M15/4/PHYSI/HP2/ENG/TZ1/XX/M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2015

Physics

Higher level

Paper 2

13 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 underlined are essential for the mark.

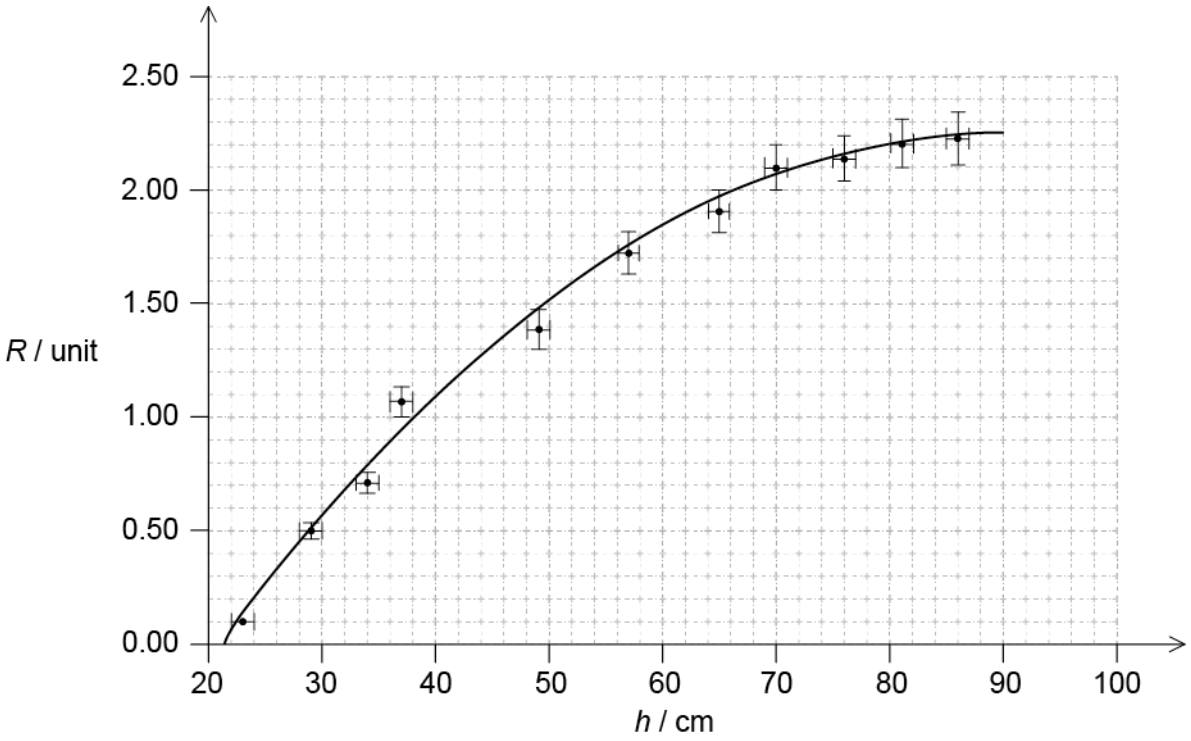
6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

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 $(= 210 \times 6\%) = 12.6 / 13 / 10$ (units) ***or*** absolute uncertainty $(= 210 \times 4\%) = 8.4 / 8$ (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;
$(= 73 \times 9.81 \times \cos 12^\circ =)\ 700$ 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);
$I\left(= \frac{4.5}{100 \times 10^3}\right) = 4.5 \times 10^{-5}$ 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 °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 $= \left(\frac{27\times10^{-3}}{2830} = 9.5\times10^{-6}\,(\text{m}) = \right) 9.5\times10^{-6}\,\text{m}$; **[2]**

or

area of CCD $= (27 \times 10^{-3} \times 27 \times 10^{-3} =)\ 7.29 \times 10^{-4}\ \text{m}^2$;

length $= \left(\sqrt{\frac{7.29\times10^{-4}}{8\times10^{6}}} = \right) 9.5 \times 10^{-6}\ \text{m}$;

(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 illumination/intensity 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) <u>energy/it</u> is wasted due to inefficient burning of oil / <u>thermal/heat energy</u> loss to surroundings/environment / <u>electrical energy</u> is used to run the power station's systems / <u>energy/it</u> 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) $\left({}^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \rightarrow {}^{92}_{36}\text{Kr} + {}^{141}_{56}\text{Ba} + 3\,{}^{1}_{0}\text{n}\right)$

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;
ΔU 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) $(p = m_e v =)\ 3.28 \times 10^{-23}$ Ns ;

$$\lambda = \left(\frac{h}{p} = \frac{6.63 \times 10^{-34}}{3.28 \times 10^{-23}} = \right) 2.02 \times 10^{-11} \text{ m} ;$$ **[2]**

(ii) $E = \left(\frac{\Delta V}{\Delta x} \right) = \frac{3.7 \times 10^{3}}{22 \times 10^{-3}} \left(= 1.68 \times 10^{5} \right)$ Vm^{-1};

$F = (Eq) = 1.68 \times 10^{5} \times 1.6 \times 10^{-19} = (2.69 \times 10^{-14})$ N;

$a = \frac{F}{m} = \left(\frac{2.69 \times 10^{-14}}{9.11 \times 10^{-31}} \right) = 2.95 \times 10^{16}$ m s^{-2}; **[3]**

or

use of appropriate equation, eg $v^2 = u^2 + 2as$;
correct substitution (ignoring powers of ten);
$a = 2.95 \times 10^{16}$ 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]** if 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 μ 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) $\omega = (2\pi f = 2\pi \times 1250) 7854 \text{ rad s}^{-1}$;
$a_0 = (-\omega^2 x_0 = -7854^2 \times 0.85 \times 10^{-3} =)\ (-)5.2 \times 10^4 \text{ m s}^{-2}$; **[2]**

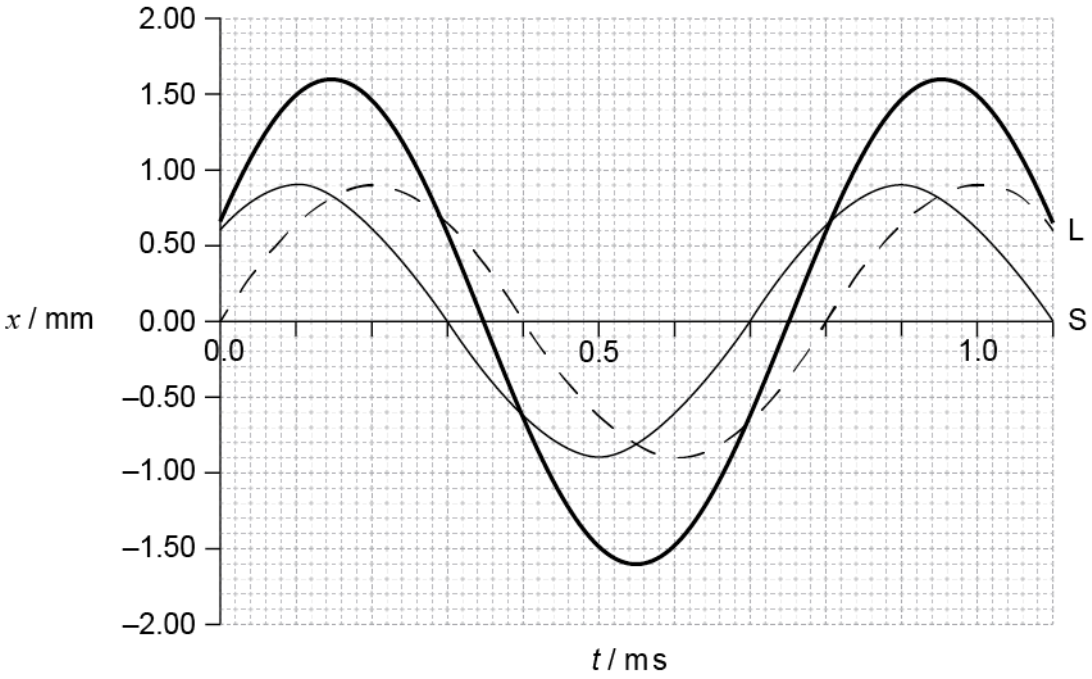
(ii) correct substitution into $E_T = \frac{1}{2} m\omega^2 {x_0}^2$ irrespective of powers of 10;
0.14 to 0.15 J; **[2]**

(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 / 1×10^{-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 ± 0.1 m s^{-1} ***or*** 1.3 ± 0.1 m s^{-1} downwards; **[3]**

or

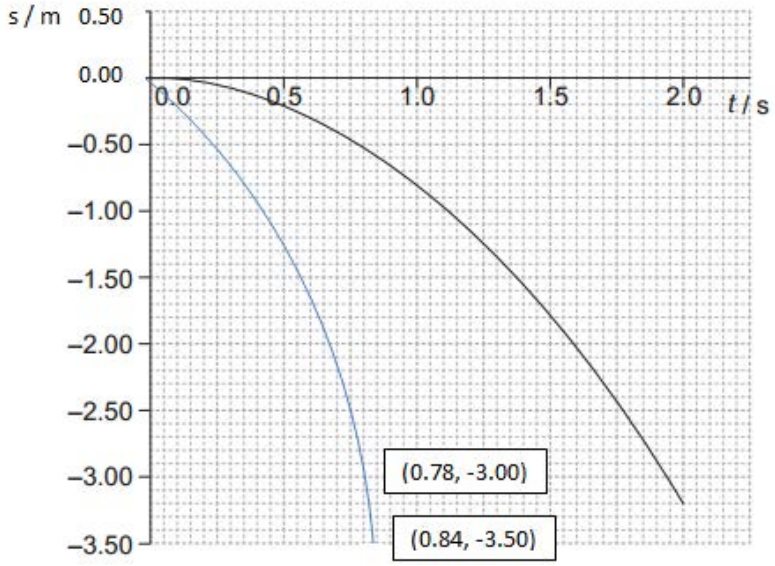
correct coordinates used from the graph;
substitution into a correct equation;
-1.3 ± 0.1 m s^{-1} ***or*** 1.3 ± 0.1 m s^{-1} downwards;

(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 5.5×10^{-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) $\left(\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{0.693}{10.6} = \right) 6.5 \times 10^{-2}$ hour^{-1} **[1]**

(ii) use of λ 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]**