M10/4/PHYSI/HP2/ENG/TZ2/XX/M+

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MARKSCHEME

May 2010

PHYSICS

Higher Level

Paper 2

14 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 **no**t 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. 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 markscheme, 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) two error bars in the correct position;

two error bars of the correct length; *(allow a square-length each side of the data points judge by eye and allow for the thickness of the line drawn)* ***[2]***

(b) suitable curve that goes through the two error bars;
and through (0,0); ***[2]***

(c) a straight line cannot be drawn through the error bars and through the origin;
so height is not directly proportional to the diameter;
(and) height is proportional to energy; ***[3]***

(d) the gradient of the line gives the value of the power coefficient/exponent/ $\lg d = \frac{1}{3}\lg h + \text{constant}$ and $\lg d = \frac{1}{4}\lg h + \text{constant}$;
gradient of data line $= 0.33\ (\pm 0.02)$;
gradient of max and gradient of min $= 0.37\ (\pm 0.02)$ and $0.29\ (\pm 0.02)$;
some conclusion as to why this supports theory 1 *e.g.* therefore the uncertainties do not allow for $n = 0.25$ so data supports theory 1; ***[4]***

A2. (a) unstable nuclei/nuclides change spontaneously/randomly/emit energy;
by the emission of <u>alpha particles</u> and/or <u>electrons</u> and/or <u>gamma rays</u>; *(accept α, β and γ particles/radiation)* ***[2]***
*To award **[2 max]** reference must be made to nuclei/nuclides and to spontaneously/ randomly.*

(b) *Z:* 18;
x: neutrino/ v / ${}^{0}_{0}v$; ***[2]***

(c) mass of 19 protons $= (19 \times 938 =) 17822\ \text{MeV}\,\text{c}^{-2}$;
mass of 21 neutrons $= (21 \times 940 =) 19740\ \text{MeV}\,\text{c}^{-2}$;
mass difference $= 17822 + 19740 - 37216 = 346\ \text{MeV}\,\text{c}^{-2}$;
binding energy per nucleon $= 8.65\,\text{MeV}$; ***[4]***
Allow answer in joule, 1.38×10^{-12} *J.*

(d) energy is released in the decay of K-40 / energy released is the difference in binding energies / decay is spontaneous / A-40 is more stable than K-40; ***[1]***

A3. (a) (i) evaporation takes place at any temperature/involves a reduction in temperature and boiling takes place at constant temperature; ***[1]***

(ii) evaporation takes place at the surface of the liquid/depends on surface area of the liquid and boiling takes place throughout the liquid/is independent of surface area; ***[1]***

(b) energy supplied $= 15\times4.5\times10^{2} = 6.8\times10^{3}\,(\mathrm{J})$;

$$lhv = \frac{6.8\times10^{3}}{1.8\times10^{-2}};$$
$$= 3.8\times10^{5}\,\mathrm{J\,kg^{-1}};$$ ***[3]***

(c) (thermal) energy/heat is lost to the surroundings / (thermal) energy is used to heat the calorimeter / some heat is given to the calorimeter;
and so less (thermal) energy/heat is available to boil the liquid / less mass boils away / *OWTTE*; ***[2]***

A4. (a) the current gives rise to a magnetic field/flux in the coil;
from Faraday's law a time changing field/flux induces an emf;
Lenz's law says that the direction of the induced emf is such as to oppose the growth of the current; ***[3]***

(b) (i) the value of the direct voltage that gives the same power dissipation/output;
as the average ac power dissipation/output; ***[2]***
Do not accept answer in terms of a formula.

(ii) 4×10^{6}; ***[1]***

A5. (a) no transfer of energy;
variable amplitude;
reference to phase *e.g.* points along the wave can have a constant phase difference;
have stationary nodal points/points of zero displacement; ***[2 max]***

(b) (i) at the open end; ***[1]***

(ii) $\lambda = 4l$;
$= \left(\frac{330}{16} = \right) 20.6$;
$l = 5.2\,\text{m}$; ***[3]***

(c) wavelength of open pipe for fundamental is $2l$ / length of open pipe for fundamental is about $10\,\text{m}$;
therefore closed pipe takes up much less space/height / length is now realistic / less material / *OWTTE*; *(accept this marking point in terms of open pipe)* ***[2]***

A6. (a) in unpolarized light the <u>electric field vector</u> may vibrate in any plane (normal to the direction of propagation);
in polarized light the vector/electric field vibrates in one plane only; ***[2]***
*To award **[2 max]** reference must be made to "electric field vector" at least once.*
*Award **[2 max]** for any relevant correctly labelled diagram.*

(b) $\cos^2\theta$ graph; *(judge shape by eye)*
max I_0 at 0° and 180° and zero at 90°; ***[2]***

SECTION B

B1. Part 1 Electrical fields and electrical resistance

(a) a conductor contains "free" electrons and insulators do not / *OWTTE*; ***[1]***

(b) to have a current electrons must be accelerated/move along the wire;
and so a (electric) force must act on them;
this is provided by the electric field; ***[3]***

(c) $8.8\times10^{-18}\ \text{N}$; ***[1]***

(d) the ratio of potential difference across a device/load/resistor to current in the device/load/resistor; ***[1]***

(e) $\rho=\frac{RA}{l}$;

$=\left(\frac{1.5\times\pi\times1.2^2\times10^{-6}}{2.2\times10^{-2}}=\right)3.1\times10^{-4}\ \Omega\,\text{m}$; ***[2]***

(f) $I=\left(\sqrt{\frac{P}{R}}=\right)\sqrt{\frac{1}{1.35}}$;

$=0.86\,\text{A}$; ***[2]***

(g) (i) the power supplied per unit current / work done per unit charge in moving charge completely round the circuit / energy per unit charge made available by the source; ***[1]***

(ii) minimum resistance is $2.0\,\Omega$, maximum resistance is $2.5\,\Omega$;

so maximum power is $\left(\frac{2.0^2}{2.0}\right)=2.0\,\text{W}$;

and minimum power is $\left(\frac{2.0^2}{2.5}\right)=1.6\,\text{W}$; ***[3]***

Part 2 Radioactive decay

(a) the different alpha particle energies represent decay of a nucleus to different energy states of a daughter nucleus;
since the energies of the alpha are discreet it means that the energy levels of the daughter nucleus must be discrete / *OWTTE*; ***[2]***

(b) the spectrum is continuous;
with a maximum value of energy;
the resulting energy difference between energy of any β and maximum β energy is accounted for by the energy of the neutrino / reference to energy difference between parent energy level and excited energy level of daughter; ***[3]***

(c) (i) $0.246 = 1.12e^{-4.00\lambda}$;
$-4.00\lambda = \ln\ 0.2196$;
$\lambda = \frac{1.516}{4.00}$; } *(evidence of algebraic manipulation)*
$= 0.379\,\text{hr}^{-1}$ ***[3]***
Note*: there are* ***[2]*** *marks for clearly showing their working.*

(ii) 1.83hr; ***[1]***

(d) $\lambda = \frac{h}{\sqrt{2mE}}$;

$= \frac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times8.4\times10^{-15}}}$;

$= 5.3\times10^{-12}$ m ***[2]***

Accept solution based on finding momentum from the speed.

B2. Part 1 Oscillations and waves

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

(ii) the acceleration is proportional to the displacement from equilibrium;
and is directed towards equilibrium / opposite to displacement; ***[2]***

(iii) $\omega^2 = \frac{14}{l}$;

$\omega^2 = \frac{4\pi^2}{T^2}$;

$l = \frac{14\times 1.4^2}{40}$;

$= 0.70\,\text{m}$ ***[3]***

(b) sine curve / negative sine curve; ***[1]***

(c) (i) $\omega^2 = \frac{14}{0.70} = 20\ \text{rad}^{-1}$;

max acceleration $= (20 \times 0.12 =)\, 2.4\,\text{m}\,\text{s}^{-2}$; ***[2]***

(ii) any point where $v = 0$; ***[1]***

(d) (i) period $= 1.4\,\text{s}$;

$c = \frac{\lambda}{T} = \frac{0.45}{1.4} = 0.32\,\text{m}\,\text{s}^{-1}$; ***[2]***

(ii) $\frac{2.8}{3.7}$;

0.76; ***[2]***

(iii) 0.57 ***or*** 0.58; ***[1]***

Part 2 Gases and thermodynamic processes

(a) can be liquefied / forces exist between molecules not in contact / molecules have finite size / does not obey $PV = nRT$ for all values of P, V and T / does not obey Boyle's law for all values of P / does not obey Charles law for all values of T / internal energy is a function of T; ***[1]***

(b) (i) (a change) in which there is no exchange of thermal energy/heat between gas and surroundings; ***[1]***

(ii) work done $= (P\Delta V =)\, 1.8 \times 10^{5} \times 4.8 \times 10^{-4} = 86\,(\text{J})$;

power $= \left(\dfrac{86}{0.020} =\right) 4.3\,\text{kW}$; ***[2]***

(iii) DA; ***[1]***

(c) energy transferred to the surroundings is dissipated/spread out/dispersed / *OWTTE*; *(do not accept "is lost")*

(and) is no longer available to perform useful work; ***[2]***

(d) the second law states that the overall entropy of the universe is increasing;
entropy is a measure of the degree of disorder of the system;
degraded energy <u>will increase the temperature</u> of the surroundings thereby increasing the disorder of the surroundings/universe; ***[3]***

B3. Part 1 Fossil fuels and the greenhouse effect

(a) wide availability / a great deal available;
ease of transportation;
power stations can be built close to the source;
high energy density; ***[2 max]***

(b) (i) the energy that can be liberated per kg/stored per kg; ***[1]***

(ii) $Eff = \frac{500}{P_{\text{in}}}$;

$P_{\text{in}} = \left[\frac{500}{0.27}\right] = 1900\,(\text{MW})$;

$\text{rate} = \left[\frac{1900}{56}\right] = 33\,\text{kg s}^{-1}$ ***or*** $34\,\text{kg s}^{-1}$; ***[3]***

*Award **[3]** for correct answer if the first marking point is omitted.*

(c) (because of increased greenhouse gases) atmosphere absorbs more (IR) energy and heats up;
atmosphere radiates in all directions;
Earth's surface absorbs some of this extra (IR) radiation hence temperature increases; ***[3]***
*Award **[2 max]** if no indication made to re-radiation in all directions either by "all directions" in second marking point or by "some" in third marking point.*

(d) (i) different surfaces absorb/reflect different intensities; ***[1]***

(ii) radiation intercepted by cross section of Earth $\pi r^2 \times 1380$;
this is distributed over surface of Earth $4\pi r^2$;
therefore, radiation incident $= \frac{\pi r^2}{4\pi r^2} 1380 = 345\ \text{W m}^{-2}$;
intensity of reflected radiation $= 0.300 \times 345$;
$= 104\ (100)\ \text{W m}^{-2}$ ***[4]***
*Award **[1]** for the use of 0.300×1380.*

(e) $\Delta V = \gamma V \Delta T = 8.8 \times 10^{-5} \times 3.6 \times 10^{14} \times 3.0 \times 10^{3} \times 2.0$;

$h = \frac{1.9 \times 10^{14}}{3.6 \times 10^{14}}$;

$= 0.53(0.5)\,\text{m}$ ***[2]***

Part 2 Electrical potential

(a) the work done per unit charge;
in bringing a positive point/test/small positive charge;
from infinity to the point; ***[3]***

(b) field is (negative) gradient of potential;
since field is zero then potential must be constant inside sphere / *OWTTE*; ***[2]***

(c) (i) $E_{\mathrm{P}} = -\dfrac{ke^2}{r}$;

$E = E_{\mathrm{P}} + E_{\mathrm{K}} = -\dfrac{ke^2}{2r}$; ***[2]***

(ii) $r = \dfrac{ke^2}{2E}$;

$= \left(\dfrac{9.0\times10^{9}\times 1.6^{2}\times10^{-38}}{4.4\times10^{-18}} = \right) 5.2\times10^{-11}\,\mathrm{m}$; ***[2]***

B4. Part 1 Momentum, energy and power

(a) when a force acts on a body an equal and opposite force acts on another body / in the interaction between two bodies A and B, the force that A exerts on B is equal and opposite to the force that B exerts on A; ***[1]***

(b) forces on Earth and book are equal and opposite / no external force acts on the system;
changes in momentum of Earth and book are equal and opposite / net force on Earth-book system is zero;
hence momentum of Earth-book system stays the same/is always zero and so is conserved; ***[3]***

(c) (i) $v = \sqrt{2 \times 9.8 \times 1.6}$;
$= 5.6\,\text{m s}^{-1}$ ***[1]***

(ii) calculation of speed of ball and spike $3.5 \times 5.6 = 4.3\text{V}$;
$V = \left(\frac{3.5 \times 5.6}{4.3} =\right) 4.6\,\text{m s}^{-1}$;

KE before $= \frac{1}{2}\left[3.5 \times 5.6^2\right]$ KE after $= \frac{1}{2}\left[4.3 \times 4.56^2\right]$;
energy dissipated $= 54.88 - 44.70$;
$= 10\,\text{J}$ ***[4]***
Accept 9.4 J if 4.6 used for V.

(d) $F = \frac{\Delta KE}{s}$;
$\Delta KE = 0.50 \times 4.3 \times 4.6^2 = 45(\text{J})$;
$F = \left(\frac{45}{7.3 \times 10^{-2}} =\right) 6.2 \times 10^2\,\text{N}$; ***[3]***

or

$a = \frac{v^2}{2s}$;
$a = 1.45 \times 10^2\ \text{m s}^{-2}$;
$F = ma = 4.3 \times 1.45 \times 10^2 = 6.2 \times 10^2\,\text{N}$;

(e) $\text{time} = \frac{\text{work}}{\text{power}}$;
$\text{work} = (3.5 \times 1.6 \times 9.8 =)\ 55(\text{J})$;
$\text{time} = \left(\frac{55}{18} =\right) 3.1\,\text{s}$; ***[3]***

Part 2 CCDs and digital data storage

(a) (i) photoelectric effect; ***[1]***

(ii) the amount of charge/potential created in a pixel is proportional to the intensity of the incident light;
the image is formed by registering the intensity of light in each pixel and the position of each pixel / *OWTTE*; ***[2]***

(b) number of photons in $15\,\text{ms} = 3.6\times10^{6}\times15\times10^{-3} = 54\times10^{3}$;

number of electrons emitted $= 43\times10^{3}$;
charge $= 43\times10^{3}\times1.6\times10^{-19} = 69\times10^{-16}\,(\text{C})$;

$V = \left(\dfrac{69\times10^{-16}}{34\times10^{-12}} = \right)0.20\,\text{mV}$; ***[4]***

(c) the retrieval speed is much faster;
since each piece of data can be assigned an electronic address;
data can be retrieved with less corruption / data less likely to be mis-read (on retrieval);
some comparison with an analogue storage system *e.g.* book/library/video tape; ***[3 max]***
To award ***[3 max]*** *the first and the third marking point must be addressed.*