M09/4/PHYSI/HP2/ENG/TZ2/XX/M+

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MARKSCHEME

May 2009

PHYSICS

Higher Level

Paper 2

15 pages

General Marking Instructions

Subject Details: Physics HL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[45 marks]** and **TWO** questions in Section B **[2 × 25 marks]**. Maximum total = **[95 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) line going through each error bar; ***[1]***

(b) (i) <u>line does not go through (0,0)</u>/<u>origin</u> so no; ***[1]***
Watch for ECF from (a).

(ii) line is curved / gradient not constant so no; ***[1]***

(c) line drawn to find intercept on *y*-axis;
$4.2\,(\pm 0.1)\,\text{m}$; ***[2]***

(d) large (at least half of line) triangle from straight line portion of graph;
$\text{slope} = 0.012(\pm 0.001)\,(\text{m s}^{-1})$;
$\text{volume per second} = \text{area} \times \text{slope}$;
$\left(0.022\,\text{m}^3\,\text{s}^{-1}\right)$ ***[3]***

*Alternatively for **[2 max]**.*

determines height difference over time range within 0 and 120 s;

$$\text{volume per second } = \frac{1.8 \times [\text{difference in heights}]}{\text{time between heights}};$$

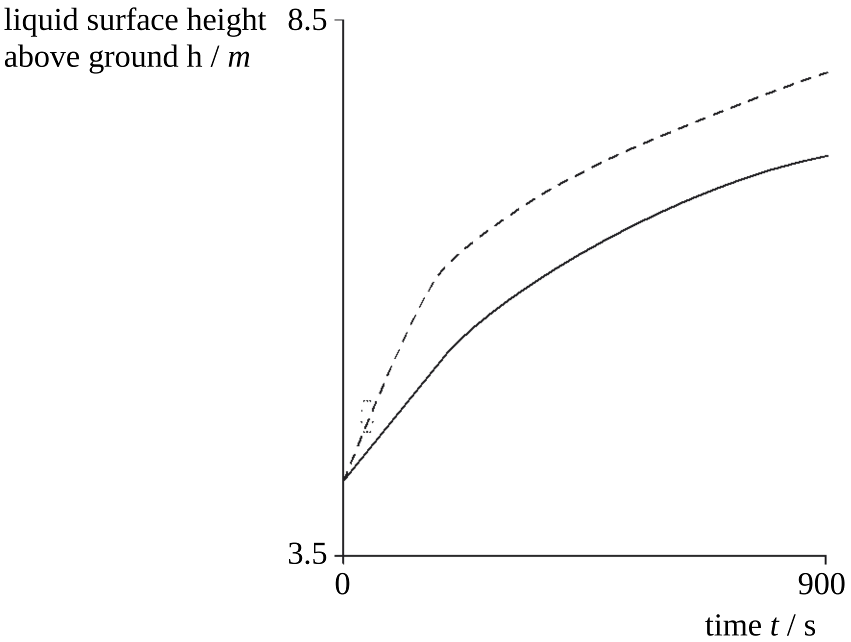
$\left(0.022\,\text{m}^3\,\text{s}^{-1}\right)$

(e) $(850 \times 0.022) = 19\,\text{m}^3$ ***or*** $(850 \times 0.02) = 17\,\text{m}^3$; ***[1]***

(f) (i) states equation $\ln h = \ln k + n \ln t$; *(accept use of log_{10})*
plot of $\ln h$ versus $\ln t$ will give straight line if hypothesis is true; ***[2]***

(ii) equates gradient/slope to *n*; ***[1]***
Award the equation $\ln h = \ln k + n \ln t$ only once in either (f)(i) or (f)(ii).

(g) graph starts at same point but half initial gradient by eye;
line always lower than original by eye and ending about $\frac{1}{4}$ way down y-axis ; ***[2]***
Original line need not be shown. Allow ECF from (c) if the curve begins at (0, 3.5).

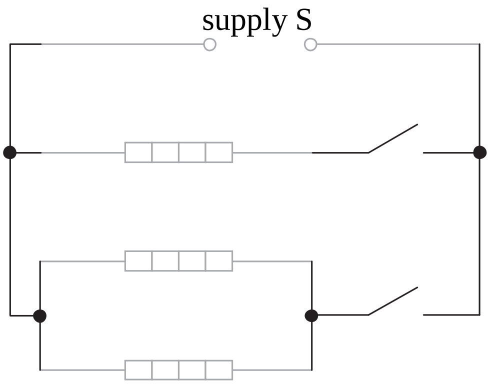


A2. (a) (i) ratio of potential difference to current / $\frac{V}{I}$ with terms defined; ***[1]***

(ii) resistance $= \frac{230^2}{980}$;
$= 54\,\Omega$; ***[2]***
*Award **[2]** for bald correct answer.*

(iii) $L = \frac{RA}{\rho}$;
$= \frac{54 \times \pi \times \left[1.75 \times 10^{-4}\right]^2}{1.3 \times 10^{-6}}$;
$(L \approx 4\,\text{m})$ ***[2]***
Must see re-arrangement of data booklet equation or completely correct substitution as shown in second line for first mark.

(b) *e.g.*



switch connected so that P can be achieved;
another switch connected so that $2P$ and $3P$ can be achieved; ***[2]***
*Award **[0]** if three or more switches used. Allow any correct alternative including case where single resistor is permanently connected to supply. There are many variants, this diagram is only one example.*

A3. (a) region/area/volume (of space);
where a mass/charge experiences a force; ***[2]***

(b)

Particle	*Charge on particle*	*Initial direction of motion of particle*	*Direction of force on particle*	*Type of field*
A	*uncharged*	*stationary*	*in direction of field*	gravitational;
B	*negative*	*along direction of field*	*opposite to direction of field*	electric; *(accept electrostatic)*
C	*positive*	*normal to direction of field*	*normal to direction of field*	magnetic;

[3]

A4. (a) conversion to mechanical energy described *e.g.* oscillating water column/duck /turbine;

mechanical energy converted to electrical energy *e.g.* dynamo/ electrical generator; *Do not allow turbine.* ***[2]***

(b) (i) mass of water in crest $= \frac{1}{2} A\lambda L\rho$;
this "falls" through a height A;
change in potential energy $= mgh = \frac{1}{2} A^2\lambda L\rho g$; ***[3]***

(ii) $\frac{v}{\lambda}$ crests pass a point in unit time;

power per unit length $= \frac{1}{2} A^2\lambda L\rho g \frac{v}{\lambda} \times \frac{1}{L}$;

$= \frac{1}{2} A^2\rho g v$ ***[2]***

(c) estimate of speed as $0.5 \rightarrow 10\,\mathrm{m\,s^{-1}}$;
power per unit length $= \frac{1}{2} \times 0.3^2 \times 1.2 \times 10^3 \times 10 \times [0.5 \rightarrow 10]$ yields
$270\,\mathrm{W\,m^{-1}} \rightarrow 5.4\,\mathrm{kW\,m^{-1}}$; ***[2]***
*Award **[1 max]** for answer where no speed estimate made, response will leave answer in form 540v. Do not apply a unit penalty in this question whether algebraic or numerical solution.*

(d) sinusoidal would have a smaller volume of water in each peak;
some indication that first marking point leads to a smaller amount; ***[2]***

A5. (a) small area on silicon/semiconductor chip/semiconductor lattice;
that is the smallest part of the chip that can detect a photon / that behaves as a capacitor / *OWTTE*; ***[2]***

(b) photons cause emission of electrons/holes;
this changes the potential difference (developed across the pixel);
potential difference is proportional to light intensity; ***[3]***

(c) position of pixel/colour/wavelength; ***[1]***

(d) *e.g.* much greater quantum efficiency;
sensitive to wider range of e.m. spectrum;
processing time of image very much shorter;
image can be processed easily / no need for image to be developed;
image data can be transmitted directly;
much less storage space needed;
digital material can be re-used unlike film;
film degrades with time;
film experiences reciprocity failure; ***[2 max]***

SECTION B

B1. Part 1 Dynamics and energy

(a) equation is for constant acceleration;
force varies and so acceleration changes; ***[2]***

(b) (i) average force $= 2100\,\text{N}$;
acceleration $= \left(\dfrac{2100}{0.0320} =\right)\ 6.6\times10^{4}\,\text{m}\,\text{s}^{-2}$; ***[2]***

(ii) uses area under the line;
1 square is equivalent to $0.125\,\text{N}\,\text{s}$;
area is $68 \to 72$ squares;
(to give momentum change $8.5 \to 9.0\,\text{N}\,\text{s}$) ***[3]***

(c) (i) use of $\Delta p = m\Delta v$;
$v = \left(\dfrac{8.8}{0.032} =\right) 280\,\text{m}\,\text{s}^{-1}$; ***[2]***
Allow value for momentum change from (b)(ii).

(ii) use of power $= \dfrac{\text{change in kinetic energy}}{\text{time taken}}$;
change in kinetic energy $= \frac{1}{2}\times0.032\times280^{2}$;
$\left(\dfrac{1300}{5\times10^{-3}}\right) = \text{power} = 0.26\,\text{MW}$; ***[3]***

or

use of $E = \dfrac{p^{2}}{2m}$;
$\dfrac{8.8^{2}}{2\times0.032}$;
power $= 0.24\,\text{MW}$;
*Award **[0]** for solution from $P = Fv$.*

(d) N3 states that action and reaction are equal and opposite;
so force on gun and force on bullet are action and reaction pair;
so force on gun is opposite direction to bullet/backwards; ***[3]***

Part 2 Motion of a charged particle in an electric field

(a) use of $\frac{1}{2}mv^2 = qV$;
$\frac{1}{2}\times 4\times 1.66\times 10^{-27}\times v^2 = 2\times 1.6\times 10^{-19}\times 2400$;
$(v = 4.8\times 10^5\ \mathrm{m\,s^{-1}})$ ***[2]***

(b) (i) $E = \dfrac{600}{0.80\times 10^{-2}}$;
$= 7.5\times 10^4\ \mathrm{V\,m^{-1}}$; *(accept unit as $N\,C^{-1}$)* ***[2]***

(ii) force $= (Eq =)\ 7.5\times 10^4 \times 2\times 1.6\times 10^{-19}$;
$(= 2.4\times 10^{-14}\ \mathrm{N})$
acceleration $= \dfrac{2.4\times 10^{-14}}{4\times 1.66\times 10^{-27}}$;
$(= 3.6\times 10^{12}\ \mathrm{m\,s^{-2}})$ ***[2]***

Do not penalize twice for omission of 2 in charge of α-particle.

(c) (i) $\left(\dfrac{2.4\times 10^{-2}}{4.8\times 10^5} =\right) 5.0\times 10^{-8}\ \mathrm{s}$; ***[1]***

(ii) for motion in direction of electric field
distance dropped in $50\,\mathrm{ns} = \frac{1}{2}\times 3.6\times 10^{12}\times (5.0\times 10^{-8})^2$;
$= 0.45\,\mathrm{cm}$;
α-particle starts 0.40 cm from above plate and so hits it / *OWTTE* ; ***[3]***

B2. Part 1 Ideal gases

(a) (i) random motion;
no gravitational effect;
no forces of attraction between molecules/atoms;
time of collision much less than time between collisions;
Newton's laws apply; ***[2 max]***

(ii) potential energy not used/irrelevant;
(because) there are no forces between molecules in an ideal gas;
gas speeds vary so need to take an average; ***[3]***

(b) (i) $n = \dfrac{pV}{RT}$;
$n = 0.18\,\text{mol}$; ***[2]***
*Award **[2]** for bald correct answer.*

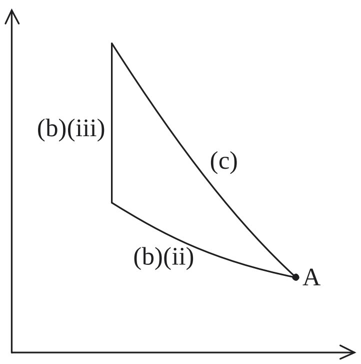
(ii) show use of $pV = \text{constant}$;
19×10^5 Pa; ***[2]***
*Award **[2]** for bald correct answer.*

(iii) pressure equals $\dfrac{420 \times 19 \times 10^5}{290}$;
(to give 2.8×10^6 Pa) ***[1]***

or

pressure $= \left(\dfrac{nRT}{V} = \right) \dfrac{0.18 \times 8.31 \times 420}{2.3 \times 10^{-4}}$;

(c) (i)



smooth curve, curving correct way for (b)(ii);
vertical straight line for (b)(iii);
smooth curve, steeper than (b)(ii) for (c); ***[3]***
Labelled curves are not needed as such but direction must be clear.

(ii) (c) identified as H; ***[1]***

(iii) recognition that area underneath curve is measure of energy;
measure area enclosed by loop / pV changes; ***[2]***

Part 2 Fossil fuels

(a) *Award any two of the following.*
peat;
coal;
oil;
gas; ***[2 max]***
Do not accept derived fuels, e.g. diesel.

(b) rate of production of fuel much smaller than rate of usage;
so fuel will be exhausted/run out; ***[2]***

(c) idea that width of arrow is related to magnitude of energy/power;
$\text{efficiency} = \frac{1.0}{2.8} = 0.36$; ***[2]***
Allow any efficiency 0.31 $\rightarrow$ 0.41 i.e. $\pm$0.1cm on each measurement.
Allow answer expressed as percentage.

(d) *e.g.* high energy density;
readily available (in short-term);
cheaper production of electrical energy;
health considerations not treated as a major issue;
not possible to generate sufficient electrical energy without it;
many transport systems rely on fossil fuels;
power stations can be built close to energy source; ***[3 max]***
These marking points are not an exhaustive list. Do not allow repetitions or vague statements they should be clear and precise.

B3. **Part 1** Simple harmonic motion and waves

(a) displacement is proportional to acceleration / *vice versa*;
because graph is straight-line through origin;
displacement and acceleration in opposite directions / acceleration always directed towards origin;
because negative gradient; ***[4]***

(b) use of $\omega^2 = (-)\frac{a}{x}$;
$\omega^2 = \frac{2900}{0.60 \times 10^{-3}}$;
$\omega = 2\pi f$;
$f = \frac{1}{2\pi}\sqrt{\frac{2900}{0.60 \times 10^{-3}}}$;
(to give $f = 350\,\text{Hz}$) ***[4]***

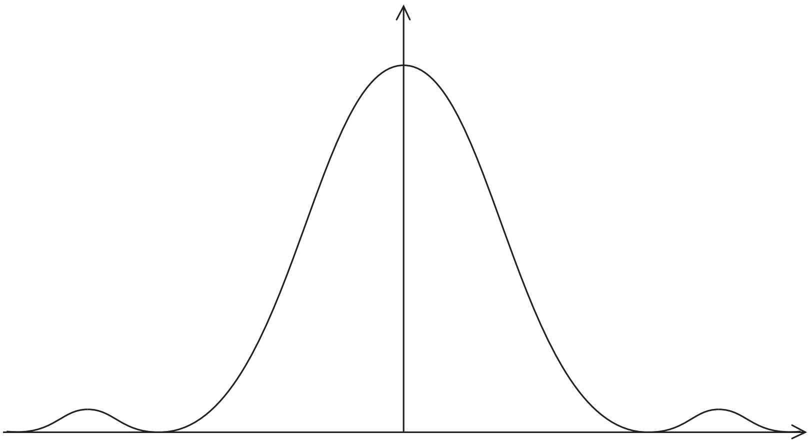
(c) (i) transfer of energy by means of vibrations/oscillations;
vibrations all in one direction parallel to direction of energy transfer; ***[2]***

(ii) $\frac{330}{350}$ ***or*** use of $c = f\lambda$;
$0.94\,\text{m}$; ***[2]***
*Award **[2]** for bald correct answer.*

Part 2 Diffraction of light

(a) (i) spreading out of light;
beyond that predicted by the geometric pattern / by the obstacle shape / *OWTTE*; ***[2]***

(ii) *diagram*:



central symmetrical maximum;
at least one secondary maximum on each side with smaller height no more than one third height of central maximum;
minima drawn to zero; *(i.e. sitting on x-axis)* ***[3]***

(iii) $\theta = \left(\frac{\lambda}{b} =\right) \frac{620\times10^{-9}}{0.4\times10^{-3}}$;

$w = (2D\theta =) \frac{2.0\times1.9\times620\times10^{-9}}{0.4\times10^{-3}}$;

$w = 5.9\,\text{mm}$; ***[3]***

*Award **[3]** for bald correct answer.*

(b) (i) the images can be seen separately; ***[1]***

(ii) diffraction occurs (at the aperture/iris of the eye);
each lamp gives rise to a diffraction pattern (at the back of the eye/on the retina);
(for distant lamps) the two diffraction patterns overlap;
so that patterns cannot be distinguished / *OWTTE*; ***[4]***

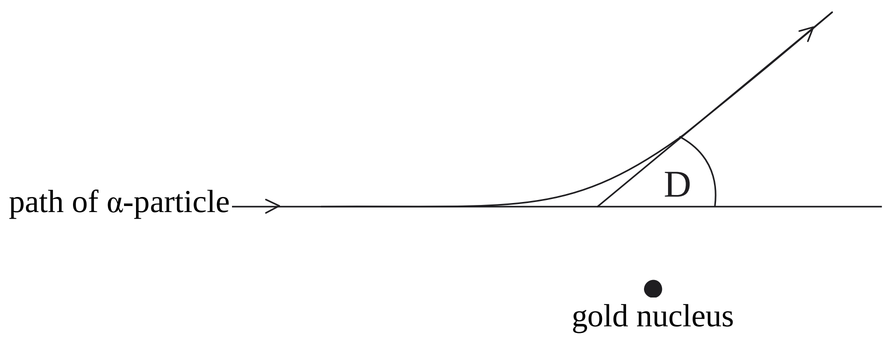
B4. **Part 1** α-particle scattering and nuclear processes

(a) ${}^{222}_{86}\text{Rn}$;
${}^{4}_{2}\alpha$; ***[2]***

(b) (i) 5.0×10^{10} s ; ***[1]***
Accept 4.9×10^{10} s if 0.69 used.

(ii) $N=\left(\dfrac{6.02\times10^{23}}{226}\right)$
$=2.66\times10^{21}$;
$A=\left(\dfrac{2.66\times10^{21}\times\ln 2}{5.0\times10^{10}}\right)$ ***or*** use of $A=\lambda N$
$=3.7\times10^{10}$ Bq ;
power $=3.7\times10^{10}\times7.6\times10^{-13}$;
$=28\times10^{-3}$ W ; ***[4]***

(c) (i)



angle shown correctly; ***[1]***
Horizontal line must be present, angle can be marked to straight portion of deviated path.

(ii) same number of protons / additional number of neutrons / nuclei are isotopes;
no charge change so deviation unchanged; ***[2]***
*Award **[0]** for bald answer or answer with incorrect explanation.*

(d) $4.0\times10^{6}\times1.6\times10^{-19}$;
$\dfrac{79\text{e}\times2\text{e}}{4\pi\varepsilon_0 r}$;
5.7×10^{-14} m ; ***[3]***
*Award **[3]** for bald correct answer.*

Part 2 Albedo of the Earth

(a) the molecules of the gas have a natural frequency of oscillation equal to the frequency of infra-red;
(the molecule will absorb radiation) because of resonance at this (resonant) frequency; ***[2]***

(b) because it traps/absorbs infra-red radiated by the surface of Earth; ***[1]***

(c) nitrogen dioxide / methane / water / NO_2 / CH_4 / H_2O; ***[1]***

(d) (i) (most of the) infra-red (radiation) absorbed is not all re-radiated into space/escaping into space / *OWTTE*; ***[1]***

(ii) $\text{albedo} = \dfrac{\text{reflected electromagnetic radiation}}{\text{incident electromagnetic radiation}}$ / measure of the amount of radiation reflected <u>into space</u>;
carbon dioxide reduces the amount of <u>reflected</u> radiation;
hence albedo decreased; ***[3]***
*Award **[0]** for a bald answer in terms of "albedo decreased".*

(e) present $\dfrac{I_{out}}{I_{\text{in}}} = 0.30$ so present $I_{out} = 102\,(\text{W m}^{-2})$;
after doubling new $I_{\text{out}} = (340 \times 0.29) = 98.6\,(\text{W m}^{-2})$;
$\text{change} = 102 - 98.6$;
$(\approx 3\,\text{W m}^{-2})$ ***[3]***
Accept working from 0.31 to 0.30.

(f) assume all the radiated energy is in the infra-red / all the extra gas absorbs the radiated radiation / no change in radiated power due to Earth temperature change; ***[1]***