



MARKSCHEME

May 2014

PHYSICS

Standard Level

Paper 2

12 pages

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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) (i) $(\pm) 1 (^{\circ}\text{C})$; [1]

(ii) absolute uncertainty is the same for the two points;
since T is higher at $B = 90$ (*stated or shown*), relative uncertainty is smaller; [2]

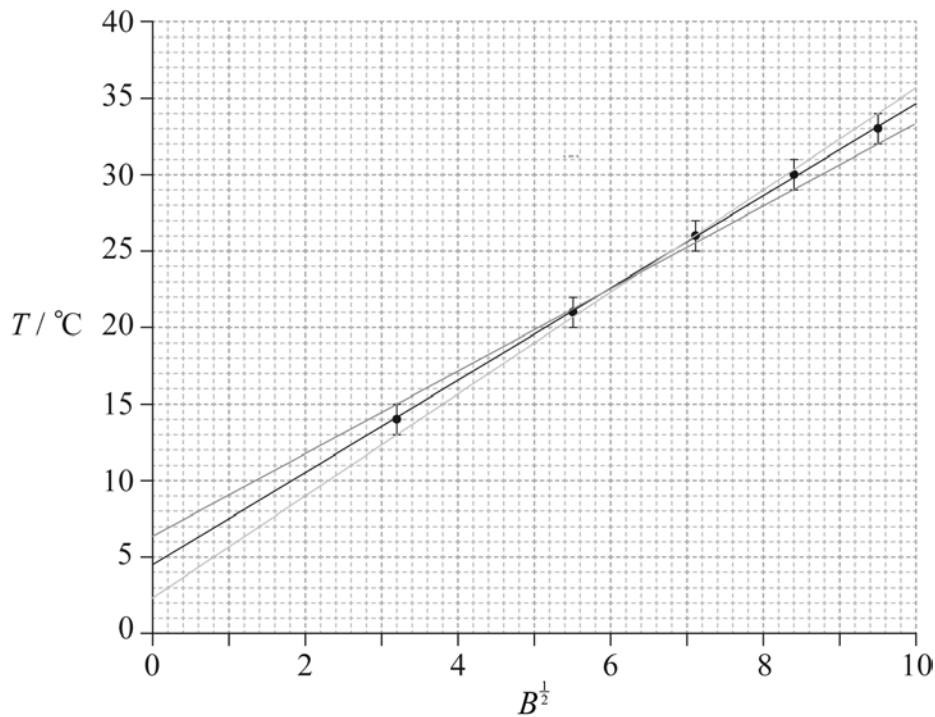
or

fractional uncertainties are $0.07/\frac{1}{14}/7\%$ for $B = 10$ and $0.03/\frac{1}{33}/3\%$ for $B = 90$;
fractional uncertainty is smaller for $B = 90$;

(iii) smooth curve passing through all error bars; [1]
Do not allow thick or hairy or doubled lines, or lines where the curvature changes abruptly.

(iv) the line is not straight/is a curve/does not have a constant gradient/is not linear; [2]
it does not pass through the origin/(0, 0)/zero;

(b) (i)



intercept read as 4.7; (*ignore significant figures, allow range of 4.5 to 4.9*)
two worst fit lines drawn through extremes of error bars;
uncertainty found from worst fit lines;
uncertainty rounded to 1 significant digit expressed in the form as \pm (value)
and intercept rounded to same precision; [4]
Award [4] for a statement of 5 ± 2 and lines drawn.

(ii) $^{\circ}\text{C}$; [1]

2. (a) (i) $m = \rho \Delta V = \rho A \Delta h;$
 $= 1.1 \times 10^3 \times 1.4 \times 10^5 \times 1.8;$
 $(\approx 2.8 \times 10^8 \text{ kg})$ [2]
- (ii) difference in height of centre of mass of water $= \frac{1.8}{2} = 0.9 \text{ (m)};$
 $\Delta E_p (= mg \Delta h = 2.8 \times 10^8 \times 9.8 \times 0.9) = 2.5 \times 10^9 \text{ (J)};$
 electrical energy $(= 0.24 \times 2.5 \times 10^9) = 5.9 \times 10^8 \text{ (J)} (= 590 \text{ MJ});$ [3]
Allow ECF for [2 max] if candidate omits factor of 2 in first marking points.
Accept $g = 10 \text{ m s}^{-2}$ giving an answer of $6.0 \times 10^8 \text{ (J)}$.
- (b) (i) friction/turbulence of flowing water / friction in turbine/generator / resistive heating in wires; [1]
Do not allow bald statement of "heating".
- (ii) it can no longer be used to do work / not available in useful form; [1]
Do not accept "it is more spread out" or similar.
3. (a) $F = qE$ **or** $1.6 \times 10^{-19} \times 2.0 \times 10^3;$
 $= 3.2 \times 10^{-16} \text{ (N)};$ [2]
- (b) (i) $(F = qvB \Rightarrow) B = \frac{F}{qv}$ **or** $(Eq = qvB \Rightarrow) B = \frac{E}{v};$
 $\left(= \frac{3.2 \times 10^{-16}}{1.6 \times 10^{-19} \times 1.6 \times 10^4} \right) = 0.13$ **or** $0.125 \text{ (T)};$
 directed into the page / *OWTTE*; [3]
- (ii) both electric and magnetic forces double / both forces increase by the same factor / both forces scale with q /charges and cancel;
 so straight line followed; (*only award if first mark awarded*) [2]
or
 straight line followed if $qE = qvB \Rightarrow E = vB;$
 E, v and B constant (so straight line followed);

SECTION B

4. Part 1 Solar radiation and the greenhouse effect

(a) power/energy per second emitted proportional to surface area;
and proportional to fourth power of absolute temperature / temperature in K; [2]
Accept equation with symbols defined.

(b) solar power given by $4\pi R^2 \sigma T^4$;
spreads out over sphere of surface area $4\pi d^2$; [2]
Hence equation given.

(c)
$$\left(\frac{\sigma R^2 T^4}{d^2} = \right) \frac{5.7 \times 10^{-8} \times [7.0 \times 10^8]^2 \times [5.8 \times 10^3]^4}{[1.5 \times 10^{11}]^2};$$

$$= 1.4 \times 10^3 \text{ (Wm}^{-2}\text{)};$$
 [2]
Award [2] for a bald correct answer.

(d) some energy reflected;
some energy absorbed/scattered by atmosphere;
depends on latitude;
depends on time of day;
depends on time of year;
depends on weather (eg cloud cover) at location;
power output of Sun varies;
Earth-Sun distance varies; [2 max]

(e) power radiated = power absorbed;
$$T = \sqrt[4]{\frac{240}{5.7 \times 10^{-8}}} (= 250 \text{ K});$$
 [2]
Accept answers given as 260 (K).

(f) radiation from Sun is re-emitted from Earth at longer wavelengths;
greenhouse gases in the atmosphere absorb some of this energy;
and radiate some of it back to the surface of the Earth; [3]

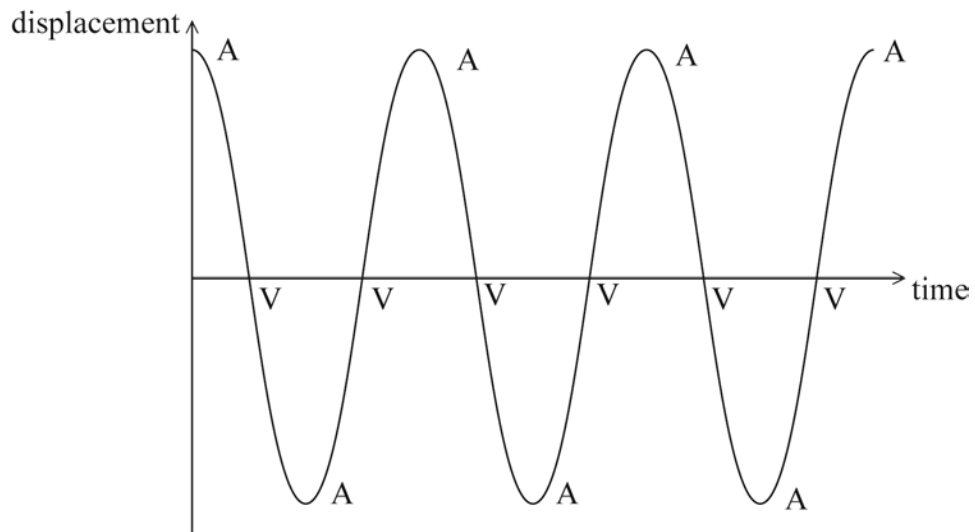
(g) more CO₂/other named greenhouse gas released into the atmosphere;
hence more energy is absorbed and radiated back to Earth's surface; [2]

Part 2 A mass on a spring

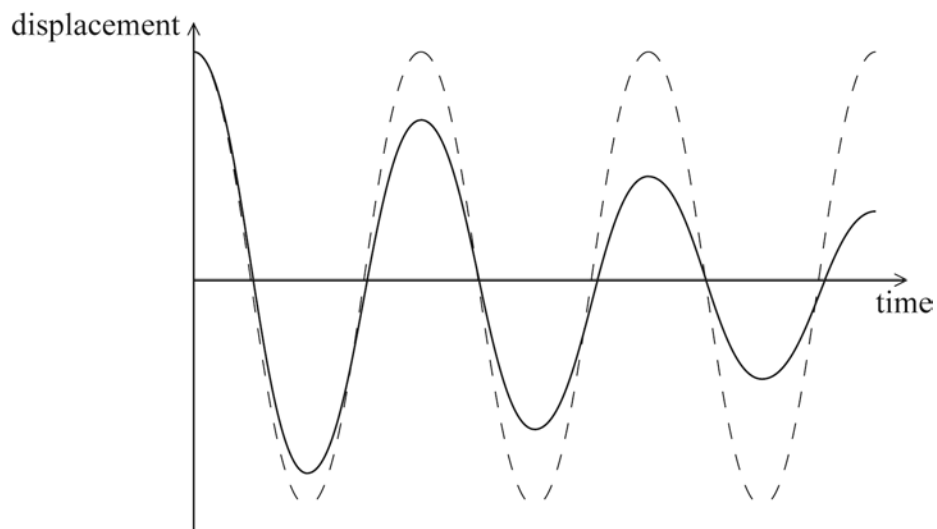
(h) the force (of the spring on the object)/acceleration (of the object/point O) must be proportional to the displacement (from the equilibrium position/centre/point O); and in the opposite direction to the displacement / always directed towards the equilibrium position/centre/point O; [2]

(i) (i) one A correctly shown; [1]

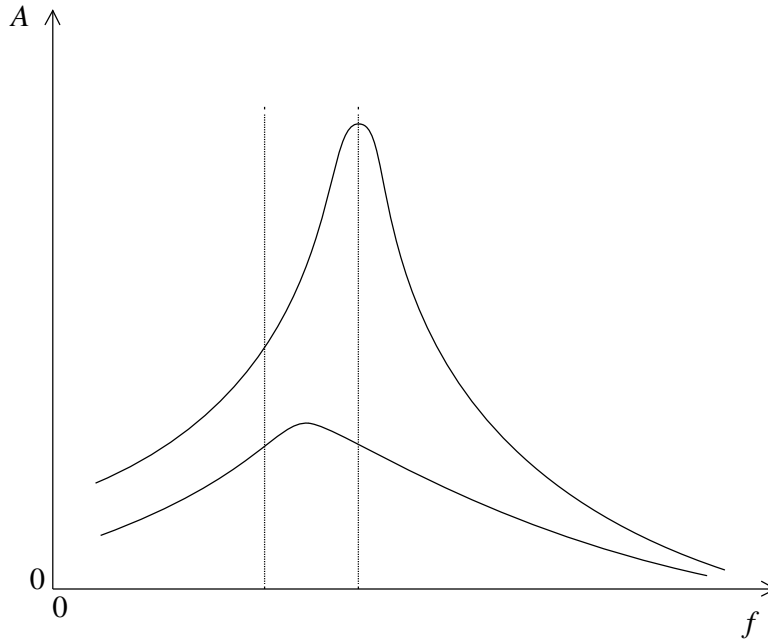
(ii) one V correctly shown; [1]



(iii) same period; (*judge by eye*) amplitude decreasing with time; [2]



- (j) (i) resonance is where driving frequency equals/is close to natural/resonant frequency;
the natural/resonant frequency is at/near the maximum amplitude of the graph; [2]
- (ii) lower amplitude everywhere on graph, bit still positive;
maximum in same place/moved slightly (*that is, between the lines*) to left on graph; [2]



5. Part 1 Nuclear reactions

(a) (i) one twelfth of the mass of a carbon-12 atom/ ${}^{12}_6\text{C}$; [1]
Do not allow nucleus.

(ii) $255.09 \times 931.5 = 237\,600 (\text{MeVc}^{-2})$; [1]
Award [1] for a bald correct answer.

(b) a particle is fired at a nucleus;
 a different nucleus/nuclide/element forms; [2]

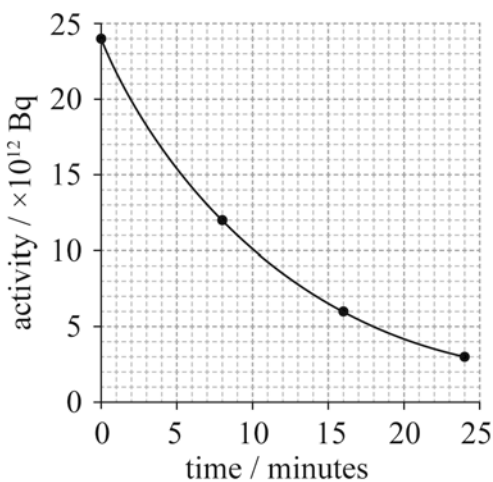
(c) (i) neutron/ ${}_0^1\text{n}$; [1]

(ii) the (rest) mass of the products is greater than that of the reactants;
 energy must be given to supply this extra mass; [2]

(iii) $\Delta m = [37\,216.560 + 938.272] - [37\,214.694 + 939.565] = 0.573 (\text{MeVc}^{-2})$;
 energy required for reaction = $0.573 (\text{MeV})$;
 kinetic energy = $(8.326 - 0.573) = 7.753 (\text{MeV})$; [3]
Award [3] for a bald correct answer.

(d) (i) time for the activity of a sample to halve / time for half the radioactive
nuclei to decay; [1]

(ii) four data points (0, 24) (8, 12) (16, 6) (24, 3) correct;
 smooth curve through points; [2]



(iii) 2 hours (= 120 minutes) = 15 half-lives;
 activity = $\frac{24 \times 10^{12}}{2^{15}} = 7.3 \times 10^8 (\text{Bq})$; [2]

or

$$\lambda = \frac{\ln 2}{8}; (A = A_0 e^{-\lambda t} \text{ method})$$

$$= 7.3 \times 10^8 (\text{Bq});$$

Award [2] for a bald correct answer.

Part 2 Thermal energy transfer

- (e) (i) the energy (absorbed/released) when a unit mass/one kg;
of liquid freezes (to become solid) at constant temperature / of solid melts
(to become liquid) at constant temperature; [2]
- (ii) potential energy changes during changes of state / bonds are weakened/
broken during changes of state;
potential energy change is greater for vaporization than fusion / more energy
is required to break bonds than to weaken them; [3]
SLH vaporization is greater than SLH fusion;
*Only award third marking point if first marking point or second marking
point is awarded.*
- (f) (i) use of $\Delta Q = mc\Delta T$ and mL ;
 $0.020 \times 3.3 \times 10^5 + 0.020 \times 4200 \times (T - 0) = 0.25 \times 4200 \times (80 - T)$;
 $T = 68(^{\circ}\text{C})$; [3]
Allow [3] for a bald correct answer.
*Award [2] for an answer of $T=74(^{\circ}\text{C})$ (missed melted ice changing
temperature).*
- (ii) no energy given off to the surroundings/environment;
no energy absorbed by beaker;
no evaporation of water; [2 max]

- 6. Part 1** Two children on a merry-go-round
- (a) (i) 2.0 *or* 0(ms^{-1}); [1]
- (ii) 1.0 *or* 0(ms^{-1}); [1]
- (b) (i) her direction is changing;
hence her velocity is changing; [2]
- or*
since her direction/velocity is changing;
a resultant/unbalanced/net force must be acting on her (hence she is accelerating);
- (ii) arrow from Aibhe towards centre of merry-go-round; [1]
Ignore length of arrow.
- (iii) the force of the merry-go-round on Aibhe/her; [1]
- (iv) no force is acting on the upper body towards the centre of the circle /
no centripetal force acting on the upper body (to maintain circular motion);
upper body (initially) continues to move in a straight line at constant speed/
velocity is tangential to circle; [2]
- (c) distance travelled by Euan = $4.0 \times 2\pi \times 1.5 (= 37.70 \text{ m})$;
 $W (= F_{av}d = 45 \times 37.70) = 1700 \text{ (J)}$; [2]
- (d) (i) Aibhe's period of revolution is the same as before;
from $v = \frac{2\pi r}{T}$, since r is halved, v is halved;
 $v = 0.5(\text{ms}^{-1})$; [3]
Award [3] for a bald correct answer.
- (ii) $a \left(= \frac{v^2}{r} \right) = \frac{0.5^2}{0.75}$;
 $a = 0.33(\text{ms}^{-2})$; [2]
*Allow ECF from (d)(i).
Award [2] for a bald correct answer.*

Part 2 Electric circuits

- (e) $\frac{\text{potential difference across the wire}}{\text{current through the wire}}$; [1]

Accept equation with symbols defined. Accept p.d. Do not accept voltage.

- (f) $A = (\pi r^2 =) \pi \times [2.5 \times 10^{-5}]^2 (= 1.963 \times 10^{-9})$;
 $l = \left(\frac{RA}{\rho} =\right) \frac{6.0 \times 1.963 \times 10^{-9}}{5.0 \times 10^{-7}}$;
 $= 2.4 \times 10^{-2} \text{ (m)}$; [3]

Award [3] for a bald correct answer.

- (g) resistance of two resistors in parallel = 3.0 (Ω), so total resistance = 6.0 + 3.0 = 9.0 (Ω);
 $I = \left(\frac{V}{R} =\right) \frac{12}{9.0} (= 1.333) \text{ (A)}$;
 $P = (VI = 12 \times 1.333 =) 16 \text{ (W)}$; [3]

or

resistance of two resistors in parallel = 3.0 (Ω), so total resistance = 6.0 + 3.0 = 9.0 (Ω);

$$P = \left(\frac{V^2}{R} =\right) \frac{144}{9.0}$$

$$P = 16 \text{ (W)}$$

- (h) total resistance is smaller (= 4.0Ω);
 p.d./voltage is the same so current is greater (= 3.0 A);
 since $P = VI$ **or** $P = I^2 R$, power is greater (= 36 W); [3]

or

total resistance is smaller (= 4.0Ω);

p.d./voltage is the same;

$$\text{since } P = \frac{V^2}{R}, \text{ power is greater } (= 36 \text{ W});$$

*Award [1] for a bald calculation of 36 (W).
 The marks are for an explanation.*