M14/4/PHYSI/HP2/ENG/TZ2/XX/M

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MARKSCHEME

May 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 x 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 <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 ***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 drawn through all error bars and curve extrapolated appropriately to x-axis;
their own intercept correctly read to within ± 6 minutes (1 small square) / 7:50 hour to 8:00 hour if no line drawn; ***[2]***

(b) calculates total energy used by house $= 8$ (kWh) ***or*** 28.8 (MJ);
estimate of total area $= 14 \pm 1$ (kWh) ***or*** 50.4 ± 3.6 (MJ);
6 ± 1 (kWh) ***or*** 21.6 ± 3.6 (MJ); *(allow ECF from first two marking points)* ***[3]***

or

clear attempt to estimate any area of graph;
correct calculation of area above 2 kW line on graph;
6 ± 1 (kWh) ***or*** 21.6 ± 3.6 (MJ); *(allow ECF from first two marking points)*

(c) read-off error bar at 12:00 hour as 0.4;
calculate uncertainty in $P = \left(\frac{100 \times 0.4}{6.0} =\right) 6.6\,\%$;
$\frac{\Delta V}{V} = \frac{\left[\frac{\Delta P}{P} - \frac{\Delta R}{R}\right]}{2} = 2.3\%$; ***[3]***

(d) intercept 8.7 ± 0.1;
gradient equals $\left(\frac{8.7}{210} =\right)(-)0.041$; *(allow ECF from first marking point)*
$P^2 = 8.7 - 0.041t$; *(negative sign essential)*
(allow ECF from first and second marking points) ***[3]***
Do not accept "inverse" relationship or "linear".
Award ***[3]*** *for a bald correct answer.*
Award ***[2 max]*** *if gradient is left as a fraction.*

2. (a) same temperature so (average) kinetic energy (of atoms/molecules) the same;

(interatomic) potential energy of atoms is greater for liquid / energy is needed to separate the atoms; *(do not allow "forces are weaker" arguments)*

internal energy $=$ potential energy $+$ kinetic energy; *(allow BOD for clear algebra)*
(so internal energy is greater) ***[3]***

(b) energy lost by freezing zinc $= 1.5 \times 113000\ (= 170000\,\text{J})$; *(watch for power of ten error)*

energy gained by iron $= 12 \times 440 \times [89 - 20] (= 364000\,\text{J})$;
energy lost by cooling solid zinc $= 195000\,(\text{J})$;

specific heat capacity of zinc $= \dfrac{195000}{1.5 \times [420 - 89]} = 390\left(\text{J kg}^{-1}\,\text{K}^{-1}\right)$; ***[4]***

*Award **[3 max]** for an answer of 733 $(kJ\ kg^{-1}\ K^{-1})$ $(1.5 \times 113$ was used).*

or

thermal energy lost by zinc $=$ thermal energy gained by iron;
indication that thermal energy lost by zinc has a latent heat contribution and a specific heat contribution expressed algebraically or numerically;
substitution correct;
answer;

3. (a) difference between mass of a nucleus and the sum of mass of nucleons/ constituents/particles; ***[1]***

(b) (i) mass defect $= \left([2 \times 1.007276 + 1.008665] - 3.014931 = \right) 0.008286$ u;

binding energy per nucleon $= \left(\dfrac{0.008286 \times 931.5}{3} = \right) \dfrac{7.7}{3}$ ***or*** 2.58(MeV); ***[2]***

(ii) binding energy of left-hand side $= 1.11 \times 2$ <u>and</u> binding energy of right-hand side $= 3 \times 2.6$; *(both needed) (allow ECF)*

energy release $= 5.58$ (MeV); *(ignore sign)* ***[2]***

(iii) line goes through Ni point and nickel is the maximum $\pm$ 2 small squares horizontally; *(allow Fe-56 as maximum – this is just outside the range allowed)*

line starts at 0, downward trend for *A* after 62, trend after nickel less steep than before; ***[2]***

Line must go through part of the X to award first marking point.
Line must not flatten out to award second marking point.
Allow smooth curve for low A.
Allow incorrect variations at low A.

(iv) nucleus produced in the reaction is higher up the curve than the reactants / *OWTTE*; *(must see reference to graph)*

reference to binding energy/other valid reason results in energy release; ***[2]***

Award ***[0]*** *for a bald correct answer.*
Award ***[0]*** *for any discussion of fission.*

4. (a) (i) along axis of pipe / horizontal / left to right;
Do not allow "right" or "left" alone. Allow correct answers that appear on the diagram. ***[1]***

(ii) P has greater/maximum amplitude;
Q does not move/has zero amplitude; ***[2]***

(b) $\lambda = 4.2$ m;
79 ***or*** 78.6 (Hz); *(do not allow 78 Hz)* ***[2]***
*Award **[2]** for a bald correct answer.*

(c) wavefronts emitted by the pipe at regular time intervals;
observer crosses the wavefronts more often than if stationary;
so frequency is higher; ***[3]***
*Award **[0]** for a bald correct answer.*

or

observer moving towards the source measures the emitted wavelength;
but (relative) wave speed measured is higher than that emitted;
so frequency is higher;
*Award **[0]** for a bald correct answer.*

or

quotes Doppler equation correctly;
deduces higher frequency correctly;
*Award **[2 max]** for this approach.*

(d) (i) required separation $= 2 \times 6.7 \times 10^{-4}$;
magnification $= \left(\frac{13.4 \times 10^{-4}}{60} =\right) 2.23 \times 10^{-5}$; $\}$ *(allow ECF from incorrect separation)* ***[2]***
*Award **[2]** for a bald correct answer.*

(ii) $\theta = \left(\frac{1.22\lambda}{d} = \frac{1.22 \times 4.5 \times 10^{-7}}{8.5 \times 10^{-4}} =\right) 6.5 \times 10^{-4}$ (rad);
$l = \left(\frac{0.06}{6.5 \times 10^{-4}} =\right) 93$ (m); ***[2]***
Allow solution that omits 1.22 factor to give d = 110 (m).
*Award **[2]** for a bald correct answer.*

5. (a) magnetic flux density/magnetic field strength normal to a surface $\times$ area of surface; ***[1]***
Allow fully explained equation or diagram.

(b) (i) $v = \frac{1}{0.02} \times 2\pi \times 0.06 \left(= 18.8\,\mathrm{m\,s^{-1}}\right)$;
$\varepsilon = (Blv =)\, 61 \times 10^{-3} \times 0.25 \times 18.8$;
$290\,(\mathrm{mV})$; ***[3]***
*Award **[3]** for a bald correct answer.*

(ii) sinusoidal curve drawn; *(at least half a cycle required)*
with a period of $0.02\,\mathrm{s}$; ***[2]***
Accept any phase.

SECTION B

6. Part 1 Renewable energy sources

(a) only non-renewable is depleted/cannot re-generate whereas renewable can / consumption rate of non-renewables is greater than formation rate and consumption rate of renewables is less than formation rate; ***[1]***
Do not allow "cannot be used again".

(b) (i) volume released $= \left(22\times10^{6}\times6=\right)1.32\times10^{8}\left(\text{m}^{3}\right)$;

volume per second $= \dfrac{1.32\times10^{8}}{6\times3600}\left(=6111\,\text{m}^{3}\right)$; ***[2]***

(ii) use of average depth for calculation (3 m);
gpe lost $= 6100\times1000\times9.81\times3$;
0.18 (GW); ***[3]***
Accept $g = 10\,\text{m}\,\text{s}^{-2}$.
*Award **[1 max]** if 6 m is used and an "average" is used at end of solution without mention of average depth.*

(iii) converts/states output with units; *(allow values quoted from question without unit)*

converts/states input with units; *(allow values quoted from question without unit)*

calculates efficiency from $\dfrac{\text{output}}{\text{input}}$ as 0.31; ***[3]***

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

eg:

power output $= \dfrac{5.4\times10^{8}}{365\times24\times3600}\left(=17\,\text{kW}\,\text{h}\,\text{s}^{-1}\right)$;

$=17\times3600000=6.16\times10^{7}$ (W);

efficiency $= \left(\dfrac{6.16\times10^{7}}{2.0\times10^{8}}=\right)31\,\%$ ***or*** 0.31;

or

0.2 GW is 1.752×10^{9} (kWh year^{-1});

$\dfrac{5.4\times10^{8}}{1.752\times10^{9}}$;

efficiency $= 0.31$;

(c) (i) cloud cover / weather conditions;
latitude;
time of year / season;
nature/colour of surface; ***[2 max]***

(ii) areas of ice/snow (at poles) will increase / alternative consistent mechanism;

any three from:
reduction in use of fossil fuels will reduce greenhouse gases/named greenhouse gas;
enhanced greenhouse effect reduced;
temperature reduces / surface will cool;
more sunlight/incident radiation reflected at surface; ***[4 max]***
Descriptions of (enhanced) greenhouse effect are irrelevant and neutral.

Part 2 Gravitational potential of the Earth

(d) recognize that $V\times$ a distance is constant / $\frac{V_1}{V_2}=\frac{R_2}{R_1}(=1.625)$;

use of R_E+r;

evaluates at least two data points 4.0×10^{14}; *(allow $V\times R$ to be expressed in any consistent unit)* ***[3]***

*Award **[2 max]** if answer fails to use radius of Earth but infers wrong conclusion from correct evaluation of two or more data points.*
*Award **[3 max]** if answer evaluates mass of Earth and shows that it is the same for two or more data points.*

(e) (i) change in gravitational potential $=(+)\,28\,(\text{MJ kg}^{-1})$;
change in gravitational potential energy $=(28\times10^6\times780=)\ 2.2\times10^{10}$ (J); ***[2]***
*Award **[2]** for a bald correct answer.*

(ii) (change in) $\frac{1}{2}mv^2=$ (change in) $\frac{GMm}{2}\left(=-\text{change in}\,\frac{mV}{2}\right)$;

$(-)\ 1.1\times10^{10}$ (J); ***[2]***
*Award **[2]** for a bald correct answer.*

(iii) change in kinetic energy $=-1.1\times10^{10}$ (J) ; *(recognition that KE is lost)*

change in gravitational potential energy $=+2.2\times10^{10}$ (J) ; *(recognition that gpe is gained)*

$(+)1.1\times10^{10}$ (J); *(direction of change required for this mark)* ***[3]***
*Award **[1 max]** for a bald correct answer with sign.*
*Award **[0]** for a bald correct answer with no sign.*

or

change in total energy = change in potential energy + change in kinetic energy;
adds (e)(i) to (e)(ii); *(allow ECF in value and sign)*
$(+)1.1\times10^{10}$ (J); *(do not allow negative answer)*
Accept correct answer only without ECF for this approach.

7. (a) acceleration is proportional to displacement;
force/acceleration is directed towards equilibrium (point)/rest position; *(do not accept "centre" or "fixed" point)*
straight line through the origin shows the proportionality;
negative gradient shows acceleration directed towards equilibrium (point) / acceleration has opposite sign to displacement; ***[4]***

(b) $\text{gradient} = (-)\omega^2$;
$\omega^2 = 1.56 \times 10^6\ (\text{s}^{-2})$;
$\omega = 1250\ (\text{rad s}^{-1})$;
$f = 198\ (\text{Hz})$; ***[4]***

or

$\omega^2 = (-)\dfrac{a}{x}$;
$\omega = \sqrt{\dfrac{75}{48 \times 10^{-6}}}$;
$f = \dfrac{1}{2\pi}\sqrt{\dfrac{75}{48 \times 10^{-6}}}$;
$f = 198\ (\text{Hz})$;
Allow substitution for fourth mark.

(c) (i) $x_0 = 4.8 \times 10^{-5}\ (\text{m})$;
$E_\text{k} = \frac{1}{2} m\omega^2 x_0{}^2 = 9.9 \times 10^{-7}\ (\text{J})$ ***or*** $1.0 \times 10^{-6}\ (\text{J})$; ***[2]***
*Allow **[2]** for a bald correct answer.*

(ii) at origin; ***[1]***

(d) (i) ray shown at 90° to wavefront A, plausible reflection and reflected ray goes in direction of position 1; *(judge by eye)* ***[1]***

(ii) $1.65\ (\text{m})$; *(allow ECF from (b))* *(accept rounding to 1.6 or 1.7)* ***[1]***

(iii) mention of diffraction;
wavelength of sound is comparable with aperture size / calculates θ to be $1.1\ \text{rad}$;
therefore diffraction is appreciable (and position 2 is within the diffracted beam); ***[3]***

(e) interference/superposition mentioned;
when sounds arrive out of phase / path difference half integer number of wavelengths / *OWTTE*;
cancellation occurs / destructive (interference);
some (back) reflection from walls so cancellation may not be complete (hence "faint" not "zero"); ***[3 max]***

(f) suitable example *eg.* cassette tape;
suitable description of recording mechanism *eg.* uses magnetism / records in magnetic form / on magnetic oxide; ***[2]***

(g) (the pixels act as capacitors so) charge creates a pd across pixel;
measure pd (in analogue form);
convert pd to digital form;
record pd and pixel position; ***[4]***

8. Part 1 Electric cells

(a) (i) conductor has free electrons/charges that are free to move within/through it / insulator does not have free electrons/charges that are free to move within/ through it;
electrons act as charge carriers;
when a pd acts across a conductor a current exists when charge (carriers) move; ***[2 max]***
Do not allow "good/bad conductor/resistor" or reference to conductivity/ resistivity.

(ii) some of the power/energy delivered by a cell is used/dissipated in driving current through the cell;
power loss can be equated to I^2r where *r* represents the (internal) resistance of the cell; *(symbols must be defined)*
resistance of contents of cell; *(do not allow "resistance of cell")* ***[2 max]***

(b) (i) voltmeter in parallel with cell; *(allow ammeter within voltmeter leads)*
ammeter in series with variable resistor; *(must draw as variable arrangement or as potential divider)* ***[2]***
Allow cell symbol for lemon/cell/box labelled "lemon cell".
Award ***[1 max]*** *if additional cell appears in the circuit.*

(ii) $E = I(R + r)$ and $V = IR$ used; *(must state both explicitly)*
re-arrangement correct *ie* $E = V + Ir$; *(accept any other correct re-arrangement eg. involving energy conversion)* ***[2]***

(iii) line correctly extrapolated to *y*-axis; *(judge by eye)*
1.6 ***or*** 1.60 (V); *(allow ECF from incorrect extrapolation)* ***[2]***

(iv) correct read-offs from large triangle greater than half line length;
gradient determined;
290 to 310 (Ω); ***[3]***
Award ***[2 max]*** *for the use of one point on line and equation.*

(v) 0.35 (C); ***[1]***

(vi) 0.55 (J); *(accept answers in the range of 0.54 to 0.57)* ***[1]***

Part 2 Atoms

(c) the emission of electrons from a (metal) surface by photons/light/electromagnetic radiation (incident on the surface); ***[1]***

(d) (i) caesium electrons are less firmly bound / mercury requires more energy to release electron; *(allow reverse argument)* ***[1]***

If answer is in terms of threshold frequency, frequency must be linked to energy via $E = hf$.

(ii) energy of photon $= \frac{6.63\times10^{-34}\times3\times10^{8}}{2.1\times10^{-7}}$ $(= 9.5\times10^{-19}\text{ (J)})$;

convert photon energy to eV, 5.9 (eV) / convert work function to joules 7.2×10^{-19} (J);

so kinetic energy of electron = (photon energy − work function =) 1.4 (eV) ***or*** 2.3×10^{-19} (J); ***[3]***

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

(e) (electron is confined to move in one dimension in a box) (de Broglie wave of) electron is a standing wave (with wavelength related to size of box);
(boundary conditions at edge of box mean that) only integer numbers of half wavelengths can exist;
so (kinetic) energies of electrons are discrete (hence changes between levels are also discrete); ***[2 max]***

(f) (Schrödinger model suggests) electron is described by wavefunction;
that gives probability of finding electron at a particular place / probability of finding electrons is proportional to square of (wavefunction) amplitude;
so position of electron is uncertain; ***[3]***

9. (a) 535 (K) / 262 (°C) ; ***[1]***

(b) constant volume change / isochoric / isovolumetric / *OWTTE*; ***[1]***

(c) Q/thermal energy transfer is zero;
$\Delta U = -W$;
as work is done by gas internal energy falls;
temperature falls as temperature is measure of average kinetic energy; ***[3 max]***

(d) work done is estimated by evaluating area;
inside the loop / *OWTTE*; ***[2]***

(e) (i) 1.6×10^{-4} (litre); ***[1]***

(ii) one litre $=\left(\dfrac{1}{4\times18\times1.64\times10^{-4}}=\right)$ 87 s of travel;
$(87\times56)=4.7$ (km); ***[2]***
Allow rounded 1.6 value to be used, giving 4.9 (km).

(f) use of a kinematic equation to determine motion time $(=12.5\,\text{s})$;
change in kinetic energy $=\frac{1}{2}\times1200\times\left[28^2-12^2\right]$ $(=384\,\text{kJ})$;
rate of change in kinetic energy $=\dfrac{384000}{12.5}$; *(allow ECF of 16^2 from $(28-12)^2$ for this mark)*
31 (kW); ***[4]***

or

use of a kinematic equation to determine motion time $(=12.5\,\text{s})$;
use of a kinematic equation to determine acceleration $(=1.28\,\text{m s}^{-2})$;
work done $=\dfrac{F\times s}{\text{time}}=\dfrac{1536\times250}{12.5}$;
31 (kW);

(g) (i) force $=\dfrac{\text{power}}{\text{speed}}$;
2300 ***or*** 2.3k (N); ***[2]***
*Award **[2]** for a bald correct answer.*

(ii) resistive force $=\dfrac{2300}{4}$ ***or*** $\dfrac{2321}{4}$ $(=575)$; *(allow ECF)*
so accelerating force = (2300 – 580 =) 1725 (N) ***or*** 1741 (N);
$a=\dfrac{1725}{1200}=1.44\,(\text{m s}^{-2})$ ***or*** $a=\dfrac{1741}{1200}=1.45\,(\text{m s}^{-2})$; ***[3]***
*Award **[2 max]** for an answer of 0.49 ($m\,s^{-2}$) (omits 2300 N).*

(h) (i) centripetal force must be < 6000 (N); *(allow force = 6000 N)*

$v^2 = F \times \frac{r}{m}$;

31.6 (m s^{-1}) ; **[3]**

Allow ***[3]*** *for a bald correct answer.*
Allow ***[2 max]*** *if 4× is omitted, giving 15.8* (m s^{-1})*.*

(ii) statement of Newton's first law;
(hence) without car wall/restraint/friction at seat, the people in the car would move in a straight line/at a tangent to circle;
(hence) seat/seat belt/door exerts centripetal force;
(in frame of reference of the people) straight ahead movement is interpreted as "outwards"; ***[3 max]***