M09/4/PHYSI/SP2/ENG/TZ1/XX/M+

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MARKSCHEME

May 2009

PHYSICS

Standard Level

Paper 2

12 pages

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 <u>underlined</u> 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. Effective communication is more important than grammatical accuracy.

9. 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. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded.

10. Only consider units at the end of a calculation. Unless directed otherwise in the mark scheme, unit errors should only be penalized once in the paper.

11. 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) (i) no
the graph is not linear / not a straight line; ***[1]***

(ii) a straight horizontal line through the initial points along the *T* axis;
a smooth curve through the remaining points (T = 4.4 K to 7.0 K); ***[2]***
The straight line and curve do not need to be joined.

(b) $R = 0\Omega$; ***[1]***
Do not apply unit mark.

(c) (i) 4.2 – 4.4 K; ***[1]***

(ii) 4.3 K;
$\pm$ 0.1 (K); ***[2]***
Allow ECF from (c)(i).

(iii) more sensitive thermometer / thermometer with a finer graduated scale / by taking resistance measurements at smaller temperature intervals; ***[1]***
*Award **[0]** for electronic digital thermometer **only**.*

(d) the data are for low temperatures well below room temperature;
no reason to assume the trend will continue to room temperature;
the data shows *R* varying sharply at T_C and another such transition might take place below room temperature;
mercury is a liquid at room temperature; ***[2 max]***
Award any other sensible answer.

A2. (a) $I = F\Delta t$ where Δt is the time for which the force acts/the change in momentum; ***[1]***

(b) (i) initial KE $= (1/2\ 0.075 \times 2.20^2) = 0.182$ J;

rebound speed = $\sqrt{\left[\dfrac{2 \times 0.8 \times 0.182}{0.075}\right]}$;

$= 1.97\,\text{m s}^{-1}$ ***[2]***

(ii) $\Delta p = 0.075 \times 2.20 + 0.075 \times 1.97$;
$= 0.313\,\text{N s}$
$=$ impulse; ***[2]***

(c) some recognition that area under graph = impulse;

$\dfrac{1}{2}F_{\text{max}}T = 0.313$;

$F_{\text{max}} = 7.00$ N;

average force $= \dfrac{1}{2}F_{\text{max}}$ = 3.50 N; ***[4]***

or

impulse $= F_{\text{ave}}\Delta t$;

$F_{\text{ave}} = \dfrac{impulse}{\Delta t}$;

$= \dfrac{0.313}{0.0894}$;

= 3.50 N;

*Award **[3 max]** if the candidate just writes impulse $= F\Delta t$ and not $F_{ave}\Delta t$.*

A3. (a) thermal energy transferred to the surroundings / energy that is converted to thermal energy;
that is no longer available to produce useful work / *OWTTE*; ***[2]***

(b) (i) the energy/power available from the (combustion of the) coal; ***[1]***

(ii) $A \rightarrow$ hot gases from burning of coal/into chimney;
$B \rightarrow$ radiation and convection from the boiler;
$C \rightarrow$ friction at the bearings/in the mechanism of the dynamo; ***[3]***

SECTION B

B1. Part 1 Greenhouse effect

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

(ii) nitrogen dioxide in the atmosphere will readily absorb infrared radiation radiated from the surface of Earth / *OWTTE*;
and re-radiate the energy in <u>random directions</u> (so preventing the energy radiated from Earth escaping into space); ***[2]***

(b) *emissivity*:
the ratio of energy/power emitted (per unit area) of a body;
to the energy/power emitted (per unit area) of a black body of the same dimensions at the same temperature;

or

ratio of power emitted by a body;
to the power emitted if it were a black body;

albedo:
the fraction of energy/power incident in a surface that is reflected / *OWTTE*; ***[3]***
Allow answers that define in terms of the albedo of Earth.

(c) (i) power per unit area $= e\sigma T^4$;
$= 0.720 \times 5.67 \times 10^{-8} \times 242^4$;
$= 140\,\mathrm{W\,m^{-2}}$ ***[2]***

(ii) $= 0.720 \times 344$;
$= 248\,\mathrm{W\,m^{-2}}$ ***[1]***

(d) (i) new power radiated by atmosphere $= \left[0.720 \times 5.67 \times 10^{-8} \times 248^4\right]$
$= 154\,\mathrm{W\ m^{-2}}$; ***[1]***

(ii) new power absorbed by Earth $= (154 + 248) = 402\,\mathrm{W\,m^{-2}}$; ***[1]***

(e) $402 = 5.67 \times 10^{-8} \times T^4$;
$T = 290\,\mathrm{K}$;
to give $\Delta T = 2\,\mathrm{K}$; ***[3]***

Part 2 Ball falling in oil

(a) average speed is the distance travelled divided by the time taken;
instantaneous speed is the rate of change of distance at a given instant (in time); ***[2]***

(b) find the area under the graph between $t = 0$ and $t = t_1$;
this equals the distance travelled (by the ball);
average speed $= \dfrac{\text{this distance}}{t_1}$; ***[3]***
Award ***[0]*** *for* $\dfrac{\textit{final speed}}{2}$ ***or*** $\dfrac{\textit{speed at } t}{2}$

(c) acceleration $= k$;
application of Newton 2 e.g. net force on ball $= Mg - F = kM$;
$F = M\ (g - k)$; ***[3]***

(d) net force $= Mg - F$;
acceleration is zero therefore net force is zero;
frictional force equals the weight/Mg; ***[3]***

B2. Part 1 Simple harmonic motion and waves

(a) is proportional to the displacement/distance (of the particle) from its equilibrium position;
is directed towards the equilibrium position; ***[2]***

(b) (i) overall correct shape;
with max of 0.06 J at $x = \pm 0.05$ and zero at $x = 0$; ***[2]***

(ii) $E_{\mathrm{K_{max}}} = \frac{1}{2} 4\pi^2 m f^2 x_0^2$;
from the graph $E_{\mathrm{K_{max}}} = 0.06\,(\mathrm{J})$;
and $x_0 = 0.050\,(\mathrm{m})$;
$f = \sqrt{\frac{2E_{\mathrm{K_{max}}}}{4\pi^2 m x_0^2}}$;
to give $f = 2.0\,\mathrm{Hz}$ ***[4]***

or

$k = \frac{2E_{\mathrm{K_{max}}}}{x_0^2}$;
$= \frac{2 \times 0.06}{0.05^2}$;
= 48;
use of $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$;
= 2.0 Hz

(c) (i) the energy of the wave is propagated in a direction at right angles;
to the direction of oscillation of the particles; ***[2]***

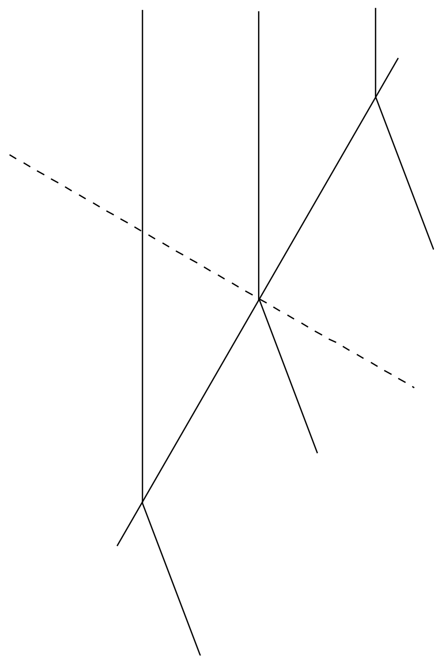
(ii) $\lambda = 0.40\,\mathrm{m}$; ***[1]***

(d) (i) use of $\sin\theta_2 = \frac{v_2}{v_1}\sin\theta_1$;

$\frac{v_2}{v_1} = 1.5$; $\Big\}$ *this marking point is not necessary to award full credit.*

$\theta_2 = \left[\sin^{-1} 0.75\right] = 49^\circ$; ***[3]***

(ii)



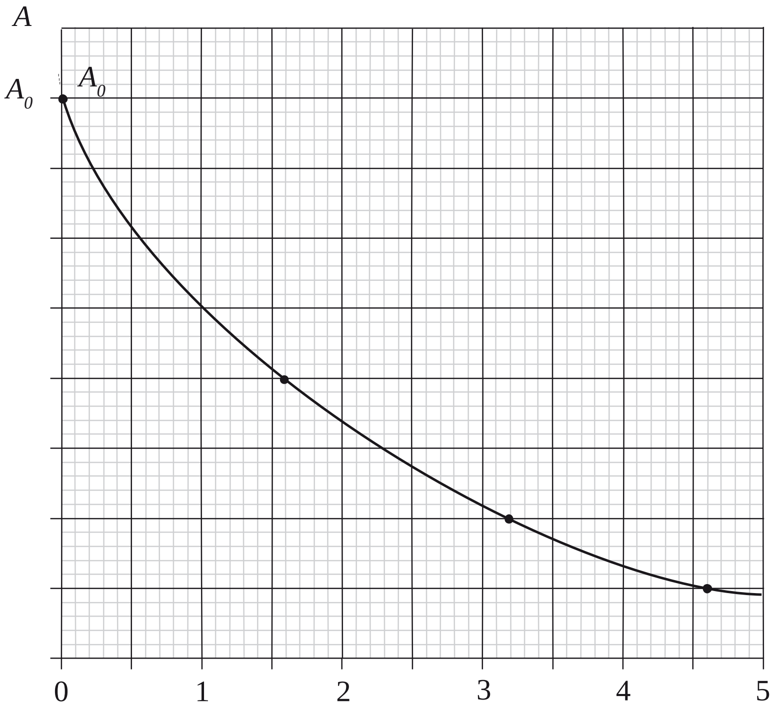
any two lines as shown bending in the correct direction; ***[1]***

Part 2 Decay of radium-226

(a) *isotopes*:
nuclei with the same number of protons but different number of neutrons / same proton/atomic number but different nucleon/mass number;

half-life:
time it takes for the activity of a (radioactive) sample to halve / *OWTTE*; ***[2]***

(b)



data points are $(0, A_0)$ and $(1.6\times10^3, \frac{1}{2}A_0)$;
data points $(3.2\times10^3, \frac{1}{4}A_0)$ and $(4.6\times10^3, \frac{1}{8}A_0)$;
smooth curve; ***[3]***

(c) (i) *proton number*: 86;
neutron number: 136;
need both to award the mark. ***[1]***

(ii) the equation shows a spontaneous change from an unstable state to a more stable state / *OWTTE*;
the less the binding energy the more unstable is a nucleus / the greater the binding energy the more stable is a nucleus; ***[2]***
Accept answers in terms of negative binding energy per nucleon e.g. the less negative the binding energy per nucleon etc.
Award ***[1]*** *for "number of protons less so (electrostatic) repulsion less and so nucleus more stable".*

(d) $226.0254 = 222.0175 + 4.0026 + Q$;
$Q = 0.0053\times931.5$ MeV;
$= 4.94\,\text{MeV}$ ***[2]***

B3. **Part 1** Internal energy, heat and ideal gases

(a) (i) *internal energy*:
the total (potential energy and) kinetic energy of the (copper) molecules/atoms/particles;

or

amount of stored energy in the copper;

heating:
the (non-mechanical) transfer of energy;
(from the surroundings/source) to the copper; ***[3]***

(ii) $c = \dfrac{\Delta Q}{m\Delta T}$;

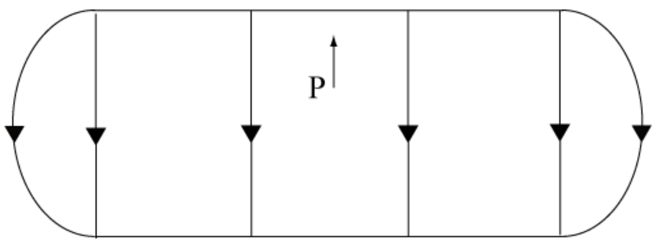
$= \left[\dfrac{1.2\times 10^3}{0.25\times 20}\right] = 240\ \mathrm{Jkg^{-1}\ K^{-1}}$; ***[2]***

(b) (i) the molecules gain kinetic energy (from the heating); ***[1]***

(ii) molecules collide with the walls with a greater velocity / momentum transferred to the piston greater;
to keep pressure constant frequency of collisions must decrease;
volume must increase; ***[3]***

Part 2 Electric fields and electric circuits

(a) (i)



uniform field equal spacing of lines;
edge effect;
direction; ***[3]***

(ii) as shown; ***[1]***

(b) combine $F = qE$ and $F = ma$;

to get $E = \dfrac{ma}{q}$;

$E = 5.0 \times 10^3$ N C^{-1} / V m^{-1}; ***[3]***

(c) $V = \dfrac{1.9 \times 10^{-17}}{1.6 \times 10^{-19}}$;

$= 120$ V ***[1]***

(d) (i) 3.0 W; ***[1]***

(ii) power dissipated in battery $= \left(0.25^2 \times 4.0\right) = 0.25$ W;

power dissipated in circuit $= \left(3.0 - 0.25\right) = 2.8\ (2.75)$ W; ***[2]***

(iii) power dissipated in lamp $= \left(3.0 \times 0.25\right) = 0.75$ W;

power dissipated in resistor $= \left(2.75 - 0.75\right) = 2.0$ W;

resistance $\left(= \dfrac{2.0}{0.25^2}\right) = 32\,\Omega$; ***[3]***

or

resistance of lamp $= 12\,\Omega$;
$12 = 0.25\,(R + 16)$;
$R = 32\ \Omega$;

or

V across $R = 8.0$ V;

$R = \dfrac{8.0}{0.25}$;

$= 32\,\Omega$; ***[3]***