International Baccalaureate®
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MARKSCHEME

May 2010

PHYSICS

Higher Level

Paper 2

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. Remember that many candidates are writing in a second language. 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. Indicate this with **ECF** (error carried forward).

10. Only consider units at the end of a calculation. Unless directed otherwise in the markscheme, unit errors should only be penalized once in the paper. Indicate this by writing **–1(U)** at the first point it occurs and **U** on the cover page.

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*

Indicate the mark deduction by writing **–1(SD)** at the first point it occurs and **SD** on the cover page.

SECTION A

SECTION A

A1. (a) reads off *R* and *T* values correctly for at least two different coordinates on line;
shows *RT* not constant / other sensible test *e.g.* *R* halves, *T* does not double;
hence hypothesis not supported; *[3]*
*Award **[0]** for bald unsupported conclusion.*

(b) (i) $\lg R = a + \frac{b}{T}$ is in the form of an equation of a straight line;
the points can be joined by a straight line / graph is a straight line; *[2]*

(ii) draws straight line through all error bars (judge by eye);
evidence of use of line to determine gradient;
b: gradient in range 1500 to 1700;
a: intercept in range -1.7 to -2.3; *[4]*

*Award **[2 max]** for solutions where a and b are found using data points (i.e. no line used)*

(iii) correctly substitutes derived values into equation, e.g. $-2.0 + \frac{1570}{260}$;
correct calculation from equation, e.g. $R = 11000\ \Omega$; *[2]*

or

$\frac{1}{T} = \frac{1}{260}$ (= 0.00385) **and** uses straight line to give correct value for lg *R*;
$R = 11000\ (\pm 2000)\ \Omega$;

A2. (a) $F\cos 25 = 470$;
520 N; *[2]*

(b) (i) work done $= 470 \times 2500$;
1.2 MJ; *[2]*
*Award **[1 max]** for power of 10 error.*

(ii) $\frac{1.2 \times 10^6}{1.2 \times 60 \times 60}$;
270 W; *[2]*
Allow correct solution from power = $F \times v$.

(c) work still done against friction ;
work done raising load vertically / increase in gravitational potential energy; *[2]*

A3. (a) total power required $= (120 \times 3000 =) 360\,\text{kW}$;
input power $= \left(\frac{360 \times 100}{18} =\right) 2000\,\text{kW}$;
area $= \left(\frac{2000 \times 1000}{650} =\right) 3.1 \times 10^3\,\text{m}^2$; *[3]*
*Award **[2 max]** if calculation is for one house only (25.8 m^2).*

(b) no/little power at night;
power fluctuates according to weather conditions/cloud;
seasonal changes;
very large surface area required; *[2 max]*

Any other sensible physical reason.
Do not allow "low efficiency" unless compared to other devices.
Do not allow "cost" or "expense".

A4. (a) work done/energy supplied by the supply per unit charge / power supplied by the supply per unit current; ***[1]***

(b) (i) peak reading $=1400\pm50\,\text{V}$;
rms $=\left(\dfrac{\text{peak reading}}{\sqrt{2}}=\right)990\,\text{V}$; ***[2]***

(ii) amplitude shown as $700\,\text{V}\pm50$;
1.5 periods shown on full scale of graph; ***[2]***

(iii) amplitude / emf: rate of change of flux is halved;
time period / frequency: period is doubled / frequency is halved; ***[2]***

A5. (a) (i) CA; ***[1]***

(ii) for isothermal change $PV=$ constant;
two points chosen and same constant calculated;
third point chosen and same constant calculated; ***[3]***

(iii) AB and CA / isothermal and isochoric/isovolumetric; ***[1]***

(iv) work done $=10\times10^{5}\times[2.0-0.2]\times10^{-3}$;
$=1800\,\text{J}$; ***[2]***

(b) maximum temperature is at $V=2\times10^{-3}$ (m^3) and $P=10^{6}$ (Pa) /values identified in substitution with correct powers of ten;
$T=\dfrac{PV}{nR}$;
$=\dfrac{10^{6}\times2\times10^{-3}}{0.74\times8.3}$;
$=330\,\text{K}$; ***[4]***
Award ***[4]*** *for correct answer and omission of second and/or third marking point.*
Accept ecf from loss of first mark due to powers of ten.

(c) at constant volume internal energy increases (but no work is done);
at constant pressure internal energy increases **and** work is done to expand (against the atmosphere)/by the gas;
therefore energy required is greater at constant pressure; ***[3]***

SECTION B

B1. Part 1 Solar radiation

(a) energy emitted per unit time / power per unit area;
proportional to [absolute temperature / temperature in K]^4; *[2]*
Must define symbols if used.

(b) (i) power $= 5.67\times10^{-8}\times4\pi\times\left[7.0\times10^{8}\right]^{2}\times5800^{4}$; *[1]*
$= 4.0\times10^{26}\,\text{W}$

(ii) $\dfrac{\text{incident energy}}{\text{area}} = \dfrac{3.97\times10^{26}}{4\pi\left[1.5\times10^{11}\right]^{2}}$;
$= 1400\,\text{W m}^{-2}$; *[2]*

(iii) max 2 of:
(albedo of Earth means) some radiation is reflected;
Earth's surface is not always normal to incident radiation;
some energy lost as radiation travels to Earth; *[2 max]*

(iv) power absorbed $=$ power radiated;
uses $5.67\times10^{-8}\times255^{4} =$ to yield answer close to 240 / evaluates $\sqrt[4]{\dfrac{240}{\sigma}}$; *[2]*

(c) radiation from the Sun is re-emitted at longer wavelengths;
(longer radiation) wavelengths are absorbed by greenhouse gases;
some radiation re-emitted back to Earth; *[3]*

(d) more CO_2/named greenhouse gas released into atmosphere;
<u>enhanced</u> greenhouse effect ;
because more re-radiation of energy towards surface; *[3]*

Part 2 Charged-coupled devices (CCDs)

(a) maximum ***two*** sensible suggestions related to image capture:
e.g.
much higher quantum efficiency / more sensitive to light than film;
much shorter exposure times than film;
sensitive to wider spectrum than film;
no moving parts required in device;
digital storage advantage;
any other image capture advantage; ***[2 max]***
Only accept one advantage of digital storage, e.g. compact storage

(b) $26\,000^2$ pixels in one image;
$26\,000^2 \times 16 = 1.08 \times 10^{10}$ bits per image;
$\frac{4.0 \times 10^{11}}{1.08 \times 10^{10}} = 36$ or 37; ***[3]***

(c) (i) individual pixel/element is a capacitor;
(X-ray) photons release electrons/charge carriers; ***[2]***

(ii) each voltage is digitized;
pd/voltage across pixel is proportional to intensity;
position of each pixel is recorded together with digitized voltage; ***[3]***

B2. Part 1 Water waves

(a) (a wave) that transfers energy between points (in a medium); *[1]*

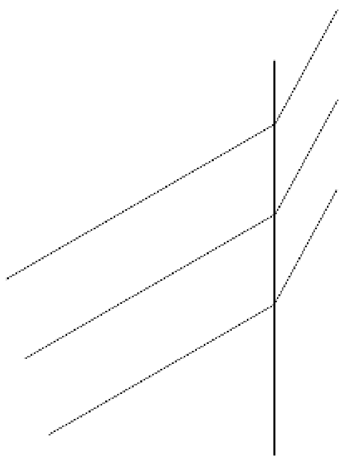
(b) (i) 1.0 mm; *[1]*

(ii) 6.0 mm; *[1]*

(iii) 37 Hz; *[1]*

(iv) $0.22\,\text{m}\,\text{s}^{-1}$; *[1]*

(c) (i) wavefronts continuous at boundary and parallel;
wavefronts closer together and equally spaced by eye and in the correct direction; *[2]*



(ii) $\frac{c_a}{c_b} = 1.4$;

$= \sqrt{\left(\frac{d_a}{d_b}\right)}$;

$\frac{d_a}{d_b} = 2.0$; *[3]*

(d) (i) reference to superposition/interference;
waves (almost) cancel to give zero/small displacement;
where waves arrive out of phase/180° out/π out; *[3]*

(ii) position of any one minimum closer to centre / minima closer together;
frequency increased so wavelength decreased / correct explanation in terms of double-slit equation; *[2]*

Part 2 Projectile motion

(a) $g = \frac{2s}{t^2}$;
$s = 1.75$ m, $t = 0.6$ s;
$g = 9.7 \pm 0.1$ m s^{-2}; ***[3]***
*Award **[2 max]** if data not from last three data points.*

(b) horizontal speed $= 3.2$ m s^{-1};
use of $v = gt$ or $s = \frac{1}{2}gt^2$;
vertical speed $= 11.6$ or 11.7 m s^{-1};
use of Pythagoras' theorem;
speed $= 12$ m s^{-1}; ***[5]***

(c) line always to left of spheres;
becoming more vertical; ***[2]***

B3. Part 1 Nuclear decay and ionization

(a) *proton number:* 89;
nucleon number: 222; ***[2]***

(b) (i) momentum conserved;
so different speeds as different masses;
opposite directions because momentum zero initially; ***[3]***

(ii) $k.e._{\alpha} \div k.e._{Rn} = \frac{1}{2}m_{\alpha}v_{\alpha}^{2} \div \frac{1}{2}m_{Rn}v_{Rn}^{2}$ / sensible ratio formed;
$= (m_{\alpha}v_{\alpha})^2 m_{Rn} \div (m_{Rn}v_{Rn})^2 m_{\alpha}$ / cancellation of momentum terms;
$= m_{Rn} \div m_{\alpha} = \frac{222}{4} (= 55.5)$; ***[3]***
*Award **[3]** for correct answer obtained by alternative correct working.*
Watch for ecf from (a) e.g. $\frac{91}{226}$ *leads to 56.5 for answer here.*

(c) (i) removal (addition) of electron from atom/molecule; ***[1]***

(ii) $\frac{4.9\times10^{6}\times1.6\times10^{-19}}{1.7\times10^{5}}$;
$4.6\times10^{-18}\,\text{J}$; ***[2]***

(d) beta have smaller mass/smaller/have greater speed than alpha;
beta have smaller charge than alpha;
therefore less likely to interact with air molecules; ***[3]***

Part 2 Radio waves

(a) (i) $\Delta f = \left(\frac{v}{c} \times 150 \times 10^6\right)$

$= 3950\,\text{Hz}$;

$= 149.99605\,\text{MHz}$; *[2]*

(ii) as approaches frequency greater than 150 MHz/higher than transmission frequency;
when opposite shuttle frequency 150 MHz/same as transmission frequency;
as recedes frequency lower than 150 MHz/lower than transmission frequency; *[3]*

(iii) equation only applies for $v << c$ / relativistic effects occur (at 0.9c); *[1]*

(b) (i) the Rayleigh Criterion is used to establish when the image of two objects are just resolved / Rayleigh criterion describes resolution condition;
the minimum of one diffraction pattern falls on the maximum of the other; *[2]*

(ii) $\left(\text{use of } \theta = \frac{1.22\lambda}{d}\right)$

resolution $= 1.22 \times \frac{5 \times 10^{-7}}{8.5 \times 10^{-2}} = 7.2 \times 10^{-6}\,\text{rad}$;

$\theta = \left(\frac{24 \times 10^{-3}}{300} = \right) 80 \times 10^{-6}\,(\text{rad})$;

separation > resolution limit so can be resolved; *[3]*

Allow ecf for third marking point.

B4. Part 1 Electrical heater

(a) (i) use of $R\left(=\frac{pl}{A}=\right)\frac{1.1\times10^{-6}\times4.5}{6.8\times10^{-8}}$; *[1]*

72.8Ω (73Ω)

(ii) $\frac{240^{2}}{72.8}$ / shows appropriate alternative equation;

790 W; *[2]*

(iii) one-third length so E_2 has one-third resistance of E_1 / evaluates *R* (24Ω);

(same V so) $3\times$ power of E_1;

so total power $= 4\times E_1 = 3.2\,\text{kW}$; *[3]*

***or** numerical method*

current in $R_1 = \frac{728}{240} = 3\,\text{A}$;

current in $R_2 = 9\,\text{A}$;

total current $= 12\,\text{A}$ and total power $= 3.2\,\text{kW}$;

*Award **[3]** for correct alternative working.*

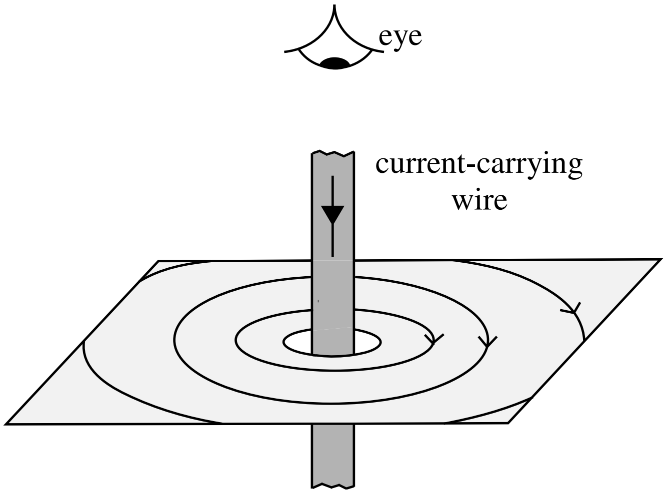
(iv) the power output will be less;

because the total resistance is greater in the series case;

hence the current is less and power depends on I^2;

$P=\frac{V^2}{R}$; ***[3 max]***

(b) (i) concentric circles (by eye);
a minimum of three circles required;
correct direction; ***[3]***



(ii) current in one turn produces magnetic field in region of adjacent turn;
this gives rise to force in adjacent turn which also has electric current;
they attract; ***[3]***

Part 2 The hydrogen atom

(a) (i) $eV = \frac{6.6\times10^{-34}\times3\times10^{8}}{4.9\times10^{-7}\times1.6\times10^{-19}}$;
energy $= 2.5\,\text{eV}$; *[2]*

(ii) 490 nm excites energy level transitions;
from $n = 2$ to $n = 4$;
energy removed from beam;
re-emitted in other directions/at other wavelengths as electrons returned to energy state; *[4]*

(b) Schrödinger suggests that electron has wave properties;
this (probability) wave has to conform to boundary conditions;
only certain wavelengths that lead to a standing wave are allowed (by these boundary conditions);
energy is determined by wavelength of electron / standing wave determines electron energy; *[4]*