N14/4/PHYSI/SP2/ENG/TZ0/XX/M

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MARKSCHEME

November 2014

PHYSICS

Standard Level

Paper 2

12 pages

Subject Details: Physics SL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[25 marks]** and **ONE** question in Section B **[25 marks]**. Maximum total=**[50 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) $\Omega\,\text{K}^{-1}$; *[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 $I^2 R = \left([0.78 \times 10^{-3}]^2 \times 7.5\right) = 4.5 \times 10^{-6}\,\text{W}$ ***or*** $4.6 \times 10^{-6}\,\text{W}$; *[1]*

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

uncertainty in power $\left(= [0.026 + 0.05] \times 4.6 \times 10^{-6}\right) = 0.34 \times 10^{-6}\,\text{W}$ to $0.35 \times 10^{-6}\,\text{W}$;

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

or

uncertainty in $I^2 = 2 \times 1.3\% / 0.026$;
total uncertainty in P $= 7.6\% / 0.076$;
answer rounded to 1 significant figure;

2. (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) (i) ammeter in series with cell <u>and</u> voltmeter across cell or variable resistor; *(both needed)* ***[1]***

(ii) $\frac{7.2\times10^{-3}}{5.8\times10^{-3}}\,(=1.24\text{ V } \textbf{\textit{or}} \text{ } 1.25\text{ V})$; ***[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 alternative;
0.20 W; ***[2]***

3. (a) same number of protons / atoms of the same element; ***[2]***
different number of neutrons;

(b) 54 <u>and</u> antineutrino/$\bar{\nu}$; *(both needed)* ***[1]***

(c) (i) range is 14 to 26 ***or*** 14 to 27;
12 ***or*** 13 days; ***[2]***
*Award **[2]** if marking points added to the graph.*

(ii) starts at 50 kBq and approximately exponential decay curve;
half-life is ~16 days / line passes through [16, 25] to within a small square; ***[2]***

SECTION B

4. **Part 1** Motion of a ship

(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 $= 250\,000 \times \cos 39^{\circ}\ (= 1.94 \times 10^{5}\ \text{N})$;
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.

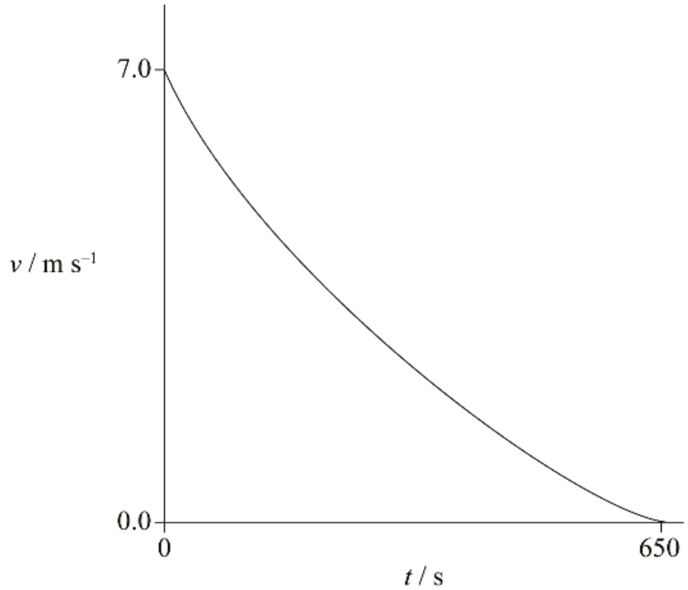
or

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 $= 7.2\ \text{m}\,\text{s}^{-1}$; *(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]***



Part 2 Melting ice

(e) in ice, molecules vibrate about a fixed point;
as their total energy increases, the molecules (partly) overcome the attractive force between them;
in liquid water the molecules are able to migrate/change position; ***[2 max]***

(f) (i) $(Q=)45.0\times125\,(=5625\,\text{J})$;
$c=\left(\dfrac{Q}{m\Delta\theta}=\right)2.01\times10^{3}\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$; ***[2]***

(ii) energy available $=125\times600$ $(=75000\text{ J})$;
energy available to warm the water $=75000-[0.15\times3.3\times10^{5}]\,(=25500\,\text{J})$;
temperature $=\left(\dfrac{25500}{0.15\times4200}=\right)40.5\,^{\circ}\text{C}$; ***[3]***

(g) ice/water spends more time below 18 °C;
so net energy transfer is in to the system;
so final water temperature is higher; ***[3]***

or

ice/water spends less time below 18 °C;
so net energy transfer is out of the system;
so final water temperature is lower;

5. Part 1 Oscillation of a mass

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

acceleration $= \frac{3.6}{0.8} = 4.5\,\text{m s}^{-2}$; *(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) $\omega = \left(\sqrt{\left(\frac{a}{x}\right)} = \right)\sqrt{\frac{4.5}{60 \times 10^{-3}}} (= 8.66\,\text{rad s}^{-1})$;

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

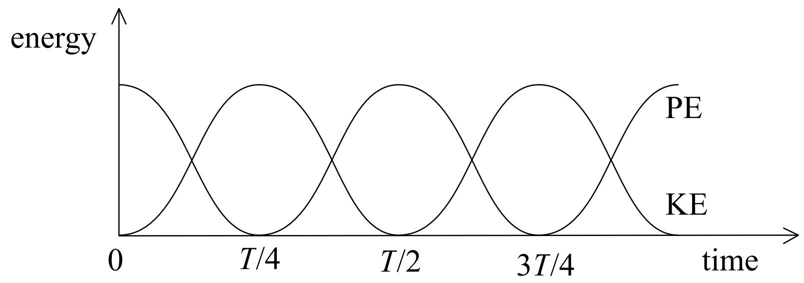
*Watch out for ECF from (a)(i) eg award **[2]** for $T = 1.0\,s$ for $a = 2.25\,\text{m s}^{-2}$.*

(b) (i) $\omega = 2\pi \times 7 \times 10^{12} (= 4.4 \times 10^{13}\,\text{Hz})$;

$5 \times 10^{-21}\,\text{J}$; ***[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 4.3×10^{-5} m; ***[1]***

(ii) mention of resonance;

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

Part 2 Nuclear fission

(d) (i) number of fissions in one day $= 9.5\times10^{19}\times24\times3600\ (=8.2\times10^{24})$;
mass of uranium atom $= 235\times1.661\times10^{-27}(=3.9\times10^{-25}\text{ kg})$;
mass of uranium in one day $(=8.2\times10^{24}\times3.9\times10^{-25}) = 3.2\text{ kg}$; ***[3]***

(ii) energy per fission $= 200\times10^{6}\times1.6\times10^{-19}(=3.2\times10^{-11}\text{ J})$;
power output $= (9.5\times10^{19}\times3.2\times10^{-11}\times0.32 =)9.7\times10^{8}\text{ W}$; ***[2]***
*Award **[1]** for an answer of* $6.1\times10^{27}\text{ eVs}^{-1}$.

(e) (i) 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]***

(ii) have high neutron capture cross-section/good at absorbing neutrons;
(remove neutrons from the reaction) thus controlling the rate of nuclear reaction; ***[2]***

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/pd; *(both needed)* ***[2]***

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

efficiency $= \left(\dfrac{210}{975} = \right) 0.22$ ***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 $= \dfrac{4200}{0.7 \times 750}$;
8 m^2; ***[2]***

(ii) calculates area of photovoltaic panels needed as about 26 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 Electric fields

(f) radial field with arrows <u>and</u> direction correct towards the sphere; *(both needed)*
no field inside sphere; ***[2]***
At least four lines of force to be shown on diagram.

(g) (i) use of $E = \frac{kQ}{r^2}$;
$1.73 \times 10^5\ \mathrm{N\,C^{-1}}$; *(must see answer to 2+ significant figures)* ***[2]***

(ii) <u>line drawn</u> showing zero field strength inside sphere;
decreasing in inverse square-like way from a value of $2 \times 10^5\ \mathrm{N\,C^{-1}}$ ***or*** $1.7 \times 10^5\ \mathrm{N\,C^{-1}}$ at the surface, $d = 25\ \mathrm{mm}$; ***[2]***

(h) (i) $\text{force} = 1.7 \times 10^5 \times 1.6 \times 10^{-19}$; *(allow use of* $2 \times 10^5\ \mathrm{N\,C^{-1}}$*)*
$\text{acceleration} = \left(\frac{2.7 \times 10^{-14}}{9.1 \times 10^{-31}} = \right) 3.0 \times 10^{16}\ \mathrm{m\,s^{-2}}$; ***[2]***

(ii) <u>radially</u> away from sphere / away from <u>centre</u> of sphere;
velocity increasing but at a decreasing rate / accelerating with decreasing acceleration;
because (electric) field (strength) is decreasing; ***[2 max]***