N11/4/PHYSI/HP2/ENG/TZ0/XX/M

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MARKSCHEME

November 2011

PHYSICS

Higher Level

Paper 2

18 pages

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 shown 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, numbers, or units 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 ***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 when marking. Indicate this by adding **ECF** (error carried forward) on the script.

10. Only penalize candidates for errors in units or significant figures, when a penalty is specifically referred to in the markscheme.

SECTION A

A1. (a) (i) fractional uncertainty in distance $=\frac{2}{150}$ and
fractional uncertainty in time $=\frac{0.5}{8.3}$;
(allow use of percentage uncertainty)

fractional uncertainty in speed $=\frac{2}{150}+\frac{0.5}{8.3}\left(=0.074\ \textbf{or}\ 7.4\,\%\right)$;
absolute uncertainty $=18\times0.074$;
$=1.3\ (\text{cm s}^{-1})$ ***[3]***

or

maximum $=\frac{152}{7.8}$;
minimum $=\frac{148}{8.8}$;
shows subtraction of maximum and minimum and division by 2;

(ii) error bars drawn as ± 1.3; ***[1]***

(b) (i) smooth curve within limits of all error bars; ***[1]***

(ii) a straight line cannot be drawn;
that goes through all the error bars / that goes through the origin; ***[2]***

(c) c versus $\sqrt{d}$ / $d^{0.5}$ ***or*** c^2 versus d ***or*** lg c versus lg d ***or*** ln c versus ln d; ***[1]***
Allow as symbols or written in words.

(d) (i) error that is identical for each reading / error caused by zero error in instrument / *OWTTE*; ***[1]***

(ii) graph will not go through origin / intercept non-zero;
graph will not be straight line/linear; ***[1 max]***

A2. (a) *internal energy*:
total energy of component particles (in the human);
comprises potential energy + (random) kinetic energy;

temperature: ***[2 max]***
measure of average kinetic energy of particles;
indicates direction of (natural) flow of thermal energy;
internal energy measured in J and temperature measured in K/°C ; *(both needed)* *(accept alternative suitable units)* ***[3 max]***

(b) vaporization requires energy/latent heat supply to (sweat) molecules;
this energy is supplied by the skin/body;
allowing body to lose energy; ***[3]***

or

faster/more energetic molecules escape during evaporation;
slower/less energetic/lower temperature molecules remain;
so internal energy removed from skin;

A3. (a) (i) refers to unstable nucleus/isotope / refers to spontaneous/random process; which emits named radiation (from nucleus) / forms different nucleus/isotope; ***[2]***

(ii) combination of two nuclei / *OWTTE*; *(do not allow "particles" or "atoms")* to form new nuclide with greater mass/larger nucleus/greater number of nucleons; ***[2]***

(b) $\lambda = \frac{\ln 2}{4500}$ $(= 1.54 \times 10^{-4})$;

$0.1N_0 = N_0 e^{-1.54 \times 10^{-4} t}$;

1.5×10^4 (d) ***or*** 1.3×10^9 (s); ***[3]***

*Award **[2 max]** if answer is time to lose 10 % (680 d).*
Allow answer to be expressed in any time units.
*Award **[3]** for a bald correct answer.*

or

$\ln 0.1 = \frac{-0.69\,t}{t_{\frac{1}{2}}}$;

$t = 3.3 \times 4500$;

1.5×10^4 (d);

*Award **[2 max]** if answer is time to lose 10 % (680 d).*
Allow answer to be expressed in any time units.
*Award **[3]** for a bald correct answer.*

(c) (i) ${}^{1}_{0}n$ / neutron; ***[1]***

(ii) number of fusions required per second $= \frac{2.5 \times 10^8}{2.8 \times 10^{-12}}$ $(= 8.93 \times 10^{19})$;

1 tritium nucleus has mass of 3 amu $= 3.0 \times 1.67 \times 10^{-27}$ (kg)$(= 5.0 \times 10^{-27})$;

total tritium mass required $= 4/4.4/4.5/4.48 \times 10^{-7}$ (kg s^{-1}); ***[3]***

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

(iii) *Award any two appropriate problems e.g.*:
difficulty in maintaining high temperature for long periods;
difficulty in maintaining high density of plasma for long periods;
difficulty in enclosing plasma for long periods;
difficulty in controlled removal of heat from plasma;
difficulty in maintaining magnetic fields; ***[2 max]***

A4. (a) (minimum) speed of object to escape gravitational field of a planet/travel to infinity;
at surface of planet;
without (further) energy input; ***[2 max]***

(b) (i) $-\frac{6.67\times10^{-11}\times3.5\times10^{21}}{8.0\times10^{5}}$;

$-2.9\times10^{5}\ \text{J kg}^{-1}$; *(allow* $N\,m\,kg^{-1}$*)* ***[2]***

*Award **[1 max]** if negative sign omitted.*

(ii) $\frac{1}{2}mv^2 = mV$;

speed $=\sqrt{2\times2.9\times10^{5}}$; *(allow ECF from (b)(i))*

$7.6\times10^{2}\ \text{m s}^{-1}$; ***[3]***

Ignore sign.
*Award **[3]** for a bald correct answer.*

(c) time to hit surface $=\sqrt{\frac{2.0\times1.5}{0.37}}\,(=2.85\,\text{s})$;

distance to impact $= 2.85\times1.8$;

$5.1\,\text{m}$; ***[3]***

A5. (a) (quantum efficiency is) ratio $\frac{\text{no. of electrons emitted}}{\text{no. of photons incident}}$; ***[1]***

(b) length of image $= 6.0\,(\text{mm})$;

area of image $= 36\,(\text{mm}^2)$;

number of pixels $=\left(\frac{36}{2.2\times10^{-5}}=\right)1.64\times10^{6}$; ***[3]***

Other approaches are possible.
*Award **[3]** for a bald correct answer.*

(c) large image capacity;
ease of storage of processed images;
immediate access to images;
ease of manipulation/deletion/transfer; ***[2 max]***

SECTION B

B1. **Part 1** Greenhouse effect

(a) effect caused by gas such as $H_2O/NH_3/CH_4/CO_2$ /greenhouse gas in the atmosphere;
gas absorbs outgoing (long wave) radiation from Earth;
gas re-radiates some of the energy back to Earth; ***[3]***

(b) (i) $\frac{3.0\times10^{8}}{6.5\times10^{13}} = 4.6\,(\mu\text{m})$;
$\approx 5\,(\mu\text{m})$ ***[1]***

(ii) water vapour molecules have a natural frequency of oscillation;
if this frequency of oscillation is 6.5×10^{13} / reference to frequency at X;
due to resonance this radiation is readily absorbed by the molecules / the radiation matches the natural frequency of oscillation; ***[3]***

or

X is a natural frequency (of oscillation) of water molecule;
so resonance effects mean that molecules are excited at this frequency;
and energy is removed/less energy transmitted from electromagnetic waves at this (particular) frequency;

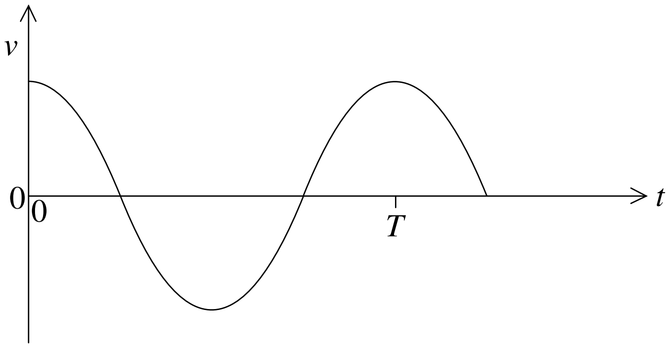
(iii) energy gained by absorption needs to be re-emitted (as molecules de-excite);
in other directions / some returns to Earth; ***[2]***

(iv) more greenhouse gases means that there is more absorption of outgoing radiation;
therefore more energy returns to Earth;
leading to a further/greater increase in the temperature of the surface (of Earth); ***[3]***

(c) change in volume $= 2.3\times10^{3}\times10^{9}\times0.5\times2.1\times10^{-4}\,(=2.4\times10^{8})$;
change in water level $= \frac{2.3\times10^{3}\times10^{9}\times0.5\times2.1\times10^{-4}}{2.4\times10^{5}\times10^{6}}\,(=1\times10^{-3}\text{ m})$;
clear statement that this value is similar to fall due to evaporation; ***[3]***

Part 2 Electromagnetic induction

(a) (i)



cosine wave same frequency as original;
phase correct; ***[2]***

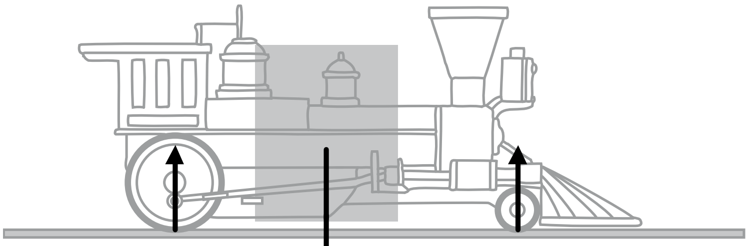
(ii) emf in phase or antiphase with answer to (a)(i); ***[1]***

(b) max speed $= 8.2\times10^{-2}\times2\pi\times2.5\,(=1.29\,\text{m s}^{-1})$;
$\varepsilon = 58\times10^{-6}\times0.18\times1.29$;
$13.5\,\mu\text{V}$; ***[3]***

(c) frequency of the emf doubles / period halves;
because same change of flux in half the time / because frequency of emf must equal frequency of oscillation;
maximum emf doubles;
maximum speed doubles / flux changes at twice rate; ***[4]***

B2. Part 1 Forces

(a)



The shaded box shows the acceptable range of position for W/mg.

single downward arrow labelled *W*/weight ***or*** *mg*/gravity force; *(do not allow gravity)*

two upward arrows labelled reaction/contact forces; *(do not allow for only one arrow seen)*

arrow positions as shown in diagram; ***[3]***

(b) horizontal forces have resultant of zero; *(must describe or imply horizontal force)*
valid statement linked to theory (*e.g.* Newton 1/Newton 2/conservation of momentum) explaining why zero force results in constant velocity/zero acceleration; ***[2]***

(c) power $= 16 \times 76000$;
1.2 MW; ***[2]***

(d) acceleration $= \frac{16^2}{2 \times 1100} (= 0.116)$;

$m = \left(\frac{7.6 \times 10^4}{0.116} = \right) 6.5 \times 10^5$ kg; ***[2]***

Award ***[2]*** *for a bald correct answer.*

or

use of $Fs = \frac{1}{2} mv^2$;

$m = \left(\frac{2 \times 7.6 \times 10^4 \times 1100}{16^2} = \right) 6.5 \times 10^5$ kg;

Award ***[2]*** *for a bald correct answer.*

(e) (i) 57 kN; ***[1]***

(ii) $F_8 = \frac{F_{16}}{2^3}$;
$F_8 = 7.1\,(\text{kN})$;
total force $= 19 + 7.1\,(\text{kN})$;
$= 26\,\text{kN}$; ***[4]***
*Award **[4]** for a bald correct answer.*

or

$k = \left(\frac{57 \times 10^3}{16^3}\right) = 13.91$;
$F_8 = (13.91 \times 8^3) = 7.1\,(\text{kN})$;
total force $= 19 + 7.1\,(\text{kN})$;
$= 26\,\text{kN}$;
*Award **[4]** for a bald correct answer.*

(f) direction of engine is constantly changing;
velocity is speed + direction / velocity is a vector;
engine is accelerating as velocity is changing; ***[3]***
*Award **[0]** for a bald correct answer.*

or

centripetal force required to maintain circular motion;
quotes Newton 1/Newton 2;
so engine is accelerating as a force acts;
*Award **[0]** for a bald correct answer.*

Part 2 Resolution

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

(ii) the first minimum of one diffraction pattern;
falls on central maximum of other diffraction pattern; *[2]*

(b) (i) $\theta = \left(1.22 \times \frac{5.1 \times 10^{-7}}{3.0 \times 10^{-3}} = \right) 2.1 \times 10^{-4}$ (rad);

angular separation of sections $= \left(\frac{0.13}{720} = \right) 1.8 \times 10^{-4}$ (rad) / required minimum separation for resolution $= (2.1 \times 10^{-4} \times 720 =)\, 0.15\,\text{m}$;
they cannot be resolved; *[3]*
Ignore omission of 1.22 (gives $\theta = 1.7 \times 10^{-4}$ and (ECF) are just resolved).
*Award **[0]** for a bald correct answer.*

(ii) $\theta = \left(1.22 \times \frac{510 \times 10^{-9}}{3.5 \times 10^{-3}} = \right) 1.78 \times 10^{-4}$ (rad);

3.6×10^{-4} (rad); *[2]*
Ignore omission of 1.22 (gives 2.9×10^{-4} (rad)).

B3. Part 1 Properties of tungsten

(a) (i) arrow pointing away from nucleus; ***[1]***

(ii) $E = \dfrac{74 \times 1.6 \times 10^{-19}}{4\pi \times 8.85 \times 10^{-12} \times [1.4 \times 10^{-10}]^2}$;

$5.4 \times 10^{12}\ \mathrm{V\,m^{-1}}$ ***or*** $\mathrm{N\,C^{-1}}$; ***[2]***

*Award **[2]** for a bald correct answer.*

(b) conduction is due to movement of the free electrons (transferring charge around circuit);
tungsten is a good electrical conductor with large numbers of free electrons;
glass is a poor electrical conductor with few/no free electrons; ***[2 max]***

(c) (i) $\dfrac{6^2}{15}$ ***or*** $I = \dfrac{15}{6}$ and $R = 6 \times \dfrac{6}{15}$;

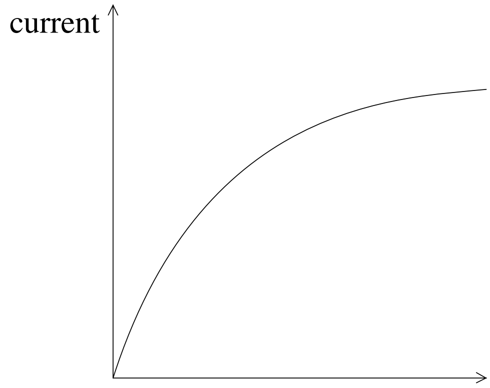
$= 2.4\,(\Omega)$ ***[1]***

(ii) $\text{area} = \dfrac{5.6 \times 10^{-7} \times 0.35}{2.4}$;

$0.082\ \mathrm{mm^2}$ ***or*** $8.2 \times 10^{-8}\ \mathrm{m^2}$; ***[2]***

(d) (i) lamp connected so that pd can be varied;
ammeter in series with lamp and voltmeter in parallel with lamp; *(both needed)* ***[2]***
*Award **[0]** if lamp cannot light.*

(ii) through origin;
correct shape; ***[2]***



(e) minimum pd across bulb is when $R = 5.0\,\Omega$;

pd across bulb $= 6.0 \times \dfrac{2.4}{7.4}$

$= 1.9\,(\mathrm{V})$ ***or*** $2.0\,(\mathrm{V})$;

so range $-1.9 - 6.0\,\mathrm{V}$ ***or*** $0\,\mathrm{V}$ across lamp cannot be obtained; ***[3]***

Part 2 Properties of a gas

(a) choice of two data points;
to show $P \times V$ constant for gas A / not constant for gas B; ***[2]***

(b) identifies area between lines as work done;
counts squares (14 squares);
each square 12.5;
175 J; *(allow answers in the range of 150 to 200 J)* ***[4]***

(c) $Q = \Delta U + W$ and $Q = 0$; *(both needed)*
so $\Delta U + W = 0$;
work done by gas is positive;
so ΔU decreases therefore temperature decreases; ***[4]***

B4. Part 1 Wave motion

(a) (i) downward arrow at P; *[1]*

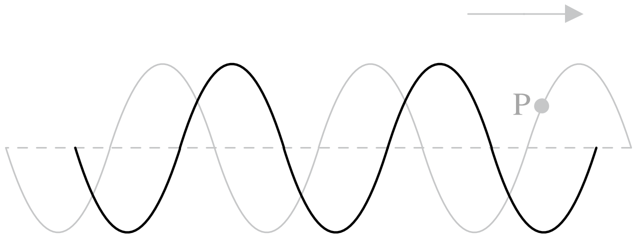
(ii) clear single wavelength marked; *[1]*

(b) (i) $\text{frequency} = \frac{18}{25}\ (\text{Hz}) = 0.72\ (\text{Hz})$;

$\text{period} = \left(\frac{1}{0.72} = \right) 1.4\ \text{s}$; *[2]*

*Award **[2]** for a bald correct answer.*

(ii) wave moved to right by one-third of a cycle by eye; *[1]*

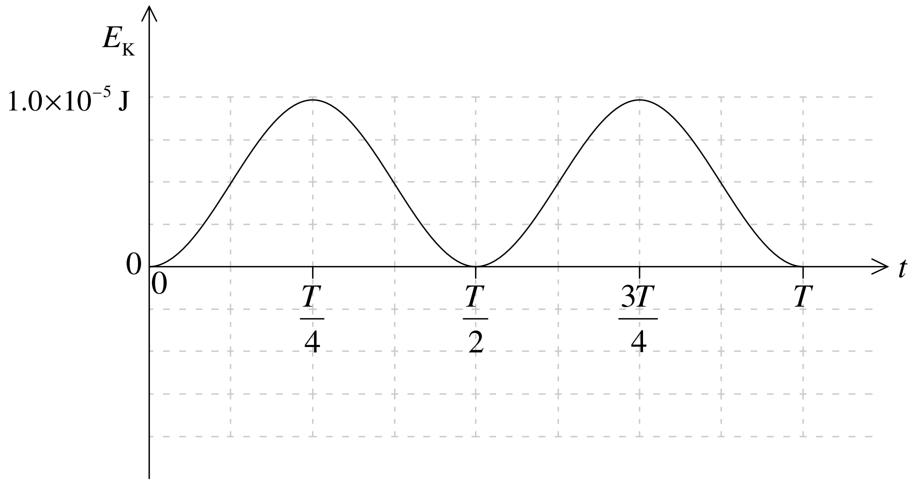


(c) (i) $\omega = \frac{2\pi}{1.4}$;

$\left(\frac{1}{2} \times 3.5 \times 10^{-3} \times \left[\frac{4\pi^2}{1.4^2}\right] \times \left[1.7 \times 10^{-2}\right]^2\right) = 1.0 \times 10^{-5}\ \text{J}$; *[2]*

*Award **[2]** for a bald correct answer.*

(ii)



correct shape $(\sin^2)$; *(allow any phase for this graph)*

varying between 0 and 1.0×10^{-5} J; *(allow ECF from (c)(i) but do not allow E to be negative)*

one period takes $\frac{T}{2}$; *[3]*

(d) (i) reduced wavelength;
reduced amplitude; ***[2]***

(ii) speed reduced and frequency constant;
therefore wavelength reduced;
some energy reflected at boundary / second string is denser/greater mass per unit length;
therefore amplitude reduced; ***[3 max]***

Part 2 Atomic spectra

(a) (i) $\frac{6.7\times10^{-34}\times3.0\times10^{8}}{4.9\times10^{-7}}$;
2.5 ***or*** 2.6 eV; ***[2]***

(ii) transition between –0.85 and –3.4;
correct direction of arrow (down); ***[2]***

(b) (i) wavelength of standing wave of electron in a box model is its de Broglie wavelength;
wavelength is $2\frac{L}{n}$;
momentum and hence energy of electron is dependent on wavelength;
only integral number of wavelengths allowed therefore energy is quantized; ***[3 max]***

or

$\lambda=\frac{h}{p}$;
wavelength is $2\frac{L}{n}$;
so $p=\frac{hn}{2l}$;
energy related to p and n is an integer so energy is quantized;

(ii) Schrödinger model describes electrons in the atom as having a wavefunction;
(leading to) electron (standing) waves have quantized orbits/energies as in box model;
electron positions are not well defined;
square of wave amplitude is measure of probability of finding electron at a point; ***[3 max]***