INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

MARKSCHEME

May 2003

PHYSICS

Higher Level

Paper 2

10 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*

Indicate the mark deduction, 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) bubbles rise at constant rate / constant temperature using a thermometer; ***[1]***

(b) can check that rate of boiling is constant;
because the two masses should be equal; ***[2]***

(c) (i) reasonable line drawn; ***[1]***

(ii) triangle for gradient with hypotenuse at least half length of line;
some working shown (*e.g.* coordinates used made clear);
answer 12 (W g^{-1}) ± 1; ***[3]***

(d) gradient = $\frac{L}{200}$;
$L = 2400$ *allow ecf from (c)(ii)*;
correct unit J g^{-1}; ***[3]***

(e) heat energy losses / systematic error;
to the atmosphere / any other detail; ***[2]***

A2. (a) gas that obeys the equation $pV = nRT$ / no forces between molecules;
at all pressures, volumes and temperatures / any other postulate; ***[2]***

(b) (i) $pV = nRT$
$20\times10^{6}\times2\times10^{-2} = n\times8.3\times290$;
$n = 170\ (166)$; ***[2 max]***

(ii) number $= n\times N_A$;
number = $166\times6.02\times10^{23} = 1.0\times10^{26}$; ***[2]***

(c) (i) average volume $= 2.0\times10^{-28}\ \text{m}^3$; ***[1]***

(ii) average separation $\approx \sqrt[3]{(2.0\times10^{-28})}$;
$= 5.8\times10^{-10}\ \text{m}$; ***[2]***
Allow solution based on sphere.

A3. (a) (i) energy = $\frac{hc}{\lambda}$ / energy = hf and $c = f\lambda$;

$= \frac{(6.63\times10^{-34}\times3.0\times10^{8})}{(6.0\times10^{-7})}$; ***[2]***

*Award **[0]** for* $= 3.3\times10^{-19}$ J.

(ii) momentum = $\frac{h}{\lambda}$;

$= \frac{(6.63\times10^{-34})}{(6.0\times10^{-7})}$; ***[2]***

*Award **[0]** for* $= 1.1\times10^{-27}$ kg m s^{-1} (N s).

(b) (i) number = $\frac{5.0}{(3.32\times10^{-19})} = 1.5\times10^{19}$ (s^{-1}); ***[1]***

(ii) change per second = $1.1\times10^{-27}\times1.5\times10^{19} = 1.7\times10^{-8}$ N / other appropriate unit; ***[1]***

(c) (i) 1.7×10^{-8} Pa;
answer in (b) (ii); ***[1 max]***

(ii) momentum of reflected photon added to momentum of incident photon;
so change in momentum of a photon would be greater;
hence pressure would be greater; ***[3]***

A4. (a) (i) M shown at peak or trough; ***[1]***

(ii) Z shown on *t*-axis; ***[1]***

(b) by Lenz's law, e.m.f. (or current) must change direction as flux cutting changes direction;
as magnet oscillates, flux is cut in opposite directions; ***[2]***

SECTION B

B1. (a) (i) wavefront parallel to D; *[1]*

(ii) frequency is constant;
since $v = f\lambda, v \propto \lambda$;
wavelength larger in medium I, **hence** higher speed in medium I; *[3]*
Allow solution based on angles marked on the diagram or speed of wavefronts.

(b) (i) velocity / displacement / direction in (+) and (–) directions;
idea of periodicity; *[2]*

(ii) period = 3.0 ms;
frequency = $\frac{1}{T}$ = 330 Hz; *[2]*

(iii) *Accept any one of the following.*
at time t = 0 / 1.5 ms / 3.0 ms / 4.5 ms *etc.*; *[1 max]*

(iv) area of half-loop = 140 squares ±10 / mean v = 4.0 m s^{-1} ±0.2;
= $140 \times 0.4 \times 0.1 \times 10^{-3}$ / $4.0 \times 1.5 \times 10^{-3}$;
= 5.6×10^{-3} m / 6.0×10^{-3} m; *[2 max]*
Award ***[1]*** *for area of the triangle.*

(v) (twice) the <u>amplitude</u>; *[1]*
Allow distance moved in 1.5 m s.

(c) (i) when two (or more) waves meet;
resultant **displacement** is the sum of the individual **displacements**; *[2]*

(ii) at M, it is loud;
at P, minimum / not so loud;
at P, path difference is ½λ and at M, no path difference;
at P, destructive interference and at M, constructive; *[4]*

(iii) because adding in a larger amplitude;
sound is louder at M;
because wave amplitudes no longer equal;
sound louder at P; *[4]*
Award ***[1]*** *for louder at M and at P.*

(iv) sources are not coherent *[1]*

(d) (i) wavelength = $\frac{c}{f}$; *[1]*

(ii) speed relative to observer = (c + v); *[1]*

(e) (i) periodic rise and fall in loudness of sound;
at frequency equal to difference in frequency of waves *(can be implied in (ii))*; ***[2]***

(ii) apparent frequency = 506 Hz;
$\frac{506}{500} = \frac{(340+v)}{340}$;
speed = 4.1 m s^{-1}; ***[3]***

B2. (a) force × distance (moved);
in the direction of the force; ***[2]***

(b) (i) force = weight = mg;
work done = mgh; ***[2]***
*Award **[0]** for quote of answer.*

(ii) power = $\frac{mgh}{t}$;
but $\frac{h}{t} = v$, so power = mgv; ***[2]***
*Award **[1]** for* power = Fv = mg$v$.

(c) kinetic energy is constant;
gravitational potential energy → thermal energy;
as a result of air resistance; ***[3]***

(d) (i) sum of (random) kinetic (and potential energies);
of the molecules of the system *(allow atoms or particles)*; ***[2]***

(ii) when a molecule strikes the piston;
rebound speed of molecule is increased;
and so <u>mean</u> kinetic energy of molecules increases;
mean kinetic energy of atoms is proportional to <u>Kelvin</u> temperature;
the temperature **rises**; ***[5]***
Do not allow an argument based on "less space".

(iii) force on piston = pA;
where A is area of piston. Piston moves distance x;
work done = pAx;
$Ax = \Delta V$, so $W = p\Delta V$; ***[4]***

(e) (i) A → B → C → D → A; ***[1]***

(ii) $pV = nRT$
$1.0\times10^5 \times 6\times10^{-4} = n\times8.3\times300$;
n = 0.024 mol; ***[2 max]***

(iii) $\frac{(1.0\times10^5 \times 6\times10^{-4})}{300} = \frac{(6.1\times10^6 \times 0.32\times10^{-4})}{T}$;
T = 976 K; ***[2]***

(iv) work done by the gas (in 1 cycle);
equal to 210 J; ***[2]***

(v) efficiency $= \left(\frac{\text{work out}}{\text{work in}}\right)$;
$= \frac{210}{310}$;
= 68 %; ***[3]***

B3. (a) *Deduct* ***[1]*** *for each error or omission, stop at zero*

Property	*Effect on rate of decay*		
	increase	*decrease*	*stays the same*
temperature of sample			✓
pressure on sample			✓
amount of sample	✓		

[2 max]

(b) (i) the probability of decay (of a nucleus);
is 4.3×10^{-4} (1 in 2326) in each year; ***[2]***

(ii) mass defect = $5.2\times10^{-3}\,u$;
energy $= mc^2$
$= 5.2\times10^{-3}\times1.661\times10^{-27}\times9.00\times10^{16}$ / 1 u = 930 MeV;
$= 7.77\times10^{-13}$ J / 4.86 MeV; ***[3 max]***

(c) (i) (linear) momentum must be conserved;
momentum before reaction is zero;
so equal and opposite after (to maintain zero total); ***[3]***

(ii) $0 = m_\alpha v_\alpha + m_{\text{Rn}} v_{\text{Rn}}$;
$\frac{v_\alpha}{v_{\text{Rn}}} = -\left(\frac{m_{\text{Rn}}}{m_\alpha}\right)$;
$= -\frac{222}{4} = -55.5$; ***[3]***
Ignore absence of minus sign.

(d) (i) $N_0 = \frac{\left(15.0\times10^{-6}\times6.02\times10^{23}\right)}{226}$;

$= 4.0\times10^{16}\ (3.996\times10^{16})$;

(ii) $N = 3.996\times10^{16}\ \exp(-4.30\times10^{-4}\times30)$;

$= 3.95\times10^{16}\quad(3.945\times10^{16})$;

(iii) mean activity $= \frac{(N_0 - N)}{t}$

$= \frac{(3.996\times10^{16} - 3.945\times10^{16})}{(30\times365\times24\times3600)}$;

$= 5.4\times10^{5}$ Bq;

Allow activity in yr^{-1}. ***[6 max]***

(e) neutrons and protons are composed of quarks;
proton is up, up, down;
neutron is up, down, down; ***[3]***

(f) (i) two (light) nuclei;
combine to form a more massive nucleus;
with the release of energy / with greater total binding energy; ***[3]***

(ii) high temperature means high kinetic energy for nuclei;
so can overcome (electrostatic) repulsion (between nuclei);
to come close together / collide;
high pressure so that there are many nuclei (per unit volume);
so that chance of two nuclei coming close together is greater; ***[5]***

B4. (a) (i) if independent of charge;
must be gravitational;

(ii) depends on charge so electric or magnetic;
independent of velocity so electric;

(iii) (depends on velocity and charge, so) magnetic; ***[5 max]***

(b) idea of change in electric potential energy = gain in kinetic energy;
$q\Delta V = \frac{1}{2}mv^2$;
$(1.6\times10^{-19}\times2.1\times10^{3}) = (\frac{1}{2}\times9.1\times10^{-31}\times v^2)\ /\ v^2 = 7.38\times10^{14}$; ***[3]***
*Award **[0]** for* $v = 2.7\times10^{7}\ \text{m s}^{-1}$.

(c) (i) correct force direction (upwards); ***[1]***

(ii) force = $\frac{qV}{d}$;

$= \frac{(1.6\times10^{-19}\times95)}{(2.2\times10^{-2})}$;

$= 6.9\times10^{-16}$ N; ***[3]***

(d) (i) time to cross plates = $\frac{(12\times10^{-2})}{(2.7\times10^{7})} = 4.44\times10^{-9}$ s; ***[1]***

(ii) vertical acceleration = $\frac{(6.9\times10^{-16})}{(9.1\times10^{-31})}$ $(= 7.58\times10^{14}\ \text{m s}^{-2})$;

distance = $\frac{1}{2}\times a\times t^2$;

$= \frac{1}{2}\times7.58\times10^{14}\times(4.44\times10^{-9})^2$ *allow ecf*;

$= 7.5\times10^{-3}$ m; ***[3]***

(e) gravitational force is very small;
small in comparison with electric or magnetic force; ***[2]***

(f) (i) force due to B-field must be downwards;
mention of Fleming's left-hand rule / right-hand palm rule;
hence field into paper; ***[3]***

(ii) $Bqv = 6.9\times10^{-16}$ N *allow ecf*

$B = \frac{(6.9\times10^{-16})}{(1.6\times10^{-19}\times2.7\times10^{7})}$;

$= 1.6\times10^{-4}$ T; ***[2 max]***

(g) (i) electric force unchanged;
magnetic force is greater;
hence deflection downwards;

(ii) both forces reversed in direction;
but not changed in magnitude;
hence undeflected;

(iii) undeflected; ***[7 max]***