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M04/431/H(2)M+

MARKSCHEME

May 2004

PHYSICS

Higher Level

Paper 2

13 pages

If you do not have a copy of the current Physics guide,
please request one from IBCA.

Subject Details: Physics HL Paper 2 Markscheme

General

A markscheme often has more specific points worthy of a mark than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

When deciding upon alternative answers by candidates to those given in the markscheme, consider the following points:

- Each marking point has a separate line and the end is signified by means of a semicolon (;).
- An alternative answer or wording is indicated in the markscheme by a "/"; either wording can be accepted.
- Words in (…) in the markscheme are not necessary to gain the mark.
- The order of points does not have to be as written (unless stated otherwise).
- If the answer has the same "meaning" or can be clearly interpreted as being the same as that in the markscheme then award the mark.
- Mark positively. Give credit for what they have achieved, and for what they have got correct, rather than penalizing them for what they have not achieved or what they have got wrong.
- Occasionally, a part of a question may require a calculation whose answer is required for subsequent parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded. Indicate this with **"ECF"**, error carried forward.
- Units should always be given where appropriate. Omission of units should only be penalized once. Ignore this, if marks for units are already specified in the markscheme.
- Deduct **1 mark in the paper** for gross sig dig error *i.e.* for an **error of 2 or more digits**.

  e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

  However, if a question specifically deals with uncertainties and significant digits, and marks for sig digs are already specified in the markscheme, then do **not** deduct again.

SECTION A

A1. (a) reasonable scale and axes labelled;
The graph must occupy at least half the grid.
plots correct to within $\frac{1}{2}$ square; *Award **[2]** if correct, **[1]** for one error and **[0]** for two or more errors.* ***[3]***

(b) (i) reasonable <u>curve</u> from $0\,^{\circ}\mathrm{C}$ to $10\,^{\circ}\mathrm{C}$; ***[1]***
Expect smooth single line within one square of each correctly plotted point.

(ii) $3800 \pm 50\ \Omega$;
$2630 \pm 20\ \Omega$; ***[2]***
Allow ecf from candidate's graph.

(c) correct line drawn; ***[1]***

(d) (i) value correct from graph, $6.2\,^{\circ}\mathrm{C}$; ***[1]***
Allow $\pm\frac{1}{2}$ *square.*

(ii) error is $1.0\,^{\circ}\mathrm{C}$;
% error $= \left(\frac{1}{5.2}\right)\times 100$;
$= 19\ \%$; ***[3]***
Allow "bald" correct answers.
*Award **[2]** if* $\left(\frac{1}{6.2}\right)\times 100 = 16\ \%$ *is used – or candidates figures.*

(e) (i) correct indication of uncertainty in T;
correct indication of uncertainty in R; ***[2]***

(ii) because straight line will not pass through the regions of uncertainty;
relationship is not linear; ***[2]***
Do not allow "bald" statement or fallacious argument.

A2. (a) horizontal component = R sin14;
= 8500 tan14
= 2119 N ≈ 2100 N **[2]**
*Award **[1]** for sin14 and **[0]** for cos14.*

(b) 2100 N;
horizontally / to centre of circle / correct angle clear; **[2]**

(c) use of $F = \frac{mv^2}{r}$;
$2100 = \frac{(8500v^2)}{(9.8 \times 150)}$;
$v = 19\,\mathrm{m\,s^{-1}}$; **[3]**
*Allow $g = 10\,\mathrm{m\,s^{-2}}$ but award answers showing the incorrect use of g **[1 max]**.*

(d) friction must supply larger force towards centre / *OWTTE*;
car tends to slide up the ramp; **[2]**

A3. (a) increase in the degree of disorder (in the system); **[1]**

(b) total entropy (of the universe);
is increasing; **[2]**

(c) entropy of surroundings increases by a greater factor;
because process gives off thermal energy / other appropriate statement; **[2]**

A4. (a) any particle has wave-like properties / other appropriate statement;
where wavelength $= \frac{h}{p}$, <u>with *h* and *p* identified</u>; **[2]**
Can be back credited from A4(b).

(b) use of $E = \frac{p^2}{2m}$;
$5.0 \times 10^3 \times 1.6 \times 10^{-19} \times 2 \times 9.1 \times 10^{-31} = p^2$
$p = 3.8 \times 10^{-23}$;
$\lambda = \frac{(6.63 \times 10^{-34})}{(3.82 \times 10^{-23})}$;
$= 1.7(4) \times 10^{-11}\,\mathrm{m}$;

OR

$\frac{1}{2}mv^2 = qV$ **or** $v = \sqrt{\left(\frac{2qV}{m}\right)}$;
$v = \sqrt{\left(\frac{2 \times 1.6 \times 10^{-19} \times 5.0 \times 10^3}{9.11 \times 10^{-31}}\right)}$
$= 4.1(9) \times 10^7\,\mathrm{m\,s^{-1}}$;
$\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 4.19 \times 10^7}$;
$= 1.7(4) \times 10^{-11}\,\mathrm{m}$; **[4]**

*Award incorrect calculation of p or v but then clear and correct evaluation of λ **[2 max]**.*

SECTION B

B1. (a) (i) zero deflection of leaf;
negative charge on cap; *(award **[0]** if charge shown elsewhere)* ***[2]***

(ii) diagram unchanged from diagram 2; ***[1]***

(iii) leaf raised;
negative charge on leaf and cap; *(disregard number of (–) signs)* ***[2]***

(b) (i) energy per unit charge; *(ratio idea necessary)*
to move positive test charge between points; ***[2]***

(ii) leaf undeflected when charge on electroscope / *vice versa*;
leaf deflects when charge moved towards / away from electroscope;
hence gives a measure of potential; ***[3]***
Allow any sensible relevant comments leading to a valid conclusion.

(c) (i) use of e.m.f. = energy / charge;

$$= \frac{(8.1\times10^3)}{(5.8\times10^3)}$$

$=1.4$ V; ***[2]***

*Award **[0]** for formula* $E = \dfrac{F}{Q}$ *seen or implied even if answer is numerically correct.*

(ii) p.d. across internal resistance $= 0.2$ V;

resistance $r = \left(\dfrac{0.2}{1.2}\right)\times 6.0$;

$=1.0\ \Omega$;

OR current $= \dfrac{1.2}{6} = 0.2\text{A}$;

total resistance $= \dfrac{1.4}{0.2} = 7.0\Omega$;

internal resistance $= 7 - 6 = 1.0\Omega$; ***[3]***

Accept any other valid route.

(iii) idea of use of ratio of resistances;
energy transfer $= 6/7 \times 8.1\times10^3$
$= 6.9(4)\times10^3$ J; ***[2]***
Accept any other valid route.

(iv) charge carriers/electrons have kinetic energy / are moving;
these carriers collide with the lattice/lattice ions; *(do not allow friction)*
causing increased (amplitude of) vibrations;
this increase seen as a temperature rise;
i.e. a transfer to thermal energy; ***[5]***
Allow any other relevant and correct statements.

(d) (i) (induced) e.m.f. proportional to rate of change of magnetic flux (linkage); *(do not allow induced current)*
as current increases, magnetic field in coil increases;
thus change in flux linkage and e.m.f. induced; ***[3]***

(ii) direction of (induced) e.m.f. such as to tend to oppose;
the change producing it;
induced e.m.f. must oppose e.m.f. of battery / growth of current in circuit; ***[3]***

(iii) energy is supplied by the battery;
in making charge move against the induced e.m.f.; ***[2]***

B2. Part 1 Earthquake Waves

(a) (i) velocity has direction;
but light travels in all directions; ***[2]***

(ii) *longitudinal*: displacement along;
transverse: displacement normal to;
direction of transfer of wave energy / propagation, **not** motion; ***[3]***
*Award **[0]** for left/right and up/down for longitudinal/transverse.*

(b) (i) $\left(\frac{700}{75}\right) = 9.3\,\text{km s}^{-1}$; (± 0.1) ***[1]***

(ii) $\left(\frac{700}{120}\right) = 5.8\,\text{km s}^{-1}$; (± 0.1) ***[1]***
*Award **[1 max]** if the answers to (i) and (ii) are given in reversed order.*

(c) (i) P shown as the earlier (left hand) pulse; ***[1]***

(ii) laboratory L_3; ***[1]***

(iii) *e.g.* pulses arrive sooner;
smaller S-P interval;
larger amplitude of pulses; ***[3]***
*Allow any feasible piece of evidence, award **[1]** for each up to **[3 max]**.*

(iv) *distance from* L_1 = 1060 km; (± 20)
distance from L_2 = 650 km; (± 20)
distance from L_3 = 420 km; (± 20)
Accept 3 significant digits in all three estimates.
some explanation of working; ***[4]***

(v) position marked, consistent with answers to (iv);
to the right of line $L_2 L_3$, closer to L_3; ***[1 max]***
If the answers given in (iv) means that the point cannot be plotted, then only allow the mark if the candidate states that the position cannot be plotted/does not make sense.

(d) (i) illustration showing node at centre, antinode at each end; ***[1]***

(ii) wavelength of standing wave = $(2 \times 280) = 560$ m / e.c.f ***or*** $\frac{3.4 \times 10^3}{6} = 570\,\text{m}$;
frequency = $\frac{(3.4 \times 10^3)}{560} \approx 6\,\text{Hz}$ ***or*** wavelength of standing wave = $(2 \times 280) = 560\,\text{m}$;
earthquake frequency is natural frequency of vibration of building / mention of resonance / multiple/submultiple if ecf; ***[3]***

B2. Part 2 The Doppler effect

(a) circular wavefronts originating from four successive source positions;
bunching of wavefronts in front, spreading out at back;
approximately, correct spacing of wavefronts in front, and behind source; ***[3]***

(b) f waves in distance $(V - v)$;
apparent wavelength $= \frac{(V - v)}{f}$;
apparent frequency $= \frac{f \times V}{(V - v)}$; ***[3]***
*Allow any other valid and correct approach or statement of formula. Award **[0]** for quote of formula with no working shown.*

(c) $\lambda' = \lambda \frac{(V - v)}{V}$;
$599.996 = \frac{600 \times (3 \times 10^8 - v)}{(3 \times 10^8)}$;
$v = 2000\,\mathrm{m\,s^{-1}}$; ***[3]***
Allow alternative version for red-shift.

B3. (a) (i) *fission*:
nucleus splits;
into two parts of similar mass;

radioactive decay:
nucleus emits;
a particle of small mass and/or a photon; ***[4]***

(ii) ${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n}$;
$\rightarrow {}^{90}_{38}\text{Sr} + {}^{142}_{54}\text{Xe} + 4{}^{1}_{0}\text{n}$; ***[2]***
Allow ecf for RHS if LHS is incorrect.

(iii) mass number unchanged;
atomic number increases by +1; ***[2]***

(b) (i) kinetic energy of neutrons;
and energy of gamma ray photons; ***[2]***
Accept other valid possibilities but do not accept "heat".

(ii) use of $E_k = \dfrac{p^2}{2m}$ / equivalent;
correct conversion of MeV to joule $(1.63 \times 10^{-11}\ \text{J})$;
correct conversion of mass to kilogram $(1.50 \times 10^{-25}\ \text{kg})$;
momentum $= 2.2 \times 10^{-18}\ \text{N s}$; ***[4]***

(iii) total momentum after fission must be zero;
must consider momentum of neutrons (and photons); ***[2]***

(iv) xenon not opposite to strontium but deviation $< 30°$);
arrow shorter / longer; ***[2]***

(c) (i) probability of decay / constant in expression $\dfrac{\text{d}N}{\text{d}t} = -\lambda N$;
per unit time / $\dfrac{\text{d}N}{\text{d}t}$ and N explained; ***[2]***

(ii) $\lambda = \dfrac{\ln 2}{(28 \times 365 \times 24 \times 3600)}$ ***(note**: substitution is essential)*
$= 7.85 \times 10^{-10}\ \text{s}^{-1}$; ***[1]***

(d) (i) $\dfrac{N_0 \exp(-7.85 \times 10^{-10}\, t)}{N_0 \exp(-0.462\, t)} = 1.2 \times 10^6$;
$\exp(0.462\, t) = 1.2 \times 10^6$;
$t = 30.3$ s; ***[3]***

(ii) activity of the strontium will be much greater than that of the xenon;
and extent of health hazard depends on activity; ***[2]***

(e) (i) (electron) antineutrino; ***[1]***

(ii) <u>weak</u> interaction; ***[1]***

(iii) fundamental forces are due to effects of exchange particles;
W^- boson / W^+ / Z^0; ***[2]***

B4. Part 1

(a) obeys the universal gas law / equation $\frac{pV}{T}$ ***or*** molecules are elastic spheres of negligible volume;
at all values of pressure, volume and temperature ***or*** no mutual force of attraction/repulsion; ***[2]***

(b) mass of gas $1.6 \times 1.2 = 1.9(2)\,\text{kg}$;
use of $\Delta Q = mc\Delta\theta$;
$1.5 \times 10^4 = 1.92 \times c \times (52 - 27)$
$c = 310\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$; ***[3]***
*Award **[1]** for use of density in place of mass to give 375 J kg^{-1} K^{-1} and **[0]** for use of volume in place of mass.*

(c) (i) use of $\frac{pV}{T}$ = constant;
$V = 1.2 \times \left(\frac{325}{300}\right)$;
$= 1.3\,\text{m}^3$ ***[2 max]***

(ii) use of $\Delta W = p\Delta V$;
$\Delta W = 1.0 \times 10^5 \times 0.1 = 1.0 \times 10^4\,\text{J}$; ***[2]***

(d) thermal energy required to raise temperature (same as for constant volume);
and to do work against the atmosphere;
so must be larger; ***[3]***
*Award **[0]** for a "bald" statement of answer or fallacious argument.*

B4. Part 2

(a) (i) speed of object at Earth's surface;
so that it will escape from the gravitational field / travel to infinity; ***[2]***

(ii) gravitational potential energy at Earth's surface $= (-)\dfrac{GMm}{R_e}$;
this must be provided for probe to escape;
energy is less than this <u>hence</u> not escape; ***[3]***

(b) (i) change $= GMm\left(\dfrac{1}{R_e} - \dfrac{1}{R}\right)$; ***[1]***

Accept $GMm\left(\dfrac{1}{R} - \dfrac{1}{R_e}\right)$.

(ii) in orbit, $\dfrac{mv^2}{r} = \dfrac{GMm}{r^2}$;

$\frac{1}{2}mv^2 = \dfrac{GMm}{2R}$; ***[2]***

(c) idea of equating energies;

$\dfrac{3GMm}{4R_e} = \dfrac{GMm}{2R} + \dfrac{GMm}{R_e} - \dfrac{GMm}{R}$;

$\dfrac{1}{4R_e} = \dfrac{1}{2R}$

$R = 2R_e$;

height above surface $= R_e$; ***[4 max]***

(d) (i) probe collides with air molecules;
giving them kinetic energy and so losing energy itself; ***[2]***
Accept answers in terms of frictional forces.

(ii) greater density, more molecules of air with which to collide;
higher speed, higher rebound speed for air molecules; ***[2]***
Accept answers in terms of magnitude of frictional force.

(iii) height becomes less;
and speed increases; ***[2]***