Diploma Programme
Programme du diplôme
Programa del Diploma

# Markscheme

## May 2015

## Physics

## Higher level

## Paper 2

13 pages

International Baccalaureate
Baccalauréat International
Bachillerato Internacional

# 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 underlined are essential for the mark.

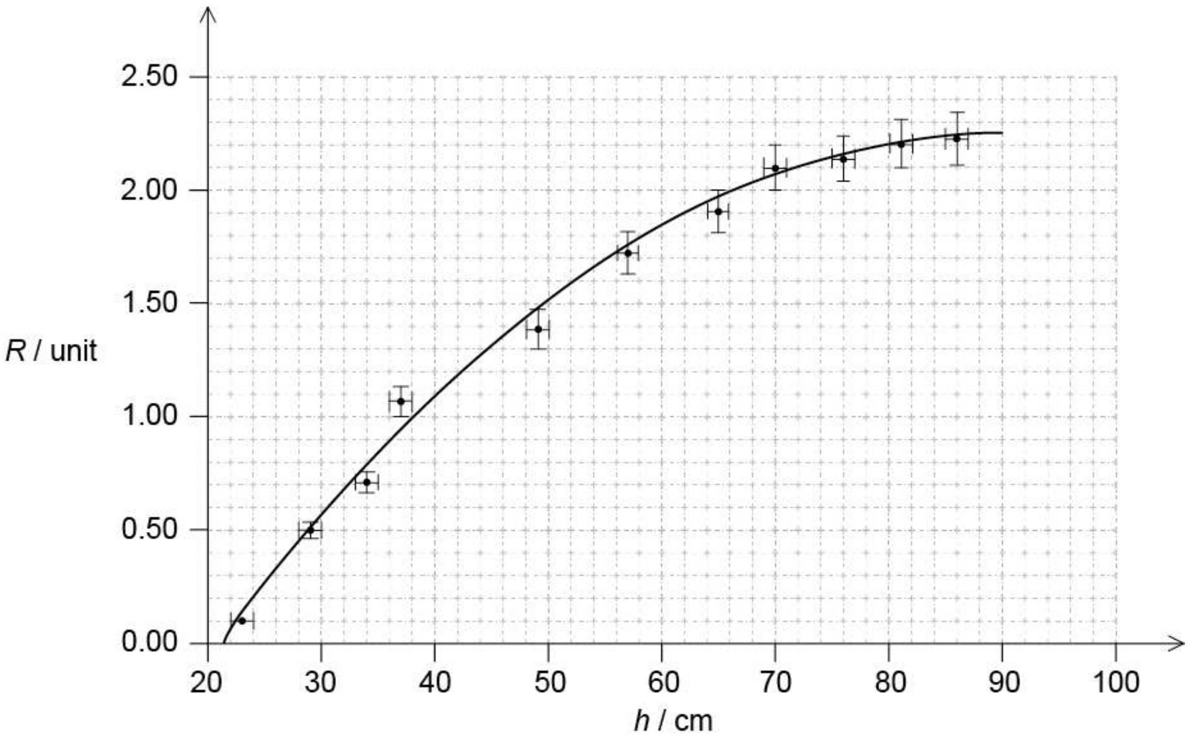
**6.** The order of marking points does not have to be as in the markscheme, unless stated otherwise.

## Section A

**1.** (a) $cm^3\ s^{-1}$ / $mm^3\ s^{-1}$/ $m^3\ s^{-1}$ / $l\ s^{-1}$ / $ml\ s^{-1}$; **[1]**

(b) (i) correctly plotted ± half square; **[1]**

(ii) error bar total horizontal length 1 (±0.2) square;
error bar total vertical length 1.7 (±0.4) square; **[2]**




(iii) line does not pass through all of the error bars/uncertainties; **[1]**

(iv) absolute uncertainties (in volume and time) should be constant;
constant percentage/relative/fractional uncertainty in $R$ means an increase in the absolute uncertainty as $R$ increases; **[2]**

(c) (i) $R_0 = -1.6(-1.5632)\ cm^3\ s^{-1}$; **[1]**

(ii) it is negative / this would mean water running uphill / gaining potential energy / *OWTTE*; **[1]**

(iii) an answer consistent with candidate's value; **[1]**

(iv) should be 2 significant figures (in line with data values); **[1]**

(d) % uncertainty in $t = 1\%$;
% uncertainty in $V\,(= 5 + 1) = 6\%$ ***or*** % uncertainty in $V\,(= 5 - 1) = 4\%$;
$V\,(= 2.1 \times 100) = 210$ (units) ;
absolute uncertainty (= 210 × 6%) = 12.6 / 13 / 10 (units) ***or*** absolute uncertainty (= 210 × 4%) = 8.4 / 8 (units); **[4]**

**2.** (a) arrow vertically downwards labelled weight/W/mg/gravitational force/$F_g$/$F_{gravitational}$/force of gravity; *(judge by eye)* **[1]**
*Do not allow "gravity".*

(b) $(N =)\ mg\cos\theta$ / correct substitution;
$(= 73 \times 9.81 \times \cos 12^\circ =)\ 700\ \text{N}$ ; **[2]**

(c) tension = frictional force + component of weight parallel to slope /
tension $= 65 + mg\sin\theta$ ;
214 / 210 N; **[2]**

(d) (Newton's first law states that a body remains at rest or moves with) constant velocity/steady speed/uniform motion unless external/net/resultant/unbalanced force acts on it;
clear link that in this case there is constant/steady <u>velocity</u> so no resultant force; **[2]**

**3.** (a) the work done per unit charge in moving a quantity of charge completely around a circuit / the power delivered per unit current / work done per unit charge made available by a source; **[1]**

(b) (i) $V_X = 7.5$ (V);
$I\left(= \frac{4.5}{100 \times 10^3}\right) = 4.5 \times 10^{-5}\ \text{A}$ ***or*** $\frac{V_X}{V_R} = \frac{R_X}{R_R}$ ;
$R_x\left(= \frac{7.5}{4.5 \times 10^{-5}}\right) = 1.67 \times 10^5\ \Omega$ ***or*** $R_x\left(= \frac{7.5}{4.5} \times 100 \times 10^3\right) = 1.67 \times 10^5\ \Omega$ ;
$T = -37$ ***or*** $-38\ ^\circ\text{C}$ ; **[4]**

(ii) –50 to (up to) –30 °C / at low temperatures; **[1]**

(iii) as the temperature decreases $R_X$ increases;
same <u>current</u> through $R$ and $X$ so the ratio increases ***or*** $V_X$ increases <u>and</u> $V_R$ decreases so the ratio increases; [2]

**4.** (a) use of area under the curve;
each (1 cm × 1 cm) square has energy of 250 J ***or*** each small square has energy of 10 J;
estimate (14 to 16 × 250) = 3500 to 4000 J; **[3]**

(b) clear use of value on AB; (*must see correct values*)
use of $PV = nRT$;
0.56 to 0.60 mol; **[3]**

(c) entropy unchanged;
gas returned to original state; **[2]**

**5.** (a) 0.016; **[1]**

(b) number of pixels along one side $= \left(\sqrt{8\times10^{6}} =\right) 2830$;

length $= \left(\frac{27\times10^{-3}}{2830} = 9.5\times10^{-6}\,(\text{m}) = \right) 9.5\times10^{-6}$ m ; **[2]**

***or***

area of CCD $= (27\times10^{-3}\times27\times10^{-3} =)\ 7.29\times10^{-4}\ \text{m}^2$;
length $= \left(\sqrt{\frac{7.29\times10^{-4}}{8\times10^{6}}} = \right) 9.5\times10^{-6}$ m;

(c) $8.0\times10^{-4} \gg 9.5\times10^{-6}$ m so (images easily) resolved/they are resolved/yes as they are more than 2 pixels apart; **[1]**
*Comment must match observation.*

(d) (i) ratio of the number of electrons produced to number of photons (of a particular energy) incident on pixel; **[1]**

(ii) for same <u>illumination/intensity</u> more electrons will be produced / lower illumination/intensity will still (build up a voltage) release enough electrons;
resulting in a clearer/brighter image / effect of noise reduced / can detect fainter objects / requires a shorter exposure time; **[2]**

## Section B

**6.** Energy sources

(a) needs to be windy/high average wind speeds;
space/land/room for wind turbines;
ability to import oil/nuclear fuel;
ability to dispose of nuclear waste;
comment relating to need for geological stability; **[3 max]**

(b) (i) $\pi 4.7^2$ ***or*** 69.4 $m^2$;
power = 15300 to 15400 W;
470 to 490 GJ; **[3]**

(ii) wind must retain kinetic energy to escape ***or*** not all KE of wind can be converted to KE of blades;
energy lost to thermal energy (due to friction) in generator/turbine/dynamo;
turbine will suffer downtime when no wind/too much wind; **[2 max]**
*Allow any two relevant factors.*

(c) (i) indication that energy supplied to islanders is output and chemical energy input / $\frac{8}{25}$ used;
32 % / 0.32; **[2]**

(ii) energy/it is wasted due to inefficient burning of oil / thermal/heat energy loss to surroundings/environment / electrical energy is used to run the power station's systems / energy/it is wasted due to frictional losses in the turbine/generator; **[1]**

(iii) heating of wires by electric current / inefficient transformers; **[1]**

(d) (i) addition of greenhouse gases/named greenhouse gas to the atmosphere;
increasing the temperature of the Earth's surface/global warming; **[2]**

(ii) radiation emitted by Earth in (long wavelength) infrared region;
frequency corresponds to resonant frequency of greenhouse gases (either vibration or difference in energy levels);
radiation absorbed by greenhouse gases is (partly) re-radiated back to Earth; **[3]**

(e) percentage of U-235 in naturally occurring ores is too low to support fission ***or*** naturally occurring U-238 does not undergo fission;
percentage of U-235 (which can usefully capture thermal neutrons) is increased; **[2]**

(f) $\left({}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{92}_{36}Kr + {}^{141}_{56}Ba + 3\,{}^{1}_{0}n\right)$
235;
36;
3; **[3]**
*The number of neutrons must be consistent with chosen isotope of uranium.*

(g) control rods absorb neutrons;
moderators slow down neutrons;
both affect the rate of reaction;
both rely on the neutrons colliding with their atoms/nuclei; **[3 max]**
*Must see reference to collision/interaction for fourth marking point.*

**7. Part 1** Thermal properties of matter

(a) energy supplied / bonds broken/heat absorbed;
increases potential energy;
no change in kinetic energy (so no change in temperature); **[3]**

(b) (i) energy required to raise temperature of object by 1 K / 1 °C; **[1]**

***or***

mass × specific heat capacity;

(ii) J K$^{-1}$ / J °C$^{-1}$; **[1]**

(iii) use of $M \times 4.2 \times 10^{3} \times \Delta\theta$;
$ml = 75 \times 10^{-3} \times 3.3 \times 10^{5}$ / 24750 J;
recognition that melted ice warms and water cools to common final temperature;
3.4 °C; **[4]**

(iv) work done on water by dropping cubes / negligible work done;
*W* negative or unchanged;
water gives thermal energy to ice;
*Q* negative;
water cools to a lower temperature;
$\Delta U$ negative / *U* decreases; **[4 max]**

**Part 2** Quantum physics

(c) bright and dark rings/circles / circular fringes;
maximum and minimum / constructive and destructive;
mention of interference / mention of superposition;
link to interference being characteristic of waves; **[3 max]**

(d) (i) $(p = m_e v =)\ 3.28\times10^{-23}$ Ns ;

$$\lambda = \left(\frac{h}{p} = \frac{6.63\times10^{-34}}{3.28\times10^{-23}} = \right) 2.02\times10^{-11}\ \text{m};$$ **[2]**

(ii) $E = \left(\frac{\Delta V}{\Delta x}\right) = \frac{3.7\times10^{3}}{22\times10^{-3}}\left(=1.68\times10^{5}\right)\ \text{Vm}^{-1}$;

$F = (Eq) = 1.68\times10^{5}\times1.6\times10^{-19} = (2.69\times10^{-14})$ N;

$a = \frac{F}{m} = \left(\frac{2.69\times10^{-14}}{9.11\times10^{-31}}\right) = 2.95\times10^{16}\ \text{m s}^{-2}$; **[3]**

***or***

use of appropriate equation, eg $v^2 = u^2 + 2as$;
correct substitution (ignoring powers of ten);
$a = 2.95\times10^{16}$ m $s^{-2}$

(e) square of amplitude (of wavefunction);
(proportional to) probability of finding an electron (at a particular point); **[2]**

(f) relates position to momentum (or velocity);
large uncertainty in momentum / most information on momentum is lost; **[2]**

**8. Part 1** Electrical and magnetic characteristics of a loudspeaker

(a) force in correct location on diagram, *ie* arrow on coil;
force direction to the right; **[2]**
*Award **[1 max] i**f any other forces drawn.*

(b) $L = (2\pi rN) = 2 \times \pi \times 1.25 \times 10^{-2} \times 150 = (11.8)$ m ;
$F = (\text{BIL}) = 0.40 \times 10^{-3} \times 0.45 \times 10^{-3} \times 11.8$ ;
$= 2.1 \times 10^{-6}$ N / 2.1 $\mu$N; **[3]**

(c) $\left(I_{\text{rms}} = \frac{I_0}{\sqrt{2}} = \right) 0.32 \times 10^{-3}$ A / 0.32 mA ; **[1]**

(d) (as the coil moves the) conductor cuts the magnetic field / there is a change in flux linkage;
induces an emf across the coil / a current through the coil;
opposes the driving potential difference;
reduces the (net) current; **[3 max]**

**Part 2** Vibrations and waves

(e) (periodic) motion in which acceleration/restoring force is proportional to the displacement from a fixed point;
directed towards the fixed point / in the opposite direction to the displacement; **[2]**

(f) (i) $\omega = \left(2\pi f = 2\pi \times 1250\right) 7854 \text{ rad s}^{-1}$;
$a_0 = (-\omega^2 x_0 = -7854^2 \times 0.85 \times 10^{-3} =)\ (-)5.2 \times 10^4 \text{ m s}^{-2}$ ; **[2]**

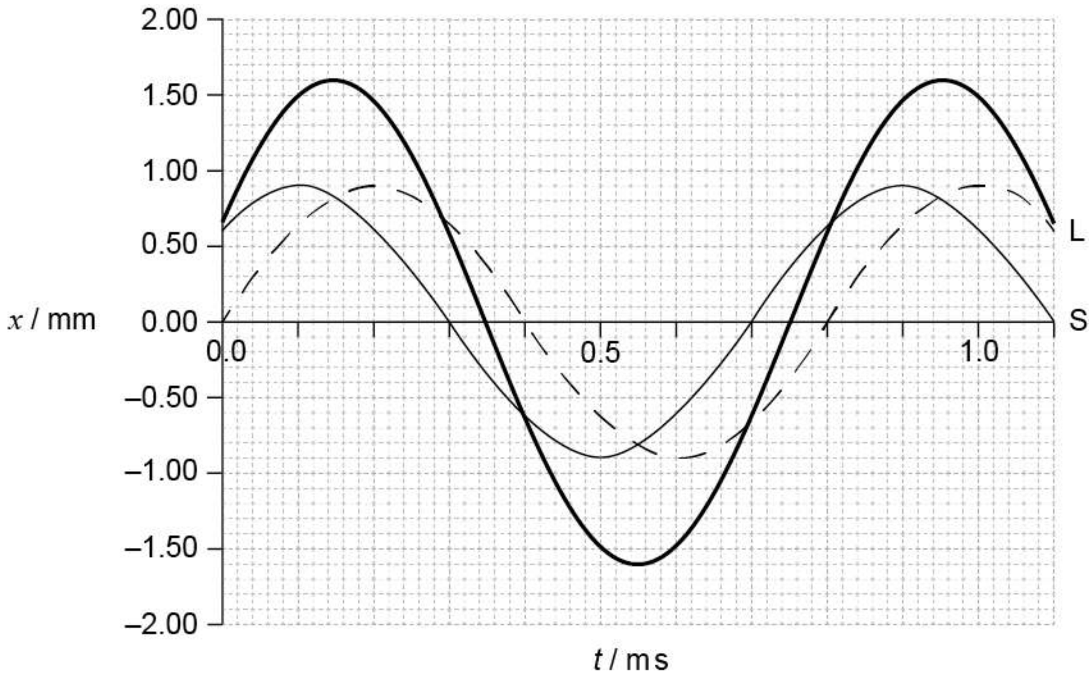
(ii) correct substitution into $E_T = \frac{1}{2} m\omega^2 {x_0}^2$ irrespective of powers of 10;
0.14 to 0.15 J; **[2]**

(g) (i) 0.264 m; **[1]**

(ii) longitudinal;
progressive / propagate (through the air) / travels with constant speed (through the air);
series of compressions and rarefactions / high and low (air) pressure; **[3]**

(h) (i) S leads L / idea that the phase of L is the phase of S minus an angle;
$\frac{1}{8}$ period / $1 \times 10^{-4}$ s / 0.1 m s;
$\frac{\pi}{4}$ / 0.79 rad / 45 degrees; **[3]**

(ii) agreement at all zero displacements;
maxima and minimum at correct times;
constant amplitude of 1.60 mm; **[3]**



**9.** **Part 1** Kinematics and gravitation

(a) upwards (or away from the Moon) is taken as positive / downwards (or towards the Moon) is taken as negative / towards the Earth is positive; **[1]**

(b) (i) tangent drawn to curve at 0.80 s;
correct calculation of gradient of tangent drawn;
$-1.3 \pm 0.1$ m s$^{-1}$ ***or*** $1.3 \pm 0.1$ m s$^{-1}$ downwards; **[3]**

***or***

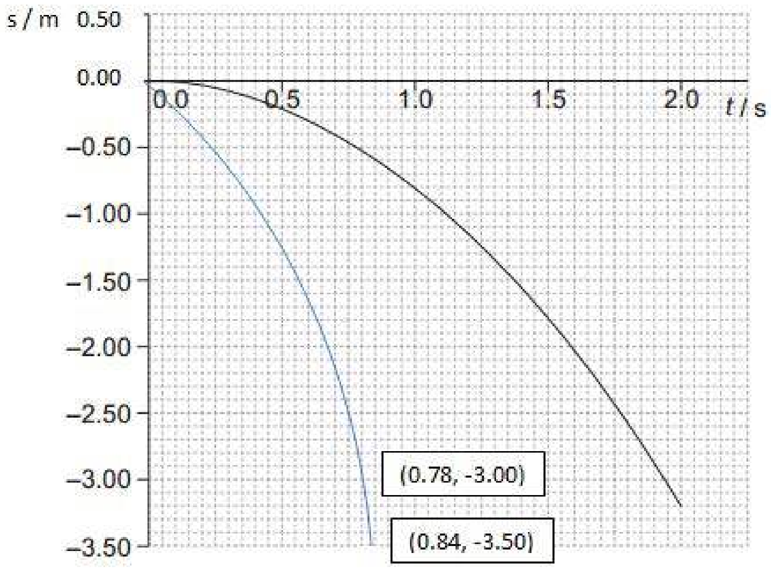
correct coordinates used from the graph;
substitution into a correct equation;
$-1.3 \pm 0.1$ m s$^{-1}$ ***or*** $1.3 \pm 0.1$ m s$^{-1}$ downwards;

(ii) any correct method used;
correct reading from graph;
1.6 to 1.7 m s$^{-2}$; **[3]**

(c) values for masses, distance and correct G substituted into Newton's law;
see subtraction (*ie r* value $= 3.84 \times 10^{8} - 1.74 \times 10^{6} = 3.82 \times 10^{8}$ m);
$F = 5.4$ to $5.5 \times 10^{-4}$ N / $a = 2.7 \times 10^{-3}$ m s$^{-2}$;
comment that it's insignificant compared with ($0.2 \times 1.63 =$) 0.32 to 0.33 N / 1.63 m s$^{-2}$; **[4]**

(d) 7.7 m s$^{-1}$; **[1]**

(e) curve permanently below Moon curve;
smooth parabola; *(judge by eye)*
line passing through s = –3.00 m, t = 0.78 s ***or*** s = –3.50 m, t = 0.84 s (±1 mm); **[3]**



**Part 2** Radioactivity

(f) (i) 208; **[1]**

(ii) 81; **[1]**

(g) because the half-life is (only) 55 s;
radon is produced slowly but decays quickly (so cannot build up); **[2]**

(h) (i) $\left(\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{0.693}{10.6} = \right) 6.5 \times 10^{-2}\ \text{hour}^{-1}$ **[1]**

(ii) use of $\lambda$ from (h)(i);
correct substitution into $N = N_0 e^{-\lambda t}$;
8.0 to 8.3 $\times$ $10^{-4}$ kg; **[3]**

(iii) the rate of decay/activity of polonium/radium;
is greater than the rate of decay/activity of lead; **[2]**