N14/4/PHYSI/HP2/ENG/TZ0/XX/M

International Baccalaureate®
Baccalauréat International
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MARKSCHEME

November 2014

PHYSICS

Higher Level

Paper 2

16 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.

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 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. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

SECTION A

1. (a) smooth curve that passes within ± 0.5 squares of all data points; *[1]*

(b) (i) a tangent drawn at [291, 5.2] and selection of two extreme points on the tangent that use $\Delta R > 3.5\,\Omega$; *(judge by eye)*

gradient magnitude determined as 0.20 ± 0.02;
negative value given; *[3]*

(ii) $\Omega\,\mathrm{K}^{-1}$; *[1]*

(c) correct error bar for 283 K (total length of bar 3–5 squares, centred on point);
correct error bar for 319 K (total length of bar 0.5–2 squares, centred on point); *[2]*

(d) (i) substituting $I^2R = \left([0.78\times10^{-3}]^2\times7.5\right) = 4.5\times10^{-6}\,\mathrm{W}$ ***or*** $4.6\times10^{-6}\,\mathrm{W}$; *[1]*

(ii) fractional uncertainty in $I^2 = 2\times\dfrac{0.01}{0.78}$ $\left(=0.026\ \ \textbf{\textit{or}}\ \ 2.6\ \%\right)$;

uncertainty in power $\left(=[0.026+0.05]\times4.6\times10^{-6}\right)=0.34\times10^{-6}\,\mathrm{W}$ to $0.35\times10^{-6}\,\mathrm{W}$;

answer rounded to 1 significant figure; *[3]*

or

uncertainty in $I^2 = 2\times1.3\%\ /\ 0.026$;

total uncertainty in P $= 7.6\%\ /\ 0.076$;

answer rounded to 1 significant figure;

2. (a) $(Q) = 45.0 \times 125\,(= 5625\,\text{J})$;

$c = \left(\dfrac{Q}{m\Delta\theta} =\right) 2.01 \times 10^{3}\,\text{J kg}^{-1}\,\text{K}^{-1}$; ***[2]***

(b) energy available $= 125 \times 600$ ($= 75000$ J);

energy available to warm the water $= 75000 - [0.15 \times 3.3 \times 10^{5}]\,(= 25500\,\text{J})$;

temperature $= \left(\dfrac{25500}{0.15 \times 4200} =\right) 40.5\,^{\circ}\text{C}$; ***[3]***

3. (a) (i) neutron / ${}^{1}_{0}\text{n}$; ***[1]***

(ii) kinetic energy / gamma radiation / binding energy; ***[1]***

(b) (i) number of fissions in one day $= 9.5 \times 10^{19} \times 24 \times 3600\,(= 8.2 \times 10^{24})$;

mass of uranium atom $= 235 \times 1.661 \times 10^{-27}\,(= 3.9 \times 10^{-25}\,\text{kg})$;

mass of uranium in one day $(= 8.2 \times 10^{24} \times 3.9 \times 10^{-25}) = 3.2\,\text{kg}$; ***[3]***

(ii) energy per fission $= 200 \times 10^{6} \times 1.6 \times 10^{-19}\,(= 3.2 \times 10^{-11}\,\text{J})$;

power output $= (9.5 \times 10^{19} \times 3.2 \times 10^{-11} \times 0.32 =) 9.7 \times 10^{8}\,\text{W}$; ***[2]***

*Award **[1]** for an answer of* $6.1 \times 10^{27}\,\text{eVs}^{-1}$.

(c) neutrons have to be slowed down (before next fission);
because the probability of fission is (much) greater (with neutrons of thermal energy);
neutrons collide with/transfer energy to atoms/molecules (of the moderator); ***[3]***

(d) kinetic energy of neutrons/thermal energy of core is transferred into thermal energy of the coolant (and elsewhere);
(thermal energy) is converted into kinetic energy in moving steam;
(kinetic energy of steam) is transferred into (rotational) kinetic energy of turbine;
(kinetic energy of turbine) is transferred into electrical energy by dynamo/generator; ***[3 max]***

4. (a) KE needs to be ≥ (magnitude of) GPE at surface $\left(-\frac{GMm}{R_E}\right)$;

But KE is $\frac{7GMm}{8R_E} < \frac{GMm}{R_E}$ / *OWTTE*; ***[2]***

or

<u>shows that</u> total energy at launch $= -\frac{GMm}{8R_E}$; *(appropriate working required)*

this is < 0, so escape impossible;

or

states that escape velocity needed is $\sqrt{\frac{2GM}{R_E}}$;

<u>shows</u> launch velocity is only $\sqrt{\frac{7GM}{4R_E}}$; *(appropriate working required)*

(b) (i) $E_{tot} = \text{PE} + \text{KE}$;

<u>shows that</u> kinetic energy $= (\frac{1}{2}mv^2 =)\frac{GMm}{2R}$; *(appropriate working required)*

adds PE $\left(-\frac{GMm}{R}\right)$ and KE to get given answer; *(appropriate working required)* ***[3]***

(ii) $-\frac{GMm}{R_E} + \frac{7GMm}{8R_E} = -\frac{GMm}{2R}$; *(equating total energy at launch and in orbit)*

$\frac{1}{8R_E} = \frac{1}{2R}$;

$R = 4R_E$; ***[3]***

*Award **[0]** for an answer such as* $R = \frac{4R_E}{7}$.

(c) total energy decreases/becomes a greater negative value, <u>so *R* decreases</u>;
as *R* decreases kinetic energy increases;
speed increases; ***[2 max]***
Allow third marking point even if reasoning is incorrect.

5. (a) energy incident on pixel $= \left(20\times10^{-3}\ \text{W m}^{-2}\times3.5\times10^{-10}\ \text{m}^2\times0.03\text{s}\right) = 2.1\times10^{-13}\ \text{J}$;

energy of each photon $= \dfrac{hc}{\lambda} = \left(3.61\times10^{-19}\ \text{J}\right)$;

so $\dfrac{2.1\times10^{-13}\ \text{J}}{3.61\times10^{-19}\ \text{J}} = 583000$ photons ; ***[3]***

or

energy of one photon $= \dfrac{hc}{\lambda}(= 3.61\times10^{-19}\ \text{J})$;

number of photons per second per $\text{m}^2 = \dfrac{20\times10^{-3}}{3.61\times10^{-19}}\left(= 5.5\times10^{16}\right)$;

number of photons during exposure $= 5.5\times10^{16}\times3.5\times10^{-10}\times3\times10^{-2} = 582000$ photons;

Answer is given so award marks for correct steps in the working <u>and</u> more than 1 significant figure in the final answer.

(b) charge released $= 582000\times0.75\times1.6\times10^{-19}\ \text{J}\ \left(= 7\times10^{-14}\ \text{C}\right)$;

potential difference change $= \dfrac{7\times10^{-14}}{60\times10^{-12}}$;

an answer in the range of 1.16 to $1.20\times10^{-3}\ \text{V}$; ***[3]***

SECTION B

6. Part 1 Energy resources

(a) *renewable sources*:
rate of use/depletion of energy source;
is less than rate of production/regeneration of source; ***[2]***
Accept equivalent statement for non-renewable sources.

or

mention of rate of production / usage;
comparison of sources in terms of being used up/depleted/lasting a long time *etc*;
*Award **[1]** if answer makes clear the difference but does not address the rate of production.*

(b) solar heating panel converts solar/radiation/photon/light energy into thermal/heat energy and photovoltaic cell converts solar/radiation/photon/light energy into electrical energy; *(both needed)*

in solar heating hot liquid is stored/circulated and photovoltaic cell generates emf/potential difference; *(both needed)* ***[2]***

(c) (i) (power available at roof) $= 1.3 \times 750$ $(= 975\text{W})$;

efficiency $= \left(\frac{210}{975} =\right) 0.22$ ***or*** 22 %; ***[2]***

(ii) depends on time of day;
depends of time of year;
depends on weather (*eg* cloud cover) at location;
power output of Sun varies;
Earth-Sun distance varies; ***[2 max]***

(d) (i) area of panel $= \frac{4200}{0.7 \times 750}$;
$8\,\text{m}^2$; ***[2]***

(ii) calculates area of photovoltaic panels needed as about $26\,\text{m}^2$ / makes a quantitative comparison;
solar heating takes up less area/more efficient/faster;
further energy conversion needed, from electrical to thermal, with photovoltaic panels, involving further losses / *OWTTE*; ***[2 max]***
Allow ECF from (d)(i) with appropriate reverse argument.

(e) aim is to cut greenhouse gases/CO_2/emissions;
principal/enhanced greenhouse emissions arise from use of fossil fuel;
reduce dependence on fossil fuels;
increase use of a named non-fossil fuel; *(must be named)*
use/improve public transport; ***[3 max]***
Accept any other reasonable responses.

Part 2 Transformers

(f) number of secondary coils < primary coils;
coils wound around an iron core;
ideally no flux leakage/zero resistive heating; ***[2 max]***

(g) solution;
with linked explanation;
another solution;
with linked explanation; ***[4]***

eg:
laminations in core;
prevents eddy currents in core;
thick/low resistance wires for primary and secondary turns;
reduces heating losses in wires;

(h) (i) 4.1 W; ***[1]***

(ii) power required at primary $= \frac{4.1}{0.95} = 4.3$ W; *(allow ECF from (h)(i))*

current $= \frac{4.3}{230} = 1.9 \times 10^{-2}$ A ; ***[2]***

(iii) approximately 1.0×10^{8} J ; ***[1]***
Allow use of either power value.

7. (a) work done $=$ force $\times$ distance moved;
(distance moved) in direction of force; ***[2]***

or

energy transferred;
from one location to another;

or

work done = $Fs\cos\theta$;
with each symbol defined;

(b) (i) horizontal force $= 250000 \times \cos 39^{\circ}\ (= 1.94 \times 10^{5}\ \text{N})$;
work done $= 1.9 \times 10^{8}\ \text{J}$; ***[2]***

(ii) power provided by kite $= (1.94 \times 10^{5} \times 8.5 =) 1.7 \times 10^{6}\ \text{W}$;
total power $= (2.7 + 1.7) \times 10^{6}\ \text{(W)}\ \ (= 4.4 \times 10^{6}\ \text{W})$;
fraction provided by kite $= \dfrac{1.7}{2.7 + 1.7}$;
38 % ***or*** 0.38; *(must see answer to 2+ sig figs as answer is given)* ***[4]***
Allow answers in the range of 37 to 39% due to early rounding.

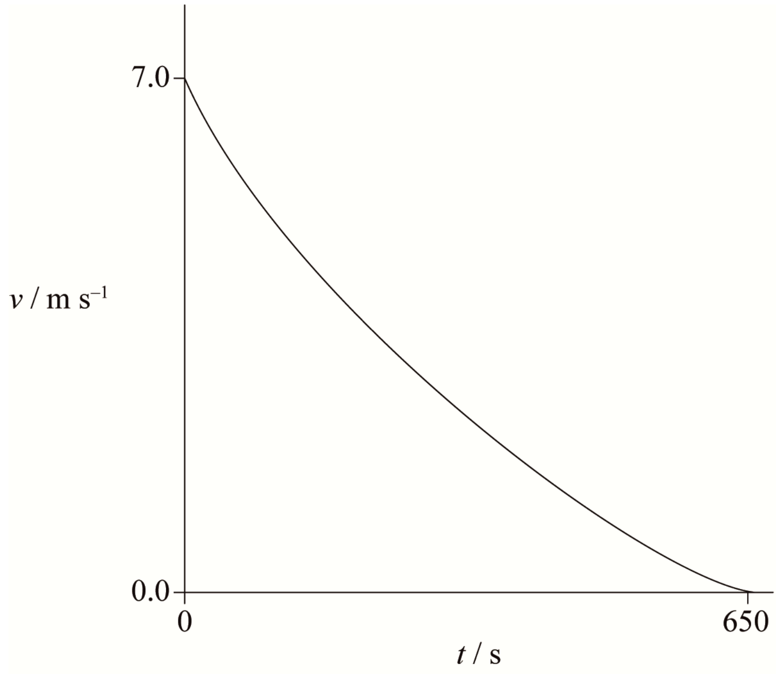
or

Award ***[3 max]*** *for a reverse argument such as:*
if 2.7 MW is 60 %;
then kite power is $\dfrac{2}{3} \times 2.7\ \text{MW} = 1.8\ \text{MW}$;
shows that kite power is actually 1.7 MW; *(QED)*

(c) $P = (kv^{2}) \times v = kv^{3}$;
$$\frac{v_1}{v_2} = \left(\sqrt[3]{\left(\frac{P_1}{P_2}\right)} = \right)\sqrt[3]{\left(\frac{2.7}{4.4}\right)};$$
final speed of ship $= 7.2\ \text{m s}^{-1}$; *(at least 2 sig figs required).* ***[3]***
Approximate answer given, marks are for working only.

(d) (i) correct substitution of 7 or 7.2 into appropriate kinematic equation;
an answer in the range of 2200 to 2400 m; ***[2]***

(ii) starts at 7.0 / 7.2 m s^{-1}; *(allow ECF from (d)(i))*
correct shape; ***[2]***



(e) use of $\theta = \frac{1.22\lambda}{d}$;

$\left(\frac{1.22 \times 520 \times 10^{-9}}{6.2 \times 10^{-3}}\right) = 1.02 \times 10^{-4}$;

distance $= \left(\frac{1.5}{1.02 \times 10^{-4}} =\right) 1.47 \times 10^{4}$ m; ***[3]***

*Award **[2 max]** if distance is* 1.79×10^{4} *m (ignoring factor of 1.22) in second marking point.*

(f) (i) partially/partly;
plane/horizontally polarized; ***[2]***

(ii) $\theta = \tan^{-1} 1.3 = 52^{\circ}$;
$90 - \theta = 38^{\circ}$; ***[2]***

(iii) the light from the sea is (predominantly) horizontally polarized;
the sunglasses are arranged to admit a particular/vertical plane of polarization;
hence polarized sunglasses absorb much of the reflected light/glare; ***[3]***

8. Part 1 Internal resistance of a cell

(a) energy/work per unit charge supplied (by a cell) driving the current completely around a circuit;
quantity of chemical/any form of energy, per unit charge, changed to electrical energy;
potential difference across a cell when no current flows;
Allow similar responses. ***[1 max]***

(b) charge carriers/electrons move through cell;
transfer energy to the components of the cell (which is not therefore available to external circuit);
energy dissipated in cell equivalent to dissipation in a resistance;
causes potential difference of cell to be less than its emf; ***[3 max]***

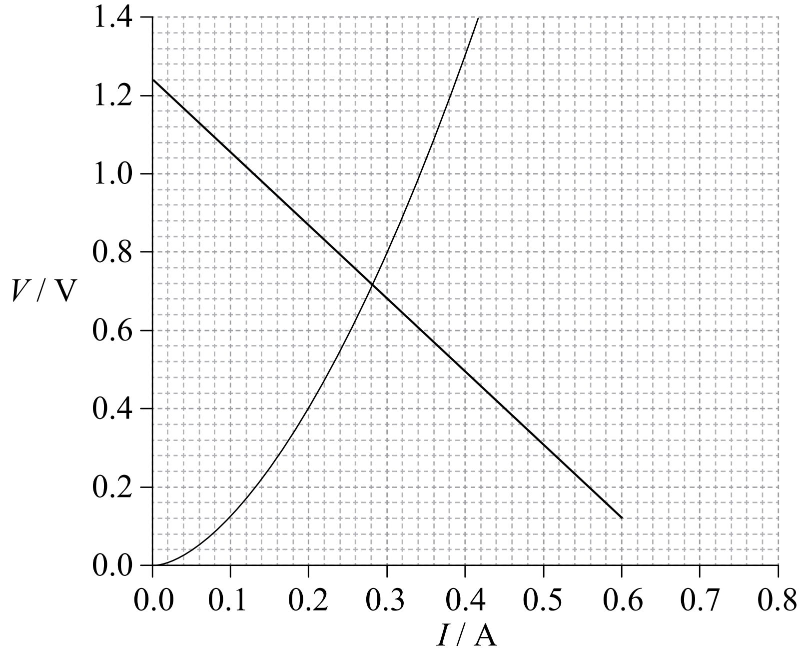
(c) (i) ammeter in series with cell and voltmeter across cell or variable resistor; *(both needed)* ***[1]***

(ii) $\frac{7.2\times10^{-3}}{5.8\times10^{-3}}$ (=1.24 V ***or*** 1.25 V); ***[1]***
Answer is given so award the mark for showing the working.

(iii) $I=\frac{0.55}{1.5}$;
$\left(1.25=0.55+Ir\right)\ r=1.9\,\Omega$; *(accept valid alternative method)* ***[2]***

(iv) use of I^2R or valid alternative;
0.20 W; ***[2]***

(d) (i) straight line of negative gradient; *(allow any straight line of negative gradient)*
intercept at 1.25 V (± 0.05) and position/gradient as shown; ***[2]***
Watch for ECF from (c)(iii).



(ii) uses a point at which lines intersect;
reads correct current value from their own graph;
0.28 A ± 0.1 A ; *(award for correct answer only)* ***[3]***

Part 2 Expansion of a gas

(e) *PV* is a constant for A / B is a steeper curve / final temperature/pressure lower for B than A;
(hence) B; ***[2]***

(f) number of small squares below $\text{A} = 180 \pm 20$;
area of 1 $\text{square} = 6.25\ \text{J}$;
adds additional 64 squares below false origin;
answer within the range of 1400 to 1650 J; } *(allow ECF for an area that excludes the area below the false origin – giving an answer within the range of 1000 to 1250 J)* ***[4]***

*Award **[2]** for a mean P of* $4.65\times10^{5}\times\Delta V$ of 4×10^{-3} *giving an answer of 1860 (J).*
Accept working in large squares (= 16 small squares) using equivalent tolerances.

(g) no thermal energy enters or leaves / $Q = 0$;
work done by the gas / W is positive;
so internal energy decreases / ΔU is negative;
temperature is a measure of internal energy and so temperature falls; ***[4]***

9. Part 1 Oscillation of a mass

(a) (i) force of 1.8 N for each spring so total force is 3.6 N;

acceleration $= \frac{3.6}{0.8} = 4.5\,\text{m}\,\text{s}^{-2}$; *(allow ECF from first marking point)*

to left/towards equilibrium position / negative sign seen in answer; ***[3]***

(ii) force/acceleration is in opposite direction to displacement/towards equilibrium position;

and is proportional to displacement; ***[2]***

(iii) $\omega = \left(\sqrt{\left(\frac{a}{x}\right)} = \right)\sqrt{\frac{4.5}{60\times10^{-3}}}(= 8.66\,\text{rad}\,\text{s}^{-1})$;

$T = 0.73\,\text{s}$; ***[2]***

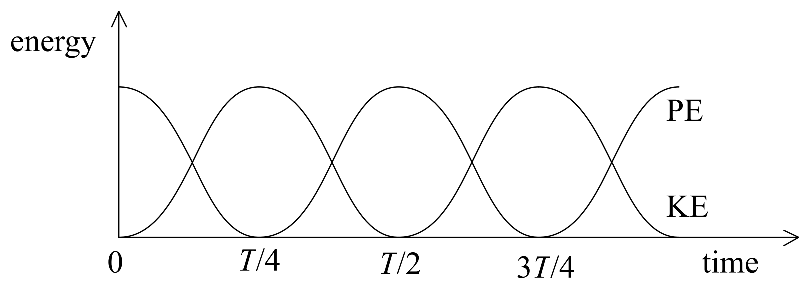
*Watch out for ECF from (a)(i) eg award **[2]** for $T = 1.0\,s$ for $a = 2.25\,\text{m}\,\text{s}^{-2}$.*

(b) (i) $\omega = 2\pi\times7\times10^{12}(= 4.4\times10^{13}\,\text{Hz})$;

$5\times10^{-21}\,\text{J}$; ***[2]***

Allow answers in the range of 4.8 to 4.9×10^{-21} J if 2 sig figs or more are used.

(ii)



KE and PE curves labelled – very roughly $\cos^2$ and $\sin^2$ shapes; } *(allow reversal of curve labels)*

KE and PE curves in anti-phase and of equal amplitude;

at least one period shown;

either E_{max} marked correctly on energy axis, or T marked correctly on time axis; ***[3 max]***

(c) (i) 7.0×10^{12} Hz is equivalent to wavelength of $4.3\times10^{-5}\,\text{m}$; ***[1]***

(ii) mention of resonance;

when frequency of (IR) radiation equals natural frequency of the lattice / *OWTTE*; ***[2]***

Part 2 Photoelectric effect

(d) light consists of photons with energy $E = hf$;
there is a minimum energy/work function required for electron to leave a particular metal;
hf must be larger than this value; ***[2 max]***

(e) (i) (value of intercept on *f*-axis =) 9.3×10^{14} Hz ; ***[1]***
Allow answers in the range of 9.0 to 9.5, but with correct power of ten.

(ii) attempted use of gradient $\left(\frac{h}{e}\right)$ to evaluate *h*;

eg $\frac{2.4}{6 \times 10^{14}} = 4 \times 10^{-15}$ eVs ; *(allow answers in the range of 3.9 to* 4.2×10^{-15}*)*
6.4×10^{-34} Js ; *(allow ECF, eg answers in the range of 6.2 to* 6.7×10^{-34}*)* ***[3]***
Do not allow a bald answer of 6.6×10^{-34} *as value is known.*

or

use of *y*-intercept $= \frac{-hf_0}{e}$;
$h = \frac{3.77 \times 1.6 \times 10^{-19}}{0.93 \times 10^{15}}$; *(allow intercept between –3.6 and –3.8 eV)*
6.4×10^{-34} Js ; *(allow ECF, eg answers in the range of 6.0 to* 6.8×10^{-34}*)*
Do not allow a bald answer of 6.6×10^{-34} *as value is known.*

(iii) $E = 6.62 \times 10^{-34} \times 9.3 \times 10^{14} (= 6.2 \times 10^{-19}\text{ J})$;
an answer in the range of 3.4 to 4.0 eV; *(allow ECF from (e)(i) and (e)(ii))* ***[2]***

or

identifies *y* intercept as work function;
an answer in the range of 3.6 to 3.8 eV;

(f) straight line of any length parallel to original data;
to left of original data, intercept on *f*-axis would be positive; ***[2]***