MARKSCHEME

May 2005

PHYSICS

Higher Level

Paper 2

13 pages

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 candidate's 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 candidates credit for what they have achieved, and for what they have got correct, rather than penalising 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.
- 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) 0.430; *[1]*
Answer must have 3 significant digits to achieve ***[1]****.*
Do not accept 0.429

(b) (i) correct point identified; *[1]*

(ii) plot correct to $\pm\frac{1}{2}$ square; *[1]*
Allow without label if unambiguous.

(iii) straight-line with acceptable fit; *[1]*
Line must have points on both sides and within 1 small square of both extreme/end points.

(c) (i) some indication that large triangle used;
(points separated by at least half-length of line)
correct value from candidate's graph; *[2]*
Award ***[0]*** *for use of data points not on candidate's line.*

(ii) intercept identified;
should be 0.32, not 0.38 so graph does not agree; *[2]*

(d) straight-line with same gradient;
having intercept of 0.32; *[2]*

(e) $4.17^{-\frac{1}{2}} = 0.490$ ***or*** $4.23^{-\frac{1}{2}} = 0.486$ ***or*** % uncertainty = 0.7 %;
error in answer is + 0.002 ***or*** – 0.002 ***or*** ± 0.002;
uncertainty is in third place of decimals so 3 significant digits is acceptable *i.e.* some justification; *[3]*

A2. (a) (i) $18t$; *[1]*

(ii) $s = \frac{1}{2} \times 4.5 \times 6^2 = 81\,\text{m}$; *[1]*

(iii) $v = at = 6 \times 4.5 = 27\,\text{m}\,\text{s}^{-1}$; *[1]*

(iv) $27(t - 6)$; *[1]*

(b) idea of (a) (i) = (a) (ii) + (a) (iv);
$18t = 81 + 27(t - 6)$
$t = 9.0\,\text{s}$; *[2]*

A3. (a) light nuclei for fusion;
heavy nuclei for fission;
more massive nucleus produced in fusion/joined together;
two lighter nuclei produced in fission/splits apart; ***[4]***

(b) number of reactions per second $= \dfrac{10^8}{(2.8\times10^{-12})} = 3.6\times10^{19}$

or mass of He nucleus $= 4\times1.66\times10^{-27}\text{ kg} (= 6.64\times10^{-27}\text{ kg})$;
mass of helium $= 3.6\times10^{19}\times6.64\times10^{-27} = 2.4\times10^{-7}\text{ kg s}^{-1}$; ***[2]***
N.B. *unit not required.*

A4. (a) photoelectric current / rate of emission independent of frequency;
photoelectric current / rate of emission depends on intensity of radiation;
(max) kinetic energy of electron dependent on frequency;
existence of threshold frequency;
instantaneous ejection;
etc.; ***[3 max]***

(b) (i) $hf = hf_0 + eV_S$;
Accept φ instead of hf_0.
identifies h and e;
identifies f_0 / φ; ***[3]***

(ii) re-arranging, $V_S = \dfrac{h}{e}\times f - \dfrac{h}{e}\times f_0$;

compares with $y = mx + c$ and hence gradient $\dfrac{h}{e}$; ***[2]***

(iii) $f_0 = 0.96\times10^{15}\text{ Hz}$;
work function $= 6.6\times10^{-34}\times0.96\times10^{15}$
$= 6.3\times10^{-19}\text{ J} / 3.9\text{ eV}$; ***[2]***

SECTION B

B1. (a) (i) momentum is mass $\times$ velocity;
impulse is force $\times$ time ***or*** change in momentum; ***[2]***
In each case, allow an equation, with symbols explained.

(ii) (vector) sum/total of momenta is constant;
for isolated system; ***[2]***

(iii) if force is zero, then acceleration is zero ***or*** $\frac{\Delta p}{\Delta t}$ is zero;

acceleration ***or*** $\frac{\Delta p}{\Delta t} = 0$ means that velocity/momentum must be constant; ***[2]***

(b) (i) $\rightarrow {}^{216}_{84}\text{Po}$;
$+{}^{4}_{2}\text{He}$; *(allow* ${}^{4}_{2}\alpha$*)* ***[2]***

(ii) energy $= 6.29 \times 10^{6} \times 1.6 \times 10^{-19}$;
$= 1.01 \times 10^{-12}\ \text{J}$; ***[2]***

(iii) $E_{\text{k}} = \frac{1}{2}mv^{2}$
$1.01 \times 10^{-12} = \frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^{2}$;
All terms in the equation must be seen.
$v = 1.74 \times 10^{7}\ \text{m s}^{-1}$ ***[1]***

(c) (i) direction opposite to that of α-particle; ***[1]***
Ignore length.

(ii) $m_{\alpha}v_{\alpha} = m_{\text{P}}v_{\text{P}}$; *(In words or as an equation - some explanation essential)*
$v_{P} = \frac{4}{216} \times 1.74 \times 10^{7}$;
$= 3.22 \times 10^{5}\ \text{m s}^{-1}$; ***[3]***

(iii) α-particle and nucleus no longer in opposite directions;
any further physics *e.g.* plausible diagram "there is momentum in forward direction";
or
if initial direction along direction of α-particle;
then no change in directions; ***[2 max]***

(d) (i) *e.g.* stability ***or*** mass defect/excess / binding energy;
number of neutrons / nucleons / mass;
diameter; ***[3]***

(ii) time for activity/mass/number of nuclei to halve;
clear indication of what halves – original isotope, (not daughters); ***[2]***

(iii) $A_t = A_0\, e^{-\lambda t}$;
at time $t = T_{\frac{1}{2}}$, $A_t = \frac{1}{2} A_0$;
<u>working</u> leading to $\lambda T_{\frac{1}{2}} = \ln 2$ ***or*** $= 0.693$; ***[3]***

(iv) $\frac{dN}{dt} = \lambda N$; *(ignore minus sign)*
$\lambda = 2.11 \times 10^{-6}\ \mathrm{s}^{-1}$;
$N = \frac{4.5}{2.11 \times 10^{-6}} = 2.2 \times 10^{6}$;
ratio is 8.4×10^{-20} ; ***[4]***

(e) radon-220 because dose in a shorter time and damage is dose-rate dependent;
radon-222 because a person may be exposed for longer time and damage depends on dose; ***[1 max]***

B2. (a) (i) energy transfer;
no interruption in transfer / without mass motion of the medium; ***[2]***
Do not accept "continuous".

(ii) speed / rate at which energy / wavefronts are propagated; ***[1]***

(b) (i) frequency: number of oscillations/vibrations <u>per unit time</u>; ***[1]***
Do not accept specific units e.g. seconds.

(ii) wavelength: distance moved by wave during one oscillation of the source; ***[1]***
Accept distance between <u>successive</u> crests or troughs.

(c) (i) wave travels down tube and is reflected;
incident and reflected waves interfere to give standing wave; ***[2]***

(ii) air (column) in tube has natural frequency of vibration;
when fork frequency equals natural frequency;
<u>maximum amplitude of vibration</u> / <u>maximum loudness</u>;
when fork frequency not equal to natural frequency, no resonance / loudness drops; ***[4]***

(iii) $\frac{1}{2}\lambda = 65\,\text{cm}$;
$\text{speed} = 0.65 \times 2 \times 256 = 330\,\text{m}\,\text{s}^{-1}$; ***[2]***
*Award **[1 max]** for $660\,m\,s^{-1}$.*

(d) $\text{pressure} = \dfrac{\text{force}}{\text{area}}$
$= \dfrac{(4.0\times10^{-5})}{(30\times10^{-6})}$;
$= 1.3\,\text{Pa}$; ***[2]***

(e) (i) idea of using area under the line / $\frac{1}{2}kx^2$;
$\text{energy} = \frac{1}{2}\times6\times10^{-5}\times1.5\times10^{-2}\times10^{-3}$ ***or*** $112.5\ (\pm2.5)$ squares;
$= 4.5\times10^{-10}\,\text{J}$; *(Allow $\pm0.1\times10^{-10}$ if candidate counts squares.)* ***[3]***

(ii) $\text{period} = 1.0\text{ ms}$;
and energy is supplied in <u>$\frac{1}{4}$ period</u> $(= 0.25\,\text{ms})$;
$\text{power} = \dfrac{4.5\times10^{-10}}{0.25\times10^{-3}}$;
$= 1.8\times10^{-6}\,\text{W}$; ***[4]***

(iii) strain energy / energy of deformation of eardrum / kinetic energy of eardrum / vibrational energy; ***[1]***

(f) (i) path difference is $2.5\,\lambda$;
wavelength $= 0.20$ m;
speed $= f\lambda = 1700 \times 0.2 = 340\,\text{m}\,\text{s}^{-1}$; ***[3]***

(ii) at X: loudness increases;
waves not same amplitude at X so not complete destructive interference;
at P: loudness decreases;
because sum of amplitudes less than before; ***[4]***

*Award **[1]** for two correct statements without explanations. Award **[0]** for statement with incorrect reasoning. Award **[1]** for correct statement with partially correct reasoning.*

B3. Part 1 Electrical components

(a) component X, battery, ammeter all in series and including means of varying current;
with voltmeter in parallel across component X; ***[2]***

(b) (i) 4.0 A; ***[1]***

(ii) use of $R = \frac{V}{I}$, and **not** gradient of graph;
resistance $= 1.5\,\Omega$; ***[2]***

(c) (i) straight-line through origin, quadrants 1 or 3 or both;
correct gradient, *i.e.* passes through $V = 4.0\,\text{V}, I = 2.0\,\text{A}$; ***[2]***

(ii) p.d.'s across X and across R will be 3.7 V ($\pm 0.1\,\text{V}$) and 6.0 V;
*Award **[0]** if only one p.d. is correct.*
total p.d. = 9.7 V; ***[2]***

Part 2 Magnetic fields

(a) concentric circles;
separation increases (at least three circles required to see this);
correct direction (anticlockwise); ***[3]***

(b) (i) current in one turn produces magnetic field in region of the other turn;
gives rise to a force on the wire;
Newton's third / idea of *vice versa* (gives rise to attraction) / idea of *vice versa* (gives rise to shortening); ***[3]***

(ii) use of $B = \frac{\mu_0 I}{2\pi r}$ (gives $B = 1.0 \times 10^{-4}\, I$);
use of $F = BIL$;
$= 1.0 \times 10^{-4} \times I^2 \times 2\pi \times 3.0 \times 10^{-2}$;
this force is equal to mg;
hence $I^2 = 52.04$, and $I = 7.2\,\text{A}$; ***[5]***

Part 3 Electromagnetic induction

(a) (i) e.m.f. (induced) proportional to;
rate of change /cutting of (magnetic) flux (linkage); ***[2]***

(ii) magnetic field / flux through coil will change as the current changes; ***[1]***

(b) (i) sinusoidal and in phase with current; ***[1]***

(ii) sinusoidal and same frequency;
with 90° phase difference to candidate's graph for φ; ***[2]***

(iii) e.m.f. is reduced;
because B is smaller; ***[2]***
Award ***[0]*** *for "e.m.f. is reduced" if argument fallacious.*

(c) advantage: no direct contact with cable required;
disadvantage: distance to wire must be fixed; ***[2]***

B4. Part 1 Ideal gases and specific heat capacity

(a) (i) no intermolecular forces;
any other two relevant assumptions of kinetic theory; ***[2]*** ***[3]***
Do not allow $pV = nRT$.

(ii) no forces between molecules/atoms so no potential energy;
and internal energy = (random) kinetic energy + potential energy; ***[2]***

(b) (i) $\frac{870}{293} = \frac{V}{294}$;
$V = 873\,\text{cm}^3$;
$\Delta V = 3\,\text{cm}^3$; ***[3]***
*Award **[1]** for use of $^\circ C$ not K giving $44\,cm^3$.*

(ii) work done $= 1.00 \times 10^5 \times 3 \times 10^{-6}$;
$= 0.3\,\text{J}$; ***[2]***

(c) (i) quantity of thermal energy (heat) required to raise temperature of unit mass;
by one degree; ***[2]***
*Award **[1 max]** for use of units, rather than quantities.*

(ii) kinetic energy / speed of atoms increases;
reference to r.m.s. speed / r.m.s. velocity / mean speed / mean kinetic energy; ***[2]***

(iii) at constant volume, $\Delta Q = \Delta U$ / all heating increases internal energy;
at constant pressure, ($\Delta Q = \Delta U + \Delta W$) / heating increases internal energy and external work is done;
hence conclusion; ***[3]***

Part 2 Satellite motion

(a) gravitational force = centripetal force;

$\frac{GMm}{x^2} = \frac{mv^2}{x}$;

hence $v = \sqrt{\left(\frac{GM}{x}\right)}$ ***[2]***

***Note**: no mark for answer.*

(b) (i) kinetic energy $= \frac{GMm}{2x}$;

potential energy $= -\frac{GMm}{x}$; ***[2]***

(ii) $E_{tot} = E_K + E_P$;

$E_{tot} = -\frac{GMm}{2x}$; ***[2]***

*Deduct **[1]** overall for (–) signs wrong.*

(c) (i) total energy is reduced; ***[1]***

(ii) $-\frac{GMm}{2x}$ must be more negative;

and so x must be smaller; ***[2]***

*Award **[0]** for a fallacious argument.*

(iii) (when x becomes smaller), v becomes larger; ***[1]***

(iv) frictional forces will increase as radius of orbit decreases;

because atmosphere more dense;

satellite's speed increases so increasing drag; ***[3]***

*Award **[0]** for a fallacious argument.*