International Baccalaureate®
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MARKSCHEME

May 2011

PHYSICS

Standard Level

Paper 2

General Marking Instructions

Subject Details: Physics SL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[25 marks]** and **ONE** question in Section B **[25 marks]**. Maximum total = **[50 marks]**

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

2. Each marking point has a separate line and the end is signified by means of a semicolon (;).

3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

5. Words that are underlined are essential for the mark.

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing ***OWTTE*** (or words to that effect).

8. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized.

9. Only consider units at the end of a correct calculation.

10. Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

e.g. if the answer is 1.63:

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

SECTION A

A1. (a) line of best fit is not straight / line of best fit does not go through origin; ***[1]***

(b) smooth <u>curve</u>;
that does not go outside the error bars; ***[2]***
Ignore extrapolations below n=1.

(c) (i) absolute uncertainty in diameter D is $\pm 0.08\,\text{cm}$;

giving a relative uncertainty in D^2 of $2\times\frac{0.08}{1.26}=0.13$ ***or*** 13%; ***[2]***

*Award **[2]** if uncertainty is calculated for a different ring number.*

(ii) it is possible to draw a straight line that passes <u>through the origin</u> (and lies within the error bars);

or

the ratio of $\frac{D^2}{n}$ is constant for all data points; ***[1]***

(iii) gradient $= k$;
calculation of gradient to give 0.23 *(accept answers in range 0.21 to 0.25)*;
evidence for drawing or working with lines of maximum and minimum slope;
answers in the form $k = 0.23 \pm 0.03$; ***[4]***
Accept an uncertainty in k in range 0.02 to 0.04. First marking point does not need to be explicit.

(iv) cm^2; ***[1]***

A2. (a) (i) $v=\sqrt{\dfrac{2eV}{m}}$;

$v=\sqrt{\dfrac{2\times 1.6\times 10^{-19}\times 250}{9.1\times 10^{-31}}}$;

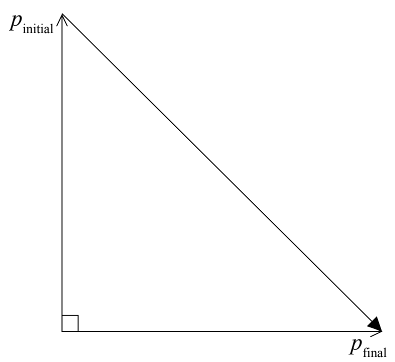
$=9.4\times 10^{6}\,\text{m}\,\text{s}^{-1}$ ***[2]***

(ii) $evB=m\dfrac{v^2}{r}$;

$r=\dfrac{9.1\times 10^{-31}\times 9.4\times 10^{6}}{1.6\times 10^{-19}\times 0.12}$;

$=4.5\times 10^{-4}\,\text{m}$ ***[2]***

(b) (i) vector as shown; ***[1]***

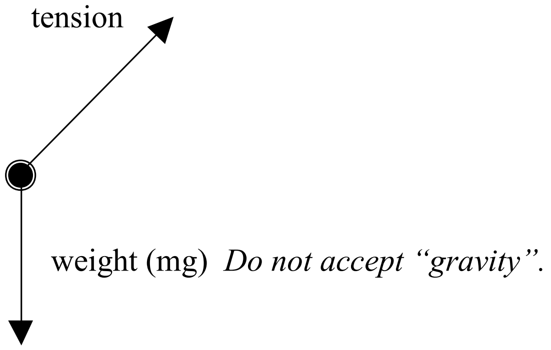


(ii) $\Delta p=\left(\sqrt{\left[8.6\times 10^{-24}\right]^2+\left[8.6\times 10^{-24}\right]^2}\right)$;

$=1.2\times 10^{-23}\,\text{N}\,\text{s}$ ***[1]***

(iii) $F\left(=\dfrac{\Delta p}{\Delta t}=\dfrac{1.2\times 10^{-23}}{7.5\times 10^{-11}}\right)=1.6\times 10^{-13}\,\text{N}$; ***[1]***

A3. (a) (i) ***[1]*** each for correct arrow <u>and</u> (any reasonable) labelling; ***[2]***



*Award **[1 max]** for arrows in correct direction but not starting at the ball.*

(ii) no;
because the two forces on the ball can never cancel out / there is a net force on the ball / the ball moves in a circle / the ball has acceleration/it is changing direction; ***[2]***
*Award **[0]** for correct answer with no or wrong argument.*

(b) $T\left(=\dfrac{mg}{\cos 30^\circ}\right)=2.832\,\text{N}$;

$\dfrac{mv^2}{r}=T\sin 30^\circ$;

$v=\left(\sqrt{\dfrac{Tr\sin 30^\circ}{m}}=\sqrt{\dfrac{2.832\times 0.33\times\sin 30^\circ}{0.25}}\right)=1.4\,\text{m}\,\text{s}^{-1}$;

or

$T\cos 30^\circ = mg$;

$T\sin 30^\circ = \dfrac{mv^2}{r}$;

$v=\left(\sqrt{gr\tan 30^\circ}=\sqrt{9.81\times 0.33\times \tan 30^\circ}\right)=1.4\ \text{m s}^{-1}$; ***[3]***

SECTION B

B1. Part 1 Nuclear reactor

(a) enrichment; ***[1]***

(b) power produced $\left(\frac{24}{0.32}\right) = 75\,\text{MW}$;

energy produced in a year $(75\times10^{6}\times365\times24\times60\times60 =)2.37\times10^{15}\,\text{J}$;

number of reactions required in one year $\left(\frac{2.37\times10^{15}}{3.2\times10^{-11}}\right) = 7.39\times10^{25}$;

mass used $(7.39\times10^{25}\times235\times1.66\times10^{-27}) \approx 29\,\text{kg}$; ***[4]***

or

mass used $\left(\frac{7.39\times10^{25}}{6.02\times10^{23}}\times235\times10^{-3}\right) = 29\,\text{kg}$;

(c) the neutrons would not be slowed down;
therefore they would not be/have less chance of being captured/induce fission;
so (much) less/no power would be produced; ***[3]***

(d) (i) beta decay; ***[1]***

(ii) the reactions end up producing plutonium (from uranium 238);
(this isotope of) plutonium may be used to manufacture nuclear weapons / can be used as fuel in other reactors / plutonium is extremely toxic;

or

the products of the reactions are radioactive for long periods of time / *OWTTE*;
therefore posing storage/safety problems; ***[2]***

B1. Part 2 Simple harmonic oscillations

(a) (i) the amplitude is constant; *[1]*

(ii) period is $0.20\,\text{s}$;

$$a_{\max} = \left(\left[\frac{2\pi}{T}\right]^2 x_0 = 31.4^2 \times 2.0 \times 10^{-2}\right) = 19.7 \approx 20\,\text{m}\,\text{s}^{-2};$$ *[2]*

*Award **[2]** for correct bald answer and ignore any negative signs in answer.*

(iii) displacement at $t = 0.12\,\text{cm}$ is $(-)1.62\,\text{cm}$;

$$v\left(=\frac{2\pi}{T}\sqrt{x_0{}^2 - x^2}\right) = 31.4\sqrt{(2.0\times10^{-2})^2 - (1.62\times10^{-2})^2} = 0.37\,\text{m}\,\text{s}^{-1};$$

Accept displacement in range 1.60 to 1.70 cm for an answer in range $0.33\,\text{m}\,\text{s}^{-1}$ to $0.38\,\text{m}\,\text{s}^{-1}$.

or

$$v_0 = \frac{2\pi}{T} x_0 = 0.628\,\text{m}\,\text{s}^{-1};$$

$$|v| = \left(\left|-v_0 \sin\left[\frac{2\pi}{T}t\right]\right| \Rightarrow |v| = |-0.628\sin[31.4\times0.12]| = |0.37|\right) = 0.37\,\text{m}\,\text{s}^{-1};$$

or

drawing a tangent at 0.12 s;
measurement of slope of tangent; *[2]*
Accept answer in range $0.33\,\text{m}\,\text{s}^{-1}$ to $0.38\,\text{m}\,\text{s}^{-1}$.

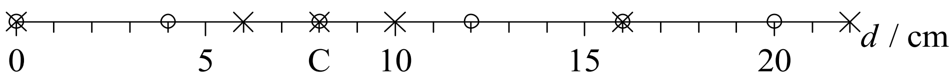
(iv) to the right; *[1]*

(b) (i) use of $f = \frac{1}{T}$;

and so $f\left(=\frac{1}{0.20}\right) = 5.0\,\text{Hz}$; *[2]*

(ii) wavelength is $16\,\text{cm}$;
and so speed is $v\left(= f\lambda = 5.0\times0.16\right) = 0.80\,\text{m}\,\text{s}^{-1}$; *[2]*

(c) (i) points at 0, 8 and 16 cm stay in the same place;
points at 4 and 20 cm move 2 cm to the right;
point at 12 cm moves 2 cm to the left; *[3]*

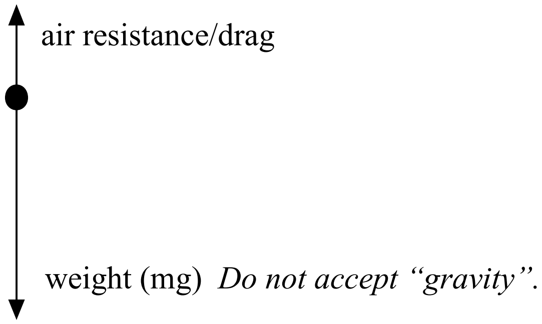


(ii) the point at 8 cm; *[1]*

B2. Part 1 Mechanics and thermal physics

(a) the area under the curve; ***[1]***

(b) (i) arrows as shown, with up arrow <u>shorter</u>; ***[1]***



(ii) drawing of tangent to curve at $t = 2.0\,\text{s}$;
calculation of slope of tangent in range $3.6 - 4.4\,\text{m s}^{-2}$; ***[2]***
*Award **[0]** for calculations without a tangent but do not be particular about size of triangle.*

(iii) calculation of F = ma = 0.50 × 4 = 2N
$R(= mg - ma = 0.50 \times 9.81 - 0.50 \times 4) \approx 3\,\text{N}$; ***[2]***

(iv) the acceleration is decreasing;
and so R is greater;

or

air resistance forces increase with speed;
since speed at 5.0 s is greater so is resistance force; ***[2]***

(c) (i) loss of potential energy is $mg\Delta h = 0.50 \times 9.81 \times 190 = 932\,\text{J}$;
gain in kinetic energy is $\frac{1}{2}mv^2 = \frac{1}{2}0.50 \times 25^2 = 156\,\text{J}$;
loss of mechanical energy is 932–156;
$\approx 780\,\text{J}$ ***[3]***

(ii) $mc\Delta\theta = 780\,\text{J}$;
$$\Delta\theta = \left(\frac{780}{0.5 \times 480}\right) \approx 3\,\text{K} / 3^\circ\text{C};$$
[2]

(iii) all the lost energy went into heating just the ball / no energy transferred to surroundings / the ball was heated uniformly; ***[1]***

Part 2 Nuclear physics

(a) (i) the (minimum) energy required to completely separate the nucleons of a nucleus / the energy released when a nucleus is assembled; *[1]*

(ii) mass defect is $94 \times 1.007276 + 145 \times 1.008665 - 238.990396 = 1.95\,\text{u}$;
binding energy is $1.95 \times 931.5 = 1816$ MeV;
binding energy per nucleon is $\frac{1816}{239}$ MeV;
$= 7.6$ MeV *[3]*

(b) (i) $x = 3$; *[1]*

(ii) binding energy of plutonium is $7.6 \times 239 = 1816 \approx 1800\,\text{MeV}$
(known in (ii))
binding energy of products is $8.6 \times 91 + 8.2 \times 146 = 1980 \approx 2000\,\text{MeV}$;
energy released is $(2000 - 1800) = 200\,\text{MeV}$; *[2]*

(c) the electric force is repulsive/tends to split the nucleus;
the electric force acts on protons, the strong nuclear force acts on nucleons;
the nuclear force is attractive/binds the nucleons;
but the electric force is long range whereas the nuclear force is short range;
so adding more neutrons (compared to protons) contributes to binding and does not add to tendency to split the nucleus / a proton repels every other proton (in the nucleus) so extra neutrons are needed for binding; *[4 max]*

B3. Part 1 Electric circuits

(a) (i) the work done per unit charge in moving a quantity of charge completely around a circuit / the power delivered per unit current / work done per unit charge made available by a source; ***[1]***

(ii) the ratio of the voltage (across) to the current in the conductor; ***[1]***

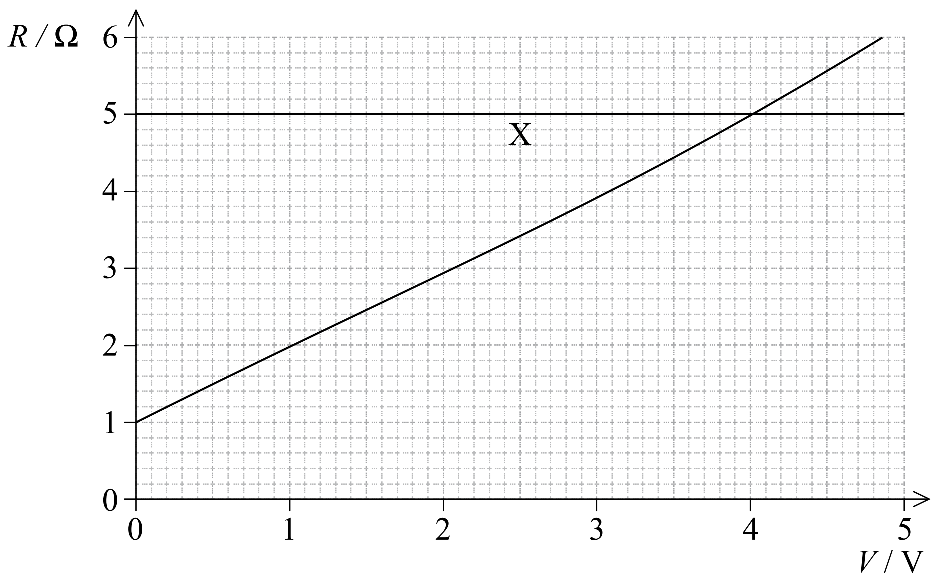
(b) (i) emf × current; ***[1]***

(ii) total power is $V_1I + V_2I$;
equating with EI to get result;

or

total energy delivered by battery is EQ;
equate with energy in each resistor $V_1Q + V_2Q$; ***[2]***

(c) graph X: horizontal straight line;
graph Y: starts lower than graph X;
rises (as straight line or curve) and intersects at 4.0 V; ***[3]***



Do not pay attention to numbers on the vertical axis.

(d) (i) realization that the voltage must be 4.0 V across each resistor;
and so emf is 8.0 V; ***[2]***

(ii) power in each resistor = 3.2 W;
and so total power is 6.4 W;

or

current is 0.80 A;
so total power is $8.0 \times 0.80 = 6.4$ W; ***[2]***

Part 2 Energy balance of the Earth

(a) the solar radiation is captured by a disc of area πR^2 where R is the radius of the Earth;
but is distributed (when averaged) over the entire Earth's surface which has an area four times as large;

*Award **[1]** for reference to absorption/reflection.*

(b) (i) 0.700; ***[1]***

(ii) $I\left(=e\sigma T_{\mathrm{a}}^{4}\right)=0.70\times5.67\times10^{-8}\times242^{4}$;
$=136\,\mathrm{W\,m^{-2}}$ ***[1]***

(iii) $\sigma T_{\mathrm{e}}^{4}=136+245\,\mathrm{W\,m^{-2}}$;
hence $T_{\mathrm{e}}\left(=\sqrt[4]{\dfrac{381}{5.67\times10^{-8}}}\right)=286\,\mathrm{K}$; ***[2]***

(c) (i) the Earth radiates radiation in the infrared region of the spectrum;
the greenhouse gases have energy level differences (in their molecular energy levels) corresponding to infrared energies;
and so the infrared photons are absorbed;

or

the Earth radiates photons of infrared frequency;
the greenhouse gas molecules oscillate/vibrate with frequencies in the infrared region;
and so because of resonance the photons are absorbed; ***[3]***

(ii) most incoming radiation consists of photons in the visible/ultraviolet region / photons of much shorter wavelength than those radiated by the Earth / photons of different wavelength of that radiated by Earth;
and so these cannot be absorbed; ***[2]***

(iii) *Source*: emissions from volcanoes / burning of fossil fuels in power plants/cars / breathing;
Sink: oceans / rivers / lakes / seas / trees; ***[2]***