IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
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M05/4/PHYSI/SP2/ENG/TZ1/XX/M+

MARKSCHEME

May 2005

PHYSICS

Standard Level

Paper 2

13 pages

Subject Details: Physics SL 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 penalizing them for what they have not achieved or what they have got wrong.
- 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 penalized. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded.
- Units should always be given where appropriate. Omission of units should only be penalized once. 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**.

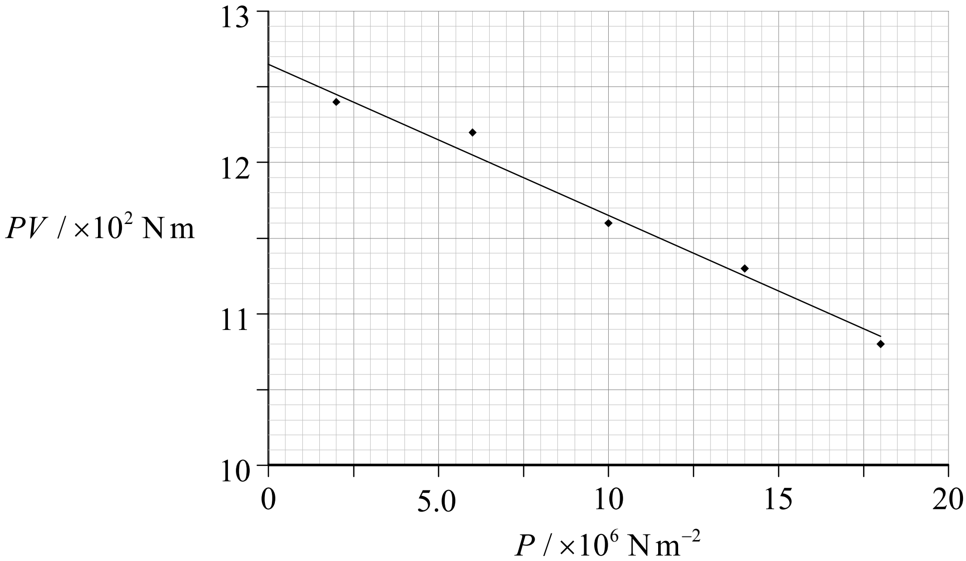
e.g. if the answer is 1.63:

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

However, if a question specifically deals with uncertainties and significant digits, and marks for sig digs are already specified in the markscheme, then do **not** deduct again.

SECTION A

A1.



(a) suitable straight-line of best fit; ***[1]***

(b) A is the intercept on the y-axis consistent with line drawn (or by implication);
$= 12.6 = 1.3 \times 10^3$ N m the best fit line should give a 2 SD value of 1.3×10^3 N m;
B is the gradient;
some evidence that reasonable values have been used $(y_2 - y_1 > 0.9, x_2 - x_1 > 8)$;
$= -1.0(\pm 0.1) \times 10^{-5}$; ***[5]***
*Accept answers based on using two data points on line. Award **[3 max]** if points not on line. Ignore any missing units and do not penalize if minus sign is omitted. Award **[1]** for determination of B if only one data point is used.*

(c) $B = 0$; ***[1]***

(d) (i) substitute into $PV = A + BP$
$PV = 1300 - (1.0 \times 10^{-5} \times 6.0 \times 10^7)$;
$= 700(640 \rightarrow 760)$ N m; ***[2]***
$= 1.9(\pm 0.5) \times 10^3$ N m *if BP is added instead of subtracted.*
*Award **[1]** for ECF.*

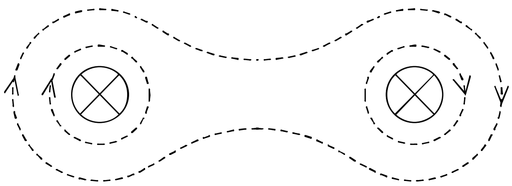
(ii) recognize that the ideal gas value is the intercept on the y-axis;
or
from $PV = RT$;
or
$=$ constant A;
difference $600(540 \rightarrow 660)$ N m; ***[2]***

A2. (a) momentum of object $= 2\times10^3 \times 6.0$;
momentum after collision $= 2.4\times10^3 \times v$;
use conservation of momentum, $2\times10^3 \times 6.0 = 2.4\times10^3 \times v$;
to get $v = 5.0\,\text{m}\,\text{s}^{-1}$; ***[4]***
*Award **[2 max]** for mass after collision $= 400\,kg$ and $v = 30\,m\,s^{-1}$.*

(b) KE of object and bar + change in PE $= 1.2\times10^3 \times 25 + 2.4\times10^3 \times 10 \times 0.75$;
use $\Delta E = Fd, 4.8\times10^4 = F\times0.75$;
to give $F = 64\,\text{kN}$;
*Award **[2 max]** if PE missed* $F = 40\,\text{kN}$.
or
$a = \dfrac{v2}{2s}$;
$F - mg = ma$;
to give $F = 64\,\text{kN}$; ***[3]***
*Award **[2 max]** if mg missed.*

A3. (a) (i) $\rightarrow\leftarrow$; ***[1]***

(ii)



general shape: at least one circle around each wire and one loop around both wires;
appropriate spacing of lines: increasing separation with distance from wires;
correct direction of field; ***[3]***

(b) velocity increases;
acceleration increases;
because the force is getting larger the closer the wires get together; ***[3]***
Watch for ECF if force is drawn in wrong direction in (a) (i) i.e. velocity increases, acceleration decreases, force gets smaller.

SECTION B

B1. Part 1

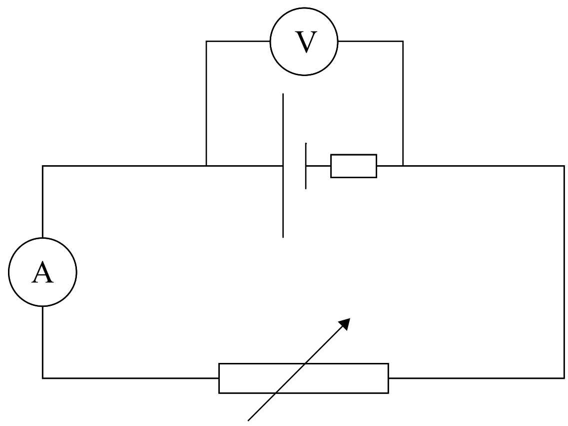
(a) (i) EI; ***[1]***

(ii) $I^2 r$; ***[1]***

(iii) VI; ***[1]***

(b) (from the conservation of energy), $EI = I^2 r + VI$;
therefore, $V = E - Ir$ / $E = V + Ir$; ***[2]***

(c)



correct position of voltmeter;
correct position of ammeter;
correct position of variable resistor; ***[3]***

(d) (i) $E = V$ when $I = 0$;
so $E = 1.5\,\mathrm{V}$; ***[2]***

(ii) recognize this is when $V = 0$;
intercept on the *x*-axis $= 1.3\,(\pm 0.1)\,\mathrm{A}$; ***[2]***

(iii) r is the slope of the graph;
sensible choice of triangle, at least half the line as hypotenuse;
$= \frac{0.7}{0.6}$;
$= 1.2\,(\pm 0.1)\,\Omega$
or
when $V = 0$ $E = Ir$;
$r = \frac{E}{I}$;
$= \frac{1.5}{1.3}$;
$= 1.2\,\Omega$ ***[3]***

(e) $R = 1.2\,\Omega$;
$I = \frac{1.5}{1.2 + 1.2} = 0.63\,\mathrm{A}$;
$P = I^2 R = (0.63)^2 \times 1.2 = 0.48\,\mathrm{W}$ / $0.47\,\mathrm{W}$; ***[3]***

B1. Part 2

(a) the amount of energy / heat required to raise the temperature of a substance / object through 1K / °C ; ***[1]***

(b) (i) to ensure that the temperature of the metal does not change during the transfer / negligible thermal energy / heat is lost during the transfer; ***[1]***
Do not accept metal and water at same temperature.

(ii) to ensure that all parts of the water reach the same temperature; ***[1]***

(c) energy lost by metal $= 82.7 \times (T - 353)\,\text{J}$;
energy gained by water $= 5.46 \times 10^2 \times 65\,\text{J}$;
energy gained by calorimeter $= 54.6 \times 65\,\text{J}$;
equate energy lost to energy gained to get $T = 825\,\text{K}$; ***[4]***
*Award **[2 max]** if any energy term is missed.*

B2. Part 1

(a) if the total external force acting upon a system is zero / for an isolated system;
the momentum of the system is constant; ***[2]***
*Award **[1 max]** if the answer is in terms of collisions.*

(b) 131 g of xenon contains $6.02\times10^{23} / N_A$ atoms;
mass of 1 atom $= \dfrac{131}{6.02\times10^{23}} = 2.2\times10^{-22}\,\text{g} = 2.2\times10^{-25}\,\text{kg}$;
or
mass of nucleon 1.66×10^{-27} kg;
mass of xenon atom $= 131\times1.66\times10^{-27}\,\text{kg} = 2.2\times10^{-25}\,\text{kg}$; ***[2]***

(c) time $= 1.5\times3.2\times10^{7} = 4.8\times10^{7}$ s;
no of atoms per second $= \dfrac{81}{2.2\times10^{-25}\times4.8\times10^{7}} = 7.7\times10^{18}\,\text{s}^{-1}$;
or
no of atoms in original mass $= \dfrac{81}{2.2\times10^{-25}} = 3.7\times10^{26}$;
time $= \dfrac{3.7\times10^{26}}{7.7\times10^{18}} = 4.8\times10^{7}\,\text{s} = 1.5$ years; ***[2]***

(d) rate of change of momentum of the xenon atoms
$= 7.7\times10^{18}\times2.2\times10^{-25}\times3.0\times10^{4}$;
$= 5.1\times10^{-2}\,\text{N}$;
$=$ mass $\times$ acceleration;
where mass $= (540+81)$ kg;
to give acceleration of spaceship $= \dfrac{5.1\times10^{-2}}{6.2\times10^{2}}$;
$= (8.2\times10^{-5}\,\text{m s}^{-2})$ ***[5]***
Accept if mass of fuel omitted $\left(=9.4\times10^{-5}\,\text{m s}^{-2}\right)$.

(e) $a = \dfrac{F}{m}$;
since m is <u>decreasing</u> with time, then a will be <u>increasing</u> with time; ***[2]***

(f) change in speed = area under graph;
$= (8.2 \times 4.8) \times 10^{2} + \frac{1}{2}(4.8 \times 1.3) \times 10^{2}$;
final speed $= (8.2 \times 4.8) \times 10^{2} + \frac{1}{2}(4.8 \times 1.3) \times 10^{2} + 1.2 \times 10^{3}$;
$5.4 \times 10^{3}\,\mathrm{m\,s^{-1}}$;
or
use of $v = u + at$
$u = 1.2 \times 10^{3}\,\mathrm{m\,s^{-1}}$;
average acceleration from the graph $= \frac{1}{2}(8.2 + 9.45) \times 10^{-5}$;
$= 8.8 \times 10^{-5}\,\mathrm{m\,s^{-2}}$;
final speed $= 4.8 \times 10^{7} \times 8.8 \times 10^{-5} + 1.2 \times 10^{3} = 5.4 \times 10^{3}\,\mathrm{m\,s^{-1}}$; ***[4]***

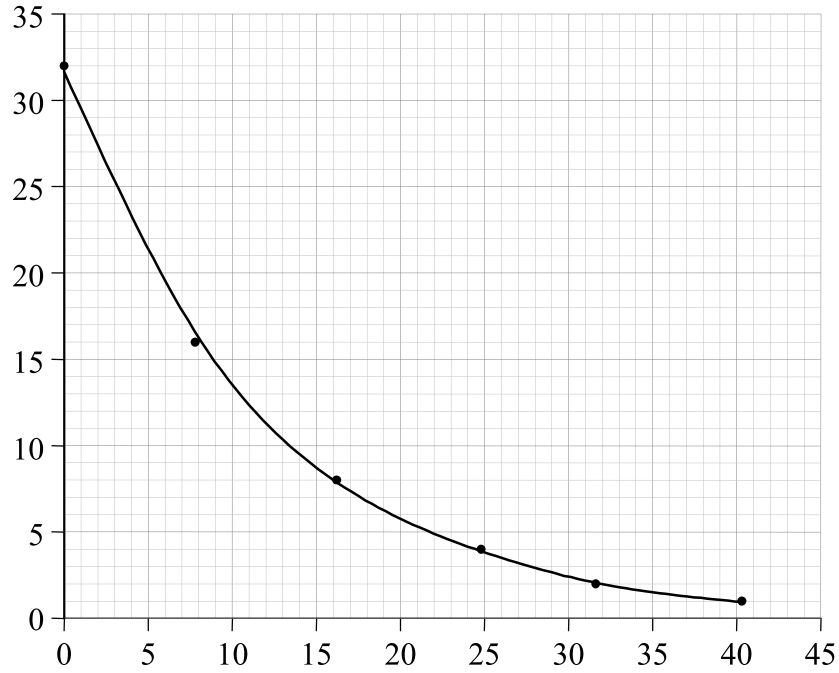
(g) $t = \frac{s}{v} = \frac{4.7 \times 10^{11}}{5.4 \times 10^{3}} = 8.7 \times 10^{7}\,\mathrm{s}$;
so total time $4.8 \times 10^{7} + 8.7 \times 10^{7}\,\mathrm{s} \approx 4.2\,\mathrm{y}$; ***[2]***

B2. Part 2

(a) the nuclei of different isotopes of an element have the same number of protons;
but different numbers of neutrons; ***[2]***
Look for a little more detail than say just "same atomic (proton) number, different mass (nucleon) number".

(b) Z for iodine = 53;
+ antineutrino; *(accept symbol)* ***[2]***
Accept neutrino or gamma or energy.

(c)



sensible line of best fit (must go through at least 3 data points); ***[1]***

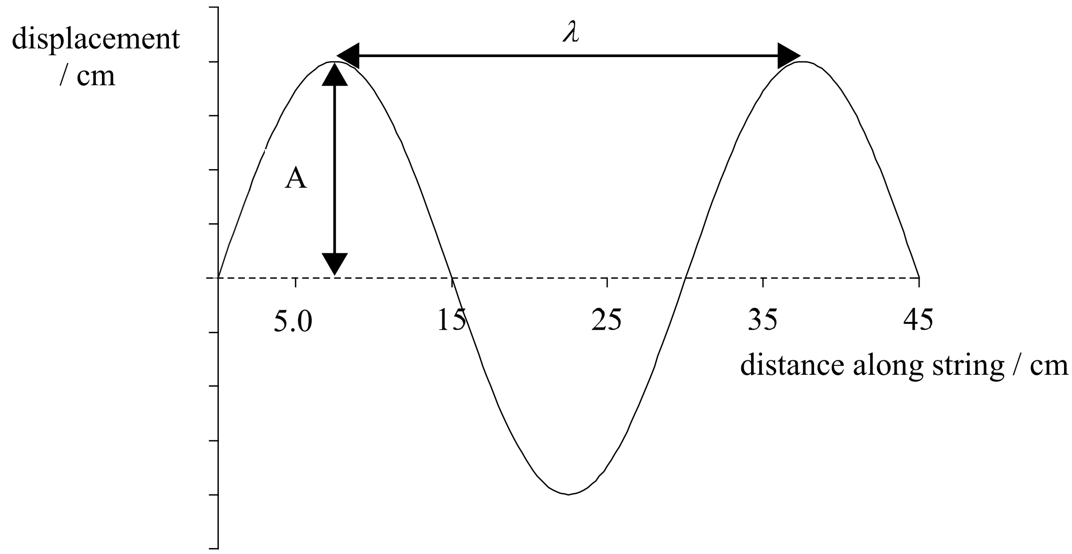
(d) 8.0 (±0.5) days; ***[1]***

B3. Part 1

(a) a wave in which the direction of energy propagation;
is at right angles to the direction of vibration of the particles of the medium through which the wave is travelling / *OWTTE*; ***[2]***
or
suitable labelled diagram e.g.

(b) any em wave / elastic waves in solids / accept water; ***[1]***

(c)



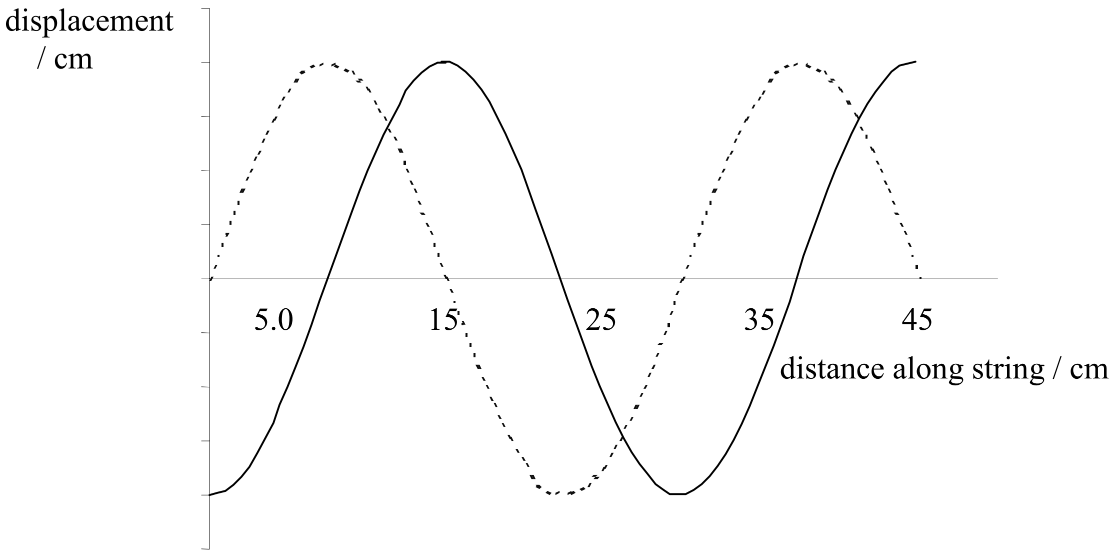
correct annotation

(i) A (4.0 cm); ***[1]***

(ii) λ (30.0 cm); ***[1]***

(d) $f = \frac{1}{T} = \frac{1}{1.2 \times 10^{-3}} = 830\,\text{Hz}$;
$c = f\lambda = 830 \times 0.30 = 250\,\text{m}\,\text{s}^{-1}$; ***[2]***

(e)



troughs / peaks moved to the right;
by $\lambda/4\,(7.5\,\text{cm})$; *(judge by eye)*
wave continuous between $x = 0$ and $x = 45\,\text{cm}$; ***[3]***

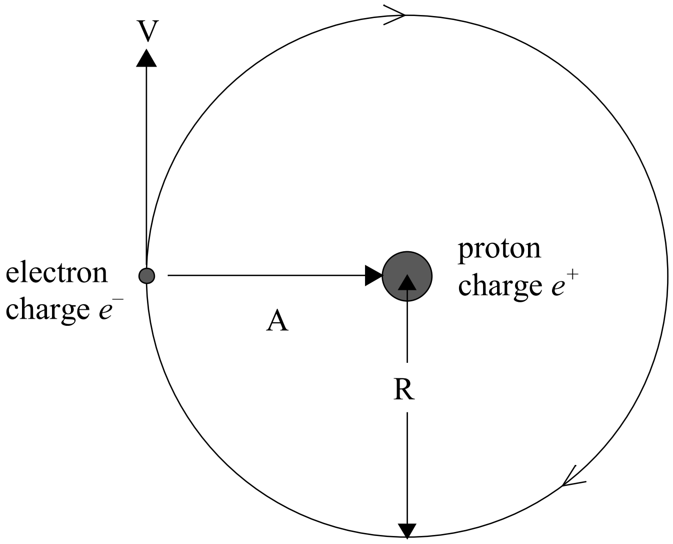
(f) a system resonates when a periodic force is applied to it;
and the frequency of the force is equal to the natural frequency of vibration of the system / *OWTTE*; ***[2]***

(g) the string could be clamped at one end and vibrated at the other end by a signal generator / tuning fork;
whose frequency is adjusted until one loop of vibration is observed / *OWTTE*;
or
string is clamped at both ends;
and plucked in the middle; ***[2]***

(h) $\lambda = 0.90\,\text{m}$;
$$f = \frac{c}{\lambda} = \frac{250}{0.90} = 280\,\text{Hz};$$ ***[2]***

B3. Part 2

(a)



(i) correct A; ***[1]***

(ii) correct V; ***[1]***

(b) $F = k\dfrac{e^2}{R^2}$ ***or*** $F = \dfrac{e^2}{4\pi\varepsilon_o R^2}$; ***[1]***

Accept if answer is seen in (c).

(c) $F = k\dfrac{e^2}{R^2} = \dfrac{mv^2}{R}$;

to give $R = \dfrac{ke^2}{mv^2}$;

correct substitution $R = \dfrac{9\times10^{9}\times(1.6)^2\times10^{-38}}{9.1\times10^{-31}\times(2.2)^2\times10^{12}}$ to give $R = 5.2\times10^{-11}\,\text{m}$; ***[3]***

(d) *Answers will be open-ended but essentially look for a description of either emission or absorption spectra e.g.*

when elements in their gaseous phase (state) are excited they emit light / discharge tubes emit light;

which has a series of well defined wavelengths ;

the wavelengths are characteristic of the element;

the existence of these characteristic wavelengths support the idea of atomic energy levels; ***[3 max]***