IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
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N05/4/PHYSI/SP2/ENG/TZ0/XX/M+

MARKSCHEME

November 2005

PHYSICS

Standard Level

Paper 2

11 pages

General Marking Instructions

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) any line (curve) through the origins;
straight-line; ***[2]***

(b) (i) a straight-line (drawn with ruler);
which is appropriate *i.e.* does not or would not go through the origin; ***[2]***
*Award **[0]** if points joined "dot to dot".*

(ii) data subjected to both types of error;
Can be implied in subsequent answer.
random since points are scattered above and below the line;
systematic since line does not/would not go through origin; ***[3]***
Accept answers that get this general idea across but do not accept answers that try to explain the source of the error without naming type of error.
*Award **[2 max]** for answers that confuse random with systematic but are otherwise correct. Award **[1 max]** for stating that there is only one type of error with correct explanation.*

(iii) use of "large triangle" for gradient (seen or implied);
Hypotenuse of triangle used should be at least half the distance between the first and the last point on the graph i.e. 5 cm.
to get gradient $= 0.59\times10^{-6} = 5.9\times10^{-7}$; ***[2]***
*Ignore any units. Award **[1 max]** for 0.59 without power of ten. Accept from 5.3 to 6.5×10^{-7}.*
*Award **[0]** if using a single point unless student's line goes through that point **and** the origin as well. Award **[0]** if using two data points as opposed to the gradient unless both data points are on candidate's line.*

(iv) use of Coulomb's law (seen or implied);
correct identification of gradient $= \mathrm{k}\,q_1q_2 = \mathrm{k}\,q^2$;
$q^2 = 6.56\times10^{-17}\ \mathrm{C}^2$;
$q = 8.1\times10^{-9}\ \mathrm{C}$; ***[4]***
*Award **[3 max]** for a bald answer without any working. Award **[1 max]** if the candidate uses a point on the graph to calculate q.*

A2. (a) zero; ***[1]***

(b) resultant vertical force from ropes $= (2.15\times10^3 - \text{weight}) = 237\,\text{N}$;
equating their result to $2T\sin 50$;
i.e. $2T\sin 50 = 237$
calculation to give $T = 154.7\,\text{N} \approx 150\,\text{N}$; ***[3]***
*Accept any value of tension from 130 N to 160 N. Award **[2]** for missing factor of 2 but otherwise correct i.e. 309 N.*

(c) correct substitution into $F = ma$;
to give $a = \dfrac{237}{1.95\times10^2} = 1.21\,\text{m s}^{-2}$; ***[2]***
Watch for ECF.
N.B. *Depending on value of g answer will vary from 1.0(3) m s^{-2} to 1.2(3) m s^{-2} all of which are acceptable.*

(d) statement that air friction increases with increased speed seen/implied;
in 10 seconds friction goes from 0 N to 237 N / force increases from zero until it equals the net upward accelerating force; ***[2]***

A3. (a) force per unit charge;
exerted on a small positive test charge / small positive charge / positive point charge; ***[2]***

(b) at least four radial lines evenly spaced around the sphere;
with arrows away from centre; ***[2]***
*Award **[1 max]** if any lines inside sphere.*

SECTION B

B1. Part 1 Electrical circuits

(a) (i) resistance = 15 Ω ; ***[1]***

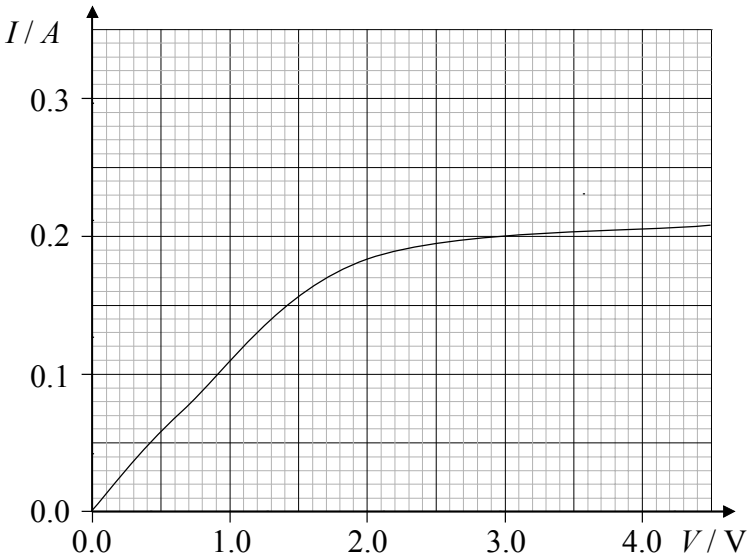
(ii) power = 0.6 W ; ***[1]***

(b) (i) resistance of circuit too high;
identification of high resistance component / other appropriate and relevant comment; ***[2]***
*Reject answers that do not explain why the lamp does not light e.g. award **[0]** for "the voltmeter should be in parallel" as this is not sufficient.*

(ii) voltmeter reads 3V; *(accept just below 3V)*
because most of the p.d. is across the voltmeter / resistance is too high / there is no current in the circuit; ***[2]***
*Award **[1 max]** if candidate attempts to calculate the precise value of the p.d. using the total resistance of the circuit.*

(c) correct location of ammeter in series with bulb;
correct location of voltmeter in parallel with bulb; ***[2]***

(d) line is initially practically straight;
and that curves;
in the right direction;
goes through the points (0,0) and (3.0 V, 0.2 A); ***[4]***



*Award **[2 max]** for a straight-line if it goes through (3.0 V , 0.2 A). Omit part of the graph from 3.0 volts but do not penalize if there.*

(e) resistance of filament increases as temperature increases;
so $\frac{I}{V}$ decreases with increasing V / OWTTE; **[2]**
Allow ECF for a straight-line in (d) only if followed by "temperature is constant" so "I is proportional to V / so ohm's law is obeyed".

B1. Part 2 Kinematics

(a) appropriate statement of principle of conservation of energy; ***[1]***
e.g. "Energy can not be created or destroyed, it just changes form."

(b) knowledge that the aircraft starts with chemical energy (in the fuel) and ends with kinetic energy;
realisation (seen or implied) that kinetic energy at end is less than chemical energy used up;
appropriate use of the principle of conservation of energy to explain where the energy "difference" goes; ***[3]***
e.g. Some energy is lost as thermal energy and sound – escapes with exhaust gases / doing work against friction / OWTTE.
Look for precision in the answers "energy goes into friction" does not gain full credit.
Answers that consider other parts of the aircraft's journey should be ignored.

(c) (i) calculation of $\text{K.E.} = \frac{1}{2} \times 8000 \times 75^2 = 2.25 \times 10^7\ \text{J}$;
appropriate use of force × distance = work done;
to get $321.4\,\text{m} \approx 320\,\text{m}$;
alternatives, of course, possible e.g.
calculation of acceleration $= \frac{F}{m} = 8.75\,\text{m s}^{-2}$;
appropriate use of $v^2 = u^2 + 2as$;
to get $321.4\,\text{m} \approx 320\,\text{m}$; ***[3 max]***
Watch for ECF. Accept 321 m but remove significant digit mark if more quoted.

(ii) $\text{P.E.} = 8000 \times 9.81 \times 1250 = 98.1\,\text{MJ} \approx 98\,\text{MJ}$; ***[1]***
Accept use of $g = 10\,ms^{-2}$ to get 100 MJ.

(d) (i) attempt at substitution into $F = \frac{mv^2}{r}$
$= \frac{8000 \times 90^2}{500}$;
$= 129.6\,\text{kN} \approx 130\,\text{kN}$; ***[2]***

(ii) in towards the centre of the circle; ***[1]***

B2. Part 1 The physics of cooling

(a) temperature is proportional to a measure of the average kinetic energy;
of the molecules of the substance;

or:
idea that temperature shows natural direction of the flow of thermal energy;
from high to low temperature / *OWTTE*; *(do not accept hot to cold)* ***[2]***
*Award **[1 max]** for a rough and ready answer and **[2 max]** for a more detailed answer.*

(b) a curve of gradually decreasing rate of loss of temperature;
that is asymptotic to $20\,^{\circ}\mathrm{C}$; ***[2]***
*Award **[0]** for a straight-line graph.*

(c) (i) temperature is falling because of thermal energy transfer to the surroundings;
with a decreasing rate;
the rate thermal energy transfer / heat loss in this region is greater;
because the temperature difference with the surroundings is greater / *OWTTE*; ***[2 max]***

(ii) realization that substance is still losing thermal energy; ***[1]***

*Award **[3 max]** for other relevant points*:
e.g. liquid and solid present / phase change taking place;
temperature stays constant until no more liquid;
at a constant rate;
loss of P.E. of atoms = thermal energy transfer;
because P.E. decreases;
K.E. of atoms constant; ***[4 max]***
*Award **[2 max]** for an answer that fails to realize that the liquid solidifies.*

(d) (i) calculation of the temperature rate of change in the range $(2.4-3.5)\times10^{-2}\,^{\circ}\mathrm{C\,s^{-1}}$;
$\frac{\Delta Q}{\Delta t} = m\,c\,\frac{\Delta Q}{\Delta t}$;
$= 0.11\times1300\times2.9\times10^{-2}$;
$\simeq 4\,(\pm1)\,\mathrm{W}$; ***[3 max]***

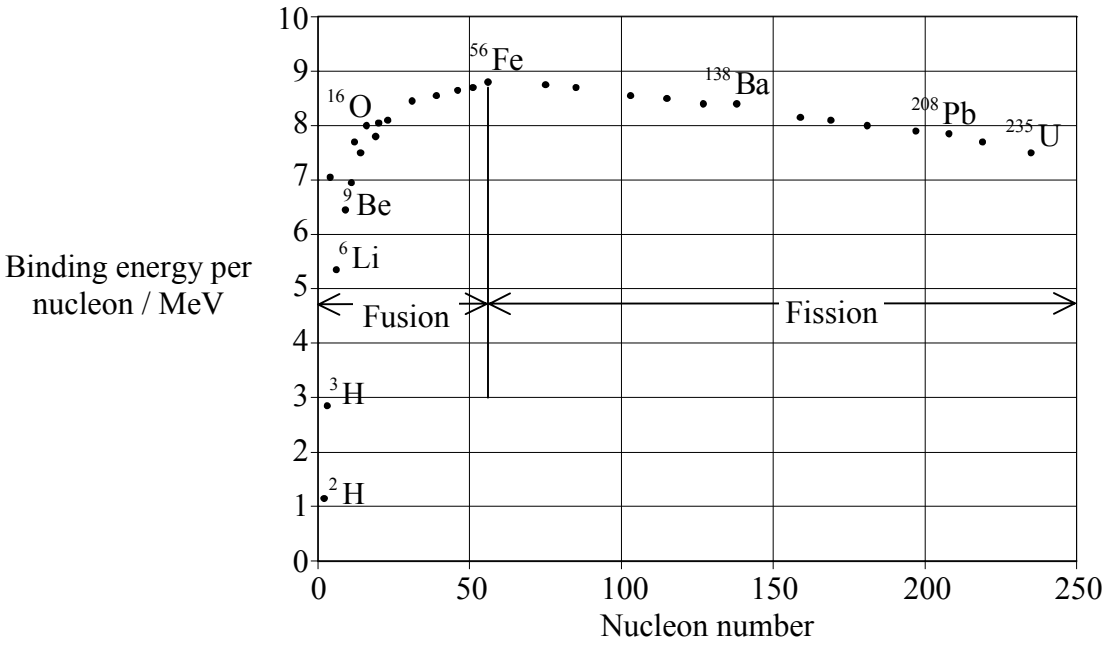
(ii) energy lost while solidifying, $E = 3600-6000\,\mathrm{J}$;
$L = \frac{E}{m}$;
$L = 33-55\,\mathrm{kJ\,kg^{-1}}$; ***[3]***

B2. Part 2 Nuclear binding energy and nuclear decay

(a) (a nucleon is either) a proton or a neutron / *OWTTE*; ***[1]***

(b) appropriate definition; ***[1]***
e.g. energy released when a nucleus is formed from its constituent nucleons / (minimum) energy needed to break a nucleus up into its constituent nucleons

(c) appropriate identification of fission *e.g.* being possible at right hand end of the graph;
appropriate identification of fusion *e.g.* being possible at left hand end;



discussion in terms of energy release being possible as products have higher (average) binding energy per nucleon; ***[3]***

(d) realisation that time elapsed is 3 half-lives;
so one eighth remains *i.e.* 5×10^{-16} kg; ***[2]***

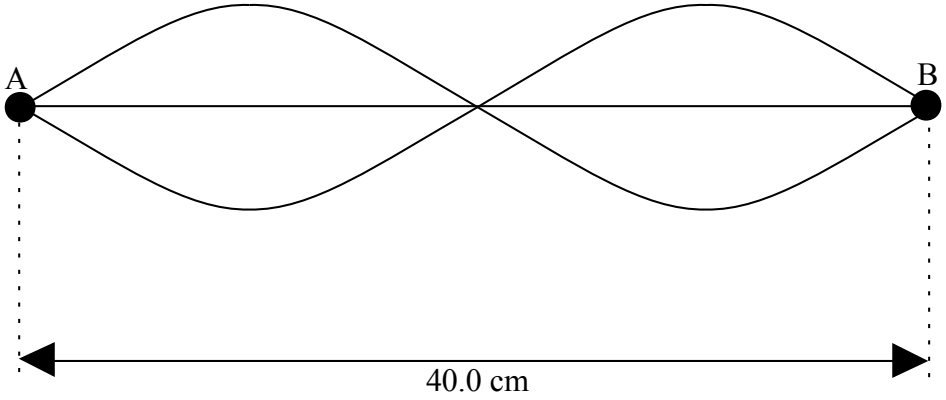
(e) $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$
proton and nucleon numbers correct for alpha particle (4 and 2);
proton and nucleon numbers correct for thorium (234 and 90); ***[2]***
Watch for ECF from incorrect values for alpha particle. Award ***[1]*** *if numbers are interchanged for all particles. Ignore mistakes in chemical symbol used for thorium.*

B3. Part 1 Standing waves

(a) standing waves have varying amplitude whereas travelling waves have a fixed amplitude;
energy transfer in travelling waves whereas no energy transfer in standing waves; ***[2]***
Allow any appropriate diagrams or descriptions that shows understanding.
*Award **[2]** for just <u>one</u> difference if it is fully described or explained.*

(b) (i) 80 cm; ***[1]***

(ii) appropriate sketch *i.e.* one wavelength, two "loops"; ***[1]***



(iii) only the standing waves that have a wavelength that fits the boundary conditions are possible / *OWTTE*;
*The above can be implied. Award **[2]** for "there always has to be a node at either end" / OWTTE.*
in this situation the boundary conditions are a node at each end / *OWTTE*; ***[2]***

(iv) use of $v = f\lambda$ with $\lambda = 40\,\text{cm}$;
to give $500\ \text{Hz}$; ***[2]***

(v) frequency of fundamental $= 250\ \text{Hz}$ / frequency of second harmonic $= 2 \times$ fundamental;
therefore, ratio $= \frac{500^2}{250^2} = 4$; ***[2]***

B3. Part 2 Linear momentum

(a) (i) product of mass and velocity / *OWTTE*; ***[1]***

(ii) change of momentum / *OWTTE*; ***[1]***
Accept product of force and time taken / OWTTE.

(b) they are vectors because they have magnitude and direction; ***[1]***
Answer needs some form of explanation to receive the mark but it can be simple.

(c) appropriate reference / naming of Newton III;
to give forces equal and opposite;
time of collision the same for each particle;
appropriate reference / naming of Newton II;
impulse / change in momentum equal and opposite; ***[5]***

(d) (i) change of momentum $= 0.05 \times (20 - (-18))$;
$= 1.9\,\text{kg m s}^{-1}$; ***[2]***
*Award **[1 max]** for forgetting vector nature i.e. $0.1\,\text{kg m s}^{-1}$.*

(ii) force = answer to (i) / 0.08;
$= 23.75\,\text{N} \approx 24\,\text{N}$; ***[2]***

(iii) shorter contact time / greater rebound speed;
so rate of change in momentum larger / *OWTTE*;
appropriate reference to Newton's laws; ***[3]***