 mark in the paper** for gross sig dig error *i.e.* for an **error of 2 or more digits**.

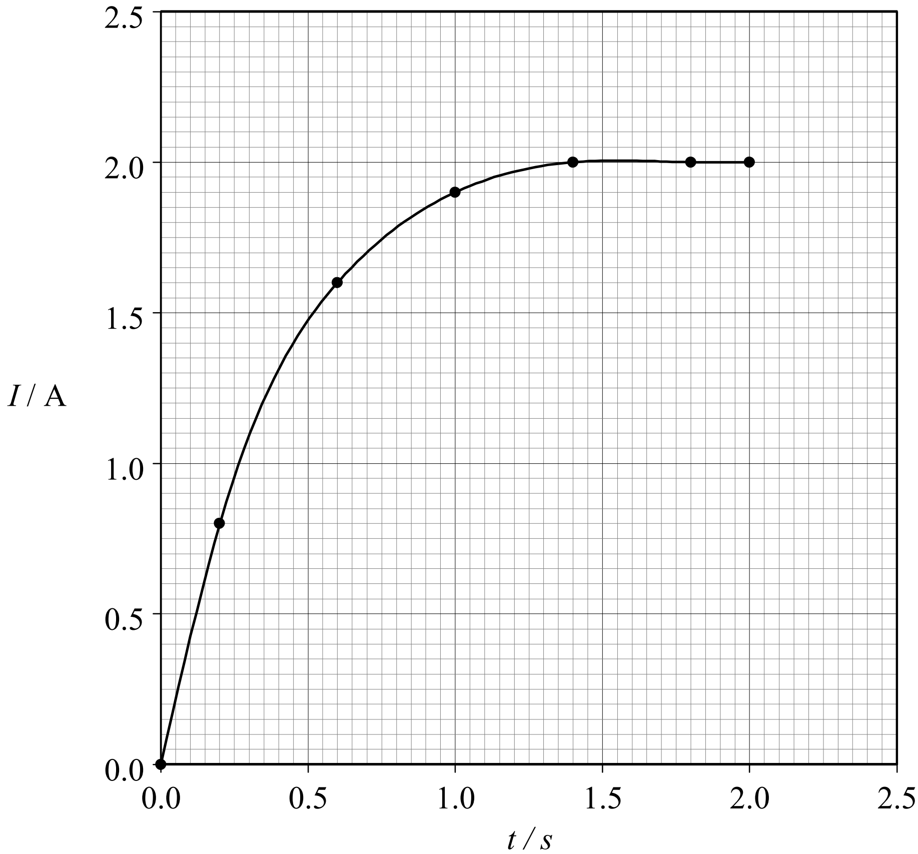
e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

Indicate the mark deduction by **"SD-1"**. However if a question specifically deals with uncertainties and significant digits, and marks for sig digs are already specified in the markscheme, then do <u>not</u> deduct again.

SECTION A

A1. (a)



appropriate size (at least half of grid); ***[1]***
axes labels (including units); ***[1]***
scale; ***[1]***
data points; ***[1]***
best fit line; ***[1]***
[max 5]

(b) 2.0 A ***[max 1]***

(c) 2.0 Ω ***[max 1]***

(d) suitable construction; ***[1]***
to give 0.4 s (allow ± 0.1); ***[1]***
[max 2]

(e) final value of the current = $\frac{V}{R}$; ***[1]***
time to reach maximum value = final value / rate of change; ***[1]***
$= \frac{V}{R} \div \frac{V}{L} = \frac{L}{R}$; ***[1]***
[max 3]

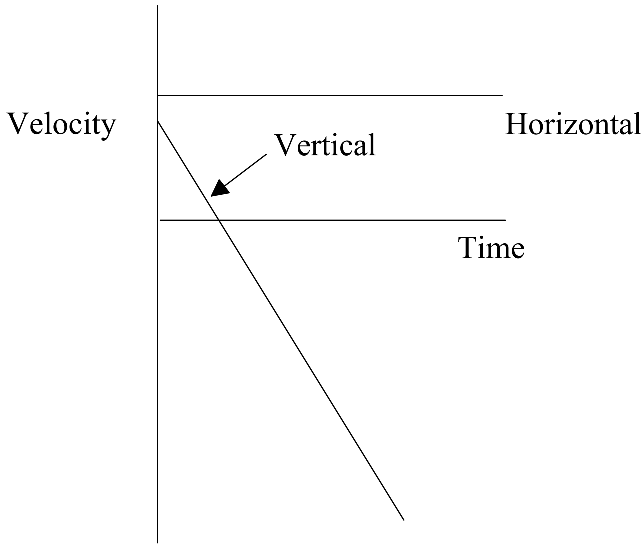
(f) $0.4 = \frac{L}{2.0}$;
to give L = 0.8 Ω s; ***[max 1]***

A2. (a) (i) use $v^2 = 2gh$; *[1]*
with $v = 12\cos 60 = 6.0\ \text{m s}^{-1}$; *[1]*
to give h = 1.8 m; *[1]*
above sea-level = 31.8 m; *[1]*
or
$v = 6.0\ \text{m s}^{-1}$; *[1]*
time to reach maximum height $= \frac{6.0}{10} = 0.6\,\text{s}$; *[1]*
height reached $= \frac{1}{2}vt = \frac{1}{2}\ (6.0)\times(0.6) = 1.8\,\text{m}$; *[1]*
max height above sea $= 30 + 1.8 = 32$ m; *[1]*
[max 4]

(ii) use $v^2 = u^2 + 2gh$ to find vertical speed with which stone hits sea with $u = 6.0\ \text{m s}^{-1}$; *[1]*

gives $v = 25\ \text{m s}^{-1}$; *[1]*
horizontal speed $= 12\cos 30 = 10\ \text{m s}^{-1}$; *[1]*
therefore speed $= \left\{(25)^2 + (10)^2\right\}^{1/2}$; *[1]*
$= 27\ \text{m s}^{-1}$; *[1]*
or they might use -30 = 12t-5t^2; *[1]*
or energy argument; *[1]*
[max 5]

(b)



correct vertical; *[1]*
correct horizontal; *[1]*
Do not penalise if the horizontal velocity is not shown to be greater than the vertical velocity.
[max 2]

A3. (a) (i) 6 V divides equally between R_B, R_C and R_D; *[1]*

therefore voltage across $R_C = 2$ V; *[1]*

or they might do it via current, total current $\frac{6}{7.5}$; *[1]*

$\frac{1}{4}$ of this flows through R_C therefore voltage across $R_C = \left(\frac{6}{7.5}\right) \times \frac{1}{4} \times 10 = 2$ V; *[1]*

[max 2]

(ii) 3 V ***[max 1]***

(iii) connect voltmeter across R_B and then R_D; *[1]*

the connection that gives a zero reading indicates which resistor is short circuit; *[1]*

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[max 2]

(b) R_C has gone open circuit; *[1]*

and R_B and R_D have both gone short circuit; *[1]*

[max 2]

A4. (a) energy $= Ve = 2.5 \times 1.6 \times 10^{-19}$ J $= 4.0 \times 10^{-19}$ J *(Accept 2.5 eV)* ***[max 1]***

(b) use $E = hf$; *[1]*

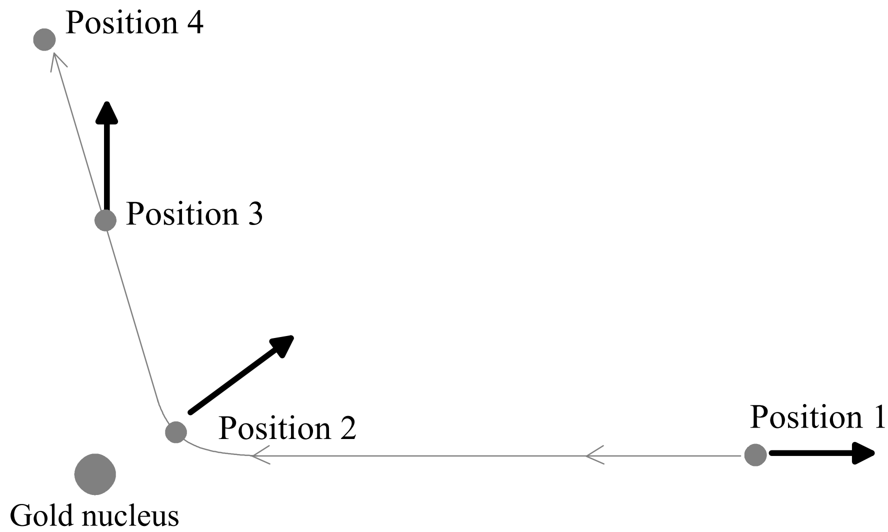
and $f = \frac{c}{\lambda}$; *[1]*

to give $h = \frac{(4.0 \times 10^{-19}) \times (4.8 \times 10^{-7})}{(3 \times 10^{8})} = 6.4 \times 10^{-34}$ J s; *[1]*

[max 3]

SECTION B

B1. (a)



[1] for each correct direction; ***[max 3]***

(b) (i) $4.2\text{ MeV} = 4.2\times10^{6}\times1.6\times10^{-19} = 6.7\times10^{-13}\text{ J}$; ***[2]***

i.e. ***[1]*** *for the* 10^{6} *and* ***[1]*** *for the* 1.6×10^{-19}

[max 2]

(ii) $p^{2} = 2Em$; ***[1]***

$= 6.7\times10^{-13}\times2\times6.6\times10^{-27}$; ***[1]***

to give $p = 9.4\times10^{-20}\text{ N s}$; ***[1]***

Or they might calculate from finding the velocity v.

$\text{KE} = \frac{1}{2}mv^{2}$;

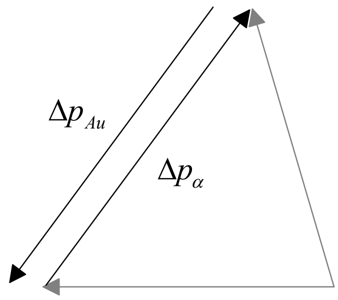
$v = \sqrt{\frac{2E}{m}}$; ***[1]***

$= 1.4\times10^{7}\text{ m s}^{-1}$; ***[1]***

$p = mv = 9.4\times10^{-20}\text{ N s}$; ***[1]***

[max 3]

(c)



completion of triangle; ***[1]***
correct direction; ***[1]***
measurement to give 11.6×10^{-20} N s / 11.6 cm; ***[1]***
[max 3]

(d) vector should be same length as Δp_{α}; ***[1]***
in the opposite direction to Δp_{α}; ***[1]***
[max 2]

(e) calculation from finding the speed:

$v=\dfrac{p}{m}$; ***[1]***

$=\dfrac{11.6\times10^{-20}}{3.2\times10^{-25}}$; ***[1]***

$=3.6\times10^{5}\ \mathrm{m\,s^{-1}}$; ***[1]***

KE $=\dfrac{1}{2}mv^2=21\times10^{-15}$ J; ***[1]***

or, more elegantly

$\Delta E=\dfrac{p^2}{2m}$; ***[2]***

$=\dfrac{(11.6)^2\times10^{-40}}{6.4\times10^{-25}}$; ***[1]***

$=21\times10^{-15}$ J; ***[1]***
[max 4]

(f) $\dfrac{\text{KE of gold nucleus}}{\text{KE of }\alpha\text{-particle}} = \dfrac{21\times10^{-15}}{6.7\times10^{-13}}$; ***[1]***

= 3 %; ***[1]***

so yes they were justified since this is a very small fraction of the α energy; ***[1]***

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Or argument in terms of momentum change of gold nucleus.

[max 3]

(g) (i) at d the α is momentarily at rest; ***[1]***

so all the KE is has been converted into electrostatic potential energy; ***[1]***

brought to rest because of the repulsive force acting on it; ***[1]***

*Some explanation is required in terms of the force acting on it for “changed to PE” would get just **[1]**.* ***[2]***

[max 3]

(ii) potential due to gold nucleus at distance $d = \dfrac{Ze}{4\pi\varepsilon_0 d}$; ***[1]***

$= \dfrac{79e}{4\pi\varepsilon_0 d}$; ***[1]***

therefore PE of α at $d = \dfrac{79e\times2e}{4\pi\varepsilon_0 d}$; ***[1]***

therefore $= \dfrac{79e\times2e}{4\pi\varepsilon_0 d} = 6.7\times10^{-13}$; ***[1]***

so $d = \dfrac{79e\times2e}{4\pi\varepsilon_0\times6.7\times10^{-13}}$; ***[1]***

$= \dfrac{79\times2\times(1.6)^2\times10^{-38}}{4\times3.14\times8.85\times10^{-12}\times6.7\times10^{-13}}$; ***[1]***

$\approx 5\times10^{-14}$ m; ***[1]***

[max 7]

B2. Part 1. Ideal gas behaviour

(a) *Award **[1]** if **measure** is omitted, **[1]** if **average** is omitted and **[1]** if **kinetic** is omitted.*
temperature is a measure of the average kinetic energy of the molecules; ***[2]***

*Award **[1]** if **total** is omitted.*
internal energy is the total energy of the molecules; ***[2]***

[max 4]

(b) (i) shifted right ***[max 1]***
Just look for this and no other features.

(ii) $\frac{p_1}{p_2} = \frac{T_1}{T_2}$ with $T_1 = 300$ K; ***[1]***
to give $T_2 = 600$ K; ***[1]***
*Award **[1]** if K not used, 54 °C.*

recognise that change in internal energy $= ms\Delta\theta$; ***[1]***
$= 4.0 \times 10^{-3} \times 3.1 \times 10^{3} \times 300$; ***[1]***
$= 3.7 \times 10^{3}$ J; ***[1]***
*335 J if 27 °C used, 7.4×10^{3} J if 600 K used – award **[2]**, award **[1]** if 54 °C used – 670 J.*

[max 5]

(c) (i) zero ***[max 1]***

(ii) $p_1V_1 = p_2V_2$; ***[1]***
with $p_1 = 2.0 \times 10^{5}$ Pa and $V_1 = 2V_2$; ***[1]***
to give $p_2 = 4.0 \times 10^{5}$ Pa; ***[1]***
[max 3]

(d) 3500 J ***[max 1]***

B2. Part 2. Magnetic forces

(a) $v\Delta t$ ***[max 1]***

(b) number of particles per unit length $= \frac{N}{L}$; ***[1]***

therefore number in length $v\Delta t = \frac{Nv\Delta t}{L}$; ***[1]***

[max 2]

(c) $\Delta q = \frac{Nvq\Delta t}{L}$; ***[1]***

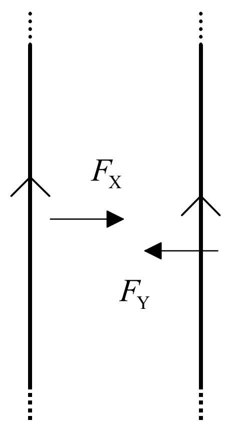
$I = \frac{\Delta q}{\Delta t} = \frac{Nvq}{L}$; ***[1]***

[max 2]

(d) upwards ***[max 1]***

(e) force on N particles $= NBqv$; ***[1]***
but from (c) $Nqv = IL$; ***[1]***
substitute to get $F = BIL$; ***[1]***
[max 3]

(f) (i)



direction of F_X and direction of F_Y; ***[max 1]***

(ii) $F_X = F_Y$; ***[1]***

$\frac{F}{l} = \frac{\mu_0 I^2}{2\pi r} = 1.6 \times 10^{-6}\,\text{N m}^{-1}$; ***[1]***

[max 2]

(iii) Y will move towards X with increasing velocity; ***[1]***
and increasing acceleration; ***[1]***
because the force is increasing as it approaches X; ***[1]***
OWTTE

[max 3]

B3. Part 1. Waves in a rubber cord

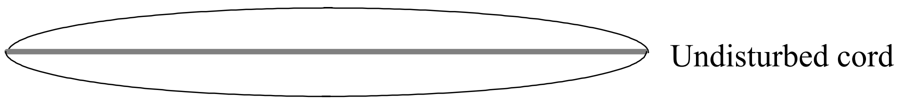
(a) (i) 10 cm ***[max 1]***

(ii) 60 cm ***[max 1]***

(b) $v = f\lambda = \frac{\lambda}{T}$; ***[1]***
$= 3.0 \text{ m s}^{-1}$; ***[1]***
[max 2]

(c) 0.1 s is half a period; ***[1]***
therefore wave has moved forward 30 cm; ***[1]***
therefore –ve sine; ***[1]***
i.e. ***[1]*** *for correct sketch.*
[max 3]

(d) (i)



[max 1]

(ii) mass per unit length $\frac{1.25}{2.5} = 0.5 \text{ kg m}^{-1}$; ***[1]***
$v = \sqrt{\frac{T}{\mu}}$ to give $v = 10 \text{ m s}^{-1}$; ***[1]***
λ of fundamental = 5.0 m; ***[1]***
$f = \frac{v}{\lambda}$; ***[1]***
= 2.0 Hz; ***[1]***
[max 5]

(iii) 4.0 Hz ***[max 1]***

B3. Part 2. Radioactive decay

(a) half-life → The time for the activity of a radioactive sample to decrease to half its initial activity ***[max 1]***
OWTTE

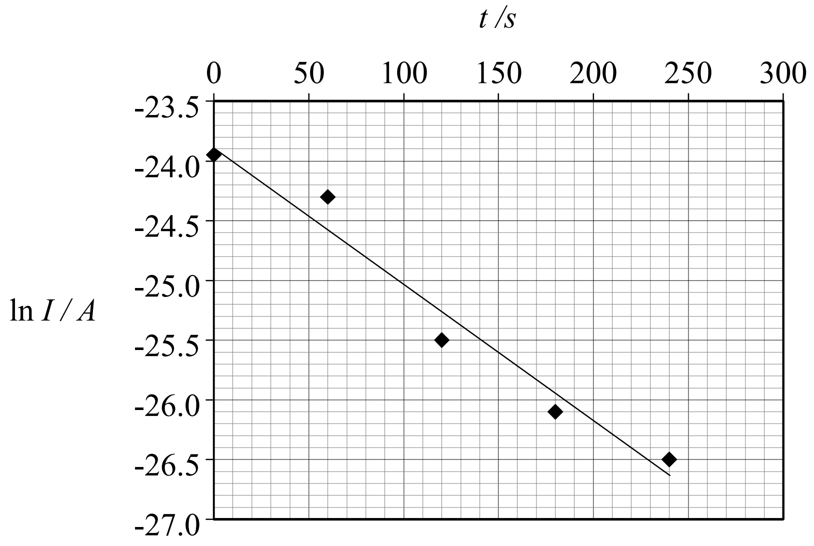
(b) (i) Z = 84 ***[max 1]***

(ii) A = 216; ***[1]***
A – Z = 132; ***[1]***
[max 2]

(c) $N = \frac{N_0}{2}$; ***[1]***
therefore $\frac{N_0}{2} = N_0 e^{-\lambda t_{1/2}}$; ***[1]***
therefore $e^{-\lambda t_{1/2}} = 2$; ***[1]***
so $t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$; ***[1]***
[max 4]

(d) the radiation "knocks off" electrons from neutral atoms; ***[1]***
thus creating an ion pair-free electron and positive ion; ***[1]***
OWTTE
[max 2]

(e) (i) look for a sensible best fit line ***[max 1]***



(ii) recognise that λ = slope of the graph; *(Do not worry about negative sign.)* ***[1]***
suitable choice of values of ΔI and Δt; ***[1]***
to get $\lambda = 0.012\,\text{s}^{-1}\,(\pm 0.002)$; ***[1]***
[max 3]

(iii) $t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$; ***[1]***
= 58 s (49 s to 69 s); ***[1]***
[max 2]

B4. Part 1. The bouncing ball

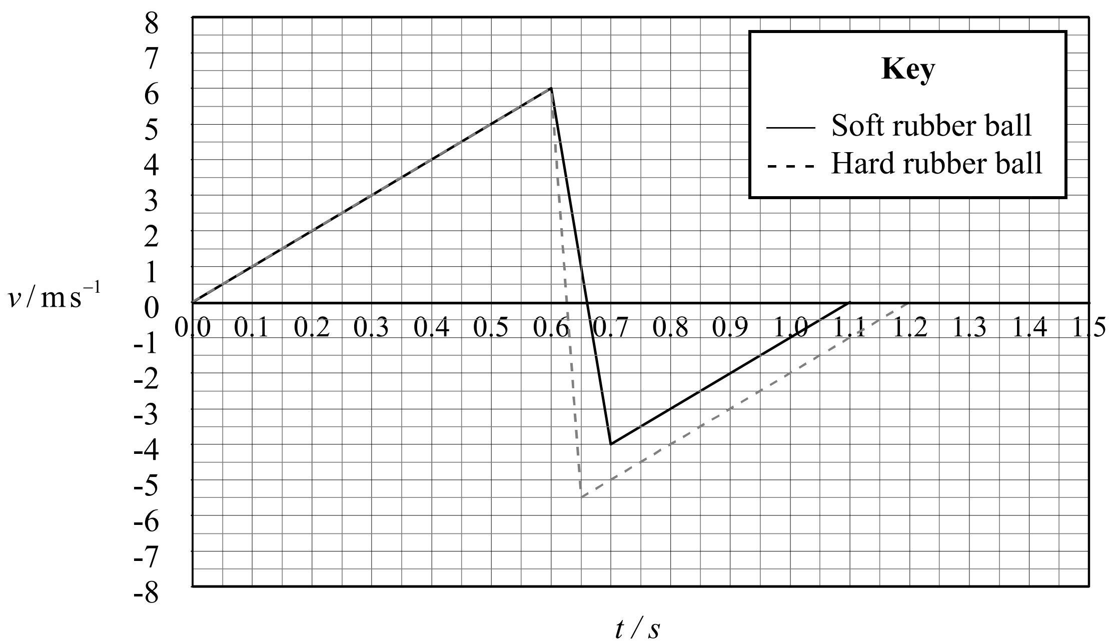
(a) $t_1 = 0.6\,\text{s}$ position; ***[1]***
$t_2 = 0.7\,\text{s}$ position; ***[1]***
[max 2]

(b) momentum at $t_1 = 0.2 \times 6.0 = 1.2\,\text{N s}$; ***[1]***
momentum at $t_2 = 0.2 \times -4.0 = -0.8\,\text{N s}$; ***[1]***
change in momentum = 2.0 N s; ***[1]***
[max 3]

(c) F = rate of change of momentum; ***[1]***
from the graph time = 0.1 s; ***[1]***
therefore $F = \frac{2.0}{0.1}$; ***[1]***
= 20 N; ***[1]***
(ECF $\Delta p = 0.4$ N s $F = 4$ N)
[max 4]

(d) Look for an answer which shows that they understand that it is the system comprising the ball and the Earth in which momentum is conserved. If they recognise that the collision is inelastic but can get no further award ***[1]***.
[max 2]

(e)



0 → 0.6 s is the same; ***[1]***
shorter contact time; ***[1]***
speed greater leaving floor; ***[1]***
same slope for rebound; ***[1]***
longer time to reach max rebound height; ***[1]***
[max 5]

B4. Part 2. The refrigerator

(a) Q_c : a → b; *(If they give two stages even if one is correct award zero.)* ***[1]***
the refrigerant has undergone an isothermal expansion; ***[1]***
to maintain constant temperature energy must be absorbed; ***[1]***
Q_h : c → d; *(If they give two stages even if one is correct award zero.)* ***[1]***
the refrigerant has undergone an isothermal compression; ***[1]***
to maintain constant temperature energy must be ejected; ***[1]***
The explanations should indicate something to the effect that the changes take place at constant temperature.

[max 6]

(b) $cop = \frac{Q_c}{W} = \frac{Q_h - W}{W}$; ***[1]***
therefore $\frac{Q_h}{W} - 1 = 5$; ***[1]***
to give $Q_h = 6W$; ***[1]***
therefore for every unit of *W* 6 units of energy are ejected; ***[1]***
[max 4]

(c) (i) the outside of the house ***[max 1]***

(ii) the maximum possible efficiency of a conventional heating element is 100 %; ***[1]***
since the *cop* is greater than 1 for a heat pump; ***[1]***
this can be done with efficiencies greater than 100 %; ***[1]***
OWTTE
Look for an answer that convincingly compares efficiencies.

[max 3]