MARKSCHEME

November 2006

PHYSICS

Higher Level

Paper 2

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.
- Words that are <u>underlined</u> are essential for 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.
- Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
- 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. Indicate this by **"U-1"** at the first point it occurs. 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**.

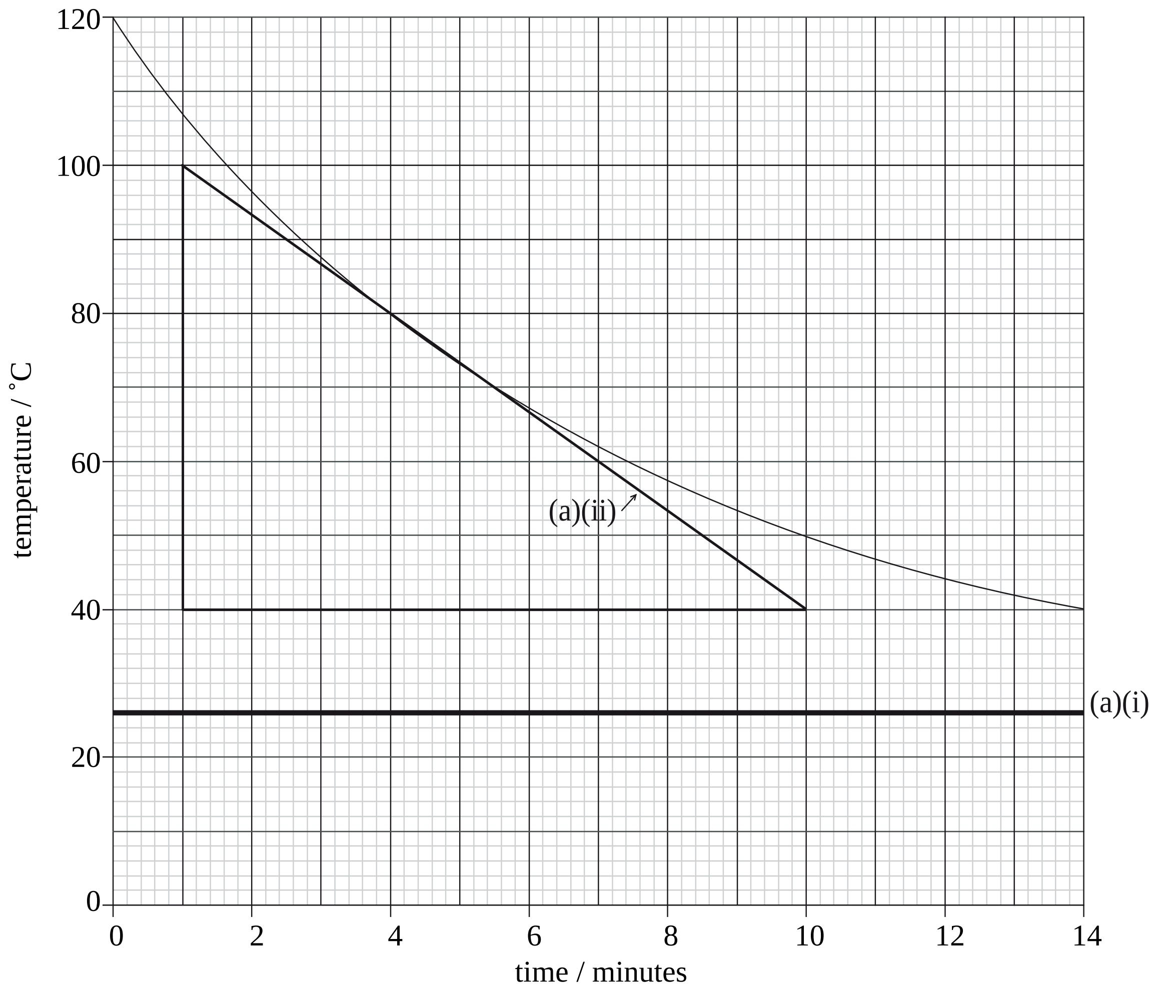
  e.g. if the answer is 1.63:

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

  Indicate the mark deduction by **"SD-1"**. 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) (i) line in correct position from $t = 0$ to $t = 14$ min ; ***[1]***

Allow $\pm\frac{1}{2}$ *square.*

(ii) reasonable tangent drawn at correct position *i.e.* at 76°C but allow 70°C → 85°C;

If tangent position is not acceptable, award ***[1 max]*** *in this section for length of tangent.*

line length used for tangent at least 8 cm;

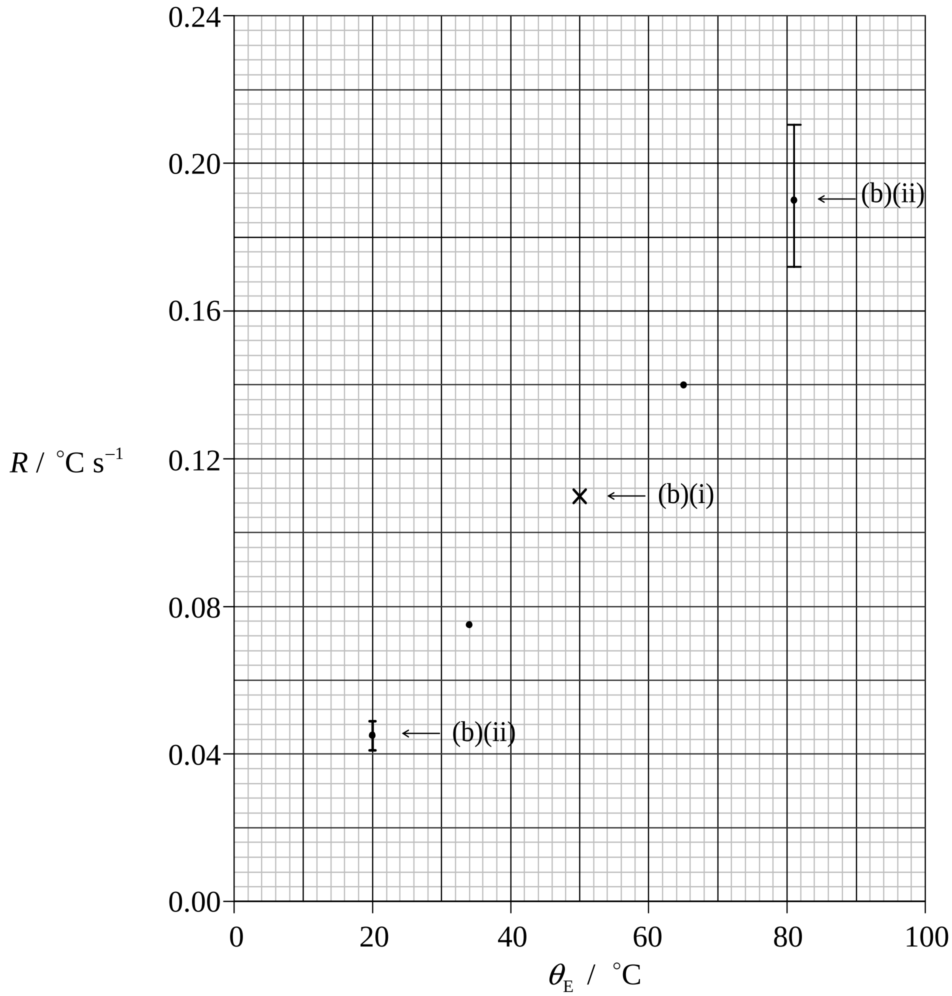
value 0.09 → 0.13;

accuracy – value within 0.10 → 0.12; ***[4]***

Award ***[1]*** *for value between ±10% and ±20% of 0.11 and* ***[2]*** *for value 0.11 ±10%.*

Unit of answer is not required. If the candidate fails to convert to s^{-1}*, then award one of the last two marks for answer in range* $6.0 \rightarrow 7.2$ *°C* min^{-1}.

(b)



(i) point plotted correctly; *(allow ECF from (b))* ***[1]***

(ii) error bar at $\theta_E = 20^\circ C : 4(\pm 2)\,mm$ long;
error bar at $\theta_E = 81^\circ C : 20(\pm 4)\,mm$ long; ***[2]***
Ignore any horizontal error bars.

(c) (i) allowing for uncertainties in readings;
points lie on straight-line;
and line passes through origin; ***[3]***
*Award **[1]** for "last point off line, so not obeyed".*

(ii) points between $\theta_E = 20^\circ C$ and $65^\circ C$ all lie close to straight-line;
point at $81^\circ C$ is at limit of uncertainty bar; ***[2]***
*Award **[1 max]** if the candidate states straight-line deviates from the points at high temperatures.*

(d) (i) straight-line with (+)ve intercept on lg*R* axis; ***[1]***

(ii) gradient is 1.0;
take antilog of value of intercept on lg*R* axis; ***[2]***

A2. (a) *Labelled schematic/block diagram showing*:
ion source and collimator;
velocity selector and B-field (Bainbridge-type) / E-field and B-field (Aston-type);
evacuated region in which ions travel;
means of detection; ***[3 max]***

(b) correct paths through spectrometer shown for ions of two masses;
peaks/lines close to one another and not $\times 2m$; ***[2]***

(c) (i) gluons; ***[1]***

(ii) vector bosons; *(allow Z or W)* ***[1]***

(iii) mesons; ***[1]***

A3. (a) mention of change in internal energy depends on mass;
mention of change in internal energy depends on specific heat capacity;
same if product of mass and specific heat capacity are same; ***[3]***

(b) (i) total entropy of universe is increasing; ***[1]***

(ii) freezing causes release of latent heat;
entropy of surroundings increases;
more than the decrease when water freezes; ***[3]***

(c) (i) adiabatic; ***[1]***

(ii) ΔQ is zero;
ΔU is negative ***or*** U decreases;
this ΔU is transferred to do external work W; ***[3]***
Accept points in any logical order.

SECTION B

B1. Part 1 Linear motion

(a) change in velocity / rate of change of velocity;
per unit time / with time; *(ratio idea essential to award this mark)* ***[2]***

(b) (i) acceleration is constant/uniform; ***[1]***

(ii) $t = \frac{2s}{(u+v)}$ and $t = \frac{(v-u)}{a}$;
clear working to obtain $v^2 = u^2 + 2as$; ***[2]***

(c) (i) $1.96 = \frac{1}{2} \times 9.81 \times t^2$;
$t = 0.632\,\text{s}$; ***[2]***

(ii) time to fall $(1.96 + 0.12)\,\text{m}$ is $0.651\,\text{s}$;
shutter open for $0.019\,\text{s}$; ***[2]***
If the candidate gives a one significant digit answer treat it as an SD-1.
*Award **[0]** if the candidate uses* $s = \frac{1}{2}at^2$ *and* $s = 12\,cm$.

(iii) greater distance means higher speed for ball;
so distance moved whilst shutter is open is greater;
so (fractional) error in measuring distance is smaller; *(do not allow "more accurate")* ***[3]***

Part 2 Collisions

(a) (i) centripetal force is provided by the cable / the ball is moving along the arc of a circle; ***[1]***

(ii) centripetal force $= \dfrac{(350 \times 2.6^2)}{5.8}$;

$= 410\,\text{N}$;

tension $= 410 + (350 \times 9.8) = 3800\,\text{N}$; ***[3]***

*Award **[0]** if* $\dfrac{v^2}{r}$ *is not used.*

(b) idea of use of area under graph / appropriate equation;

distance $= \frac{1}{2} \times 0.15 \times 2.6$ *(allow 0.14 → 0.15 s for the time)*

$= 0.195\,\text{m}$; *(allow 0.20 m, not 0.2 m)* ***[2]***

(c) (i) idea of momentum as *mv*;

total change $(= 2.6 \times 350) = 910\,\text{N s}$; ***[2]***

(ii) idea of average force as $\dfrac{\Delta p}{\Delta t}$;

force $\left(= \dfrac{910}{0.15}\right) = 6100\,\text{N}$; ***[2]***

(d) (i) for isolated/closed system;

total momentum remains constant; ***[2]***

(ii) external force acts on ball;

so law does not apply to the ball;

or

system is ball + wall/Earth;

momentum loss of ball = momentum gain of wall/Earth; ***[2]***

(e) $E_K = \frac{1}{2} \times 350 \times 2.6^2$;

thermal energy $= 350 \times 450 \times \Delta\theta$;

idea of $0.12 \times E_K = mc\Delta\theta$;

$\Delta\theta = 9.0 \times 10^{-4}\,\text{K}$; ***[4]***

B2. **Part 1** Gravitation

(a) centripetal force is provided by the gravitational force; *(do not allow "equals" or "is")*

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

to give $GM = Rv^2$ *(no mark for the answer)*

(b) (i) $6.67\times10^{-11}\times5.69\times10^{26} = (1.36\times10^{8})\times v^2$

$v = 1.67\times10^{4}\ \text{m s}^{-1}$;

$T = \frac{2\pi r}{v}$;

$T = 5.1\times10^{4}\ \text{s}$; **[3]**

*Award **[2 max]** for use of diameter, answer 7.24×10^{4} s.*

(c) (i) $E_P = \frac{-GMm}{r}$; **[1]**

(ii) if E_P decreases, then r decreases;

because rv^2 constant, then speed increases; **[2]**

*Award **[0]** in (ii) if answer states r increases.*

*Award **[0]** if argument is based on p. e. decreases so k. e. increases, v increases.*

(d) speed (of object) at surface (of planet) / specified starting point;

so that object may move to infinity / escape gravitational field of planet; **[2]**

(e) loss in kinetic energy = gain in (gravitational) potential energy;

$\frac{1}{2}mv^2 = \frac{GMm}{R}$;

but $g = \frac{GM}{R^2}$;

hence $v = \sqrt{(2gR)}$ *(no mark for answer)*

assumption: *e.g.* planet is isolated / no friction / no atmosphere *etc.*; **[4]**

(f) $v_{es} = \sqrt{(2\times1.6\times1.7\times10^{6})}$;

$= 2.3\times10^{3}\ \text{m s}^{-1}$; **[2]**

(g) $\frac{1}{2}\times4\times1.66\times10^{-27}\times(2.3\times10^{3})^2 = 2.1\times10^{-23}\times T$;

$T = 840\ \text{K}$; **[2]**

(h) atoms have a distribution of speeds / atoms may collide in upper atmosphere; **[1]**

Part 2 Electromagnetic induction

(a) (i) 3.3×10^{-2} T ; ***[1]***

(ii) flux linkage $= 3.3\times10^{-2}\times1.7\times10^{-4}\times250$;
$= 1.4\times10^{-3}$ Wb (turns); ***[2]***
Award ***[0]*** *if answer given as flux in (a)(ii) but allow full credit in (b)(i).*

(b) (i) new flux linkage $= 7.23\times10^{-4}$ Wb turns ***or*** $\Delta B = 1.6\times10^{-2}$ T ;
change $= (1.4 - 0.7)\times10^{-3}$ ***or*** change $= 1.6\times10^{-2}\times1.7\times10^{-4}\times250$; ***[2]***
change $= 7\times10^{-4}$ Wb turns *(no mark for answer)*

(ii) e.m.f. is proportional/equal to rate of change of flux (linkage); *(do not allow "induced current")*

$$\text{e.m.f.} = \frac{(7\times10^{-4})}{0.35} = 2\times10^{-3}\text{ V};$$ ***[2]***

(c) (i) e.m.f./induced current acts in such a direction to (produce effects to) oppose the change causing it; ***[1]***

(ii) induced current produces a magnetic field in the coil / induced current is in field of magnet;
this produces a force; *(award only if the first marking point is correct)*
the force acts to oppose the motion of the coil; ***[3]***

B3. (a) (i) wave that transfers energy; ***[1]***

(ii) amplitude $= 4.0\,\text{mm}$; ***[1]***
wavelength $= 2.4\,\text{cm}$; ***[1]***
frequency $= \frac{1}{0.3}$;
$= 3.3\,\text{Hz}$; ***[1 max]***
speed $= 3.3 \times 2.4$;
$= 8.0\,\text{cm}\,\text{s}^{-1}$; ***[1 max]***

(b) (i) angle of incidence $= 40^\circ$;
$\sin r = \frac{\sin 40}{1.4}$
$r = 27^\circ$;
angle $= 63^\circ$; ***[3]***
Award ***[1 max]*** *for angle of incidence $= 50^\circ$, $r = 33^\circ$.*

(ii) construction: wavefronts equally spaced;
separation less in medium B;
angle in medium B correct – by eye; ***[3]***

(c) *e.g.* coherent; *(do not allow "same frequency / monochromatic / crest meets crest")*
(approximately) same amplitude/intensity;
polarised in same plane;
waves from source meet at a point; ***[2 max]***

(d) (i) wavelength is shorter;
hence fringes are closer together; ***[2]***
Award ***[1 max]*** *for wavelength longer <u>hence</u> fringes further apart.*

(ii) centre fringe is white;
because all wavelengths give constructive interference here;
fringes are coloured;
with blue "inner" edge / with red "outer" edge;
because constructive interference occurs at different positions;
far from centre position, no fringes observed; ***[4 max]***

(e) frequency determines maximum kinetic energy of photo-electron;
instantaneous;
intensity determines rate of production of photo-electrons;
intensity does not determine maximum kinetic energy of photo-electron; ***[2 max]***

(f) idea of $eV = \frac{hc}{\lambda}$;

$1.6 \times 10^{-19} \times 2.4 = \frac{(6.63 \times 10^{-34} \times 3.0 \times 10^{8})}{\lambda}$;

$\lambda = 5.2 \times 10^{-7}$ m; ***[3]***

Award ***[2 max]*** *if factor 1.6×10^{-19} is missing.*

(g) (i) current is $2i_P$ / doubled;
because photon flux is doubled;
photon energy is unchanged; ***[3]***

(ii) current is less than i_P;
because photon flux is reduced;
since photon energy is increased; ***[3]***

B4. **Part 1** Electricity

(a) metal conductor: positive charges fixed;
mobile electrons;
plastic insulator: (positive charges and) electrons fixed; ***[3]***

(b) (i) moving charge from Earth to electroscope;
would require work to be done; ***[2]***

(ii) electric field causes movement of electrons (in metal);
and charges are not moving; ***[2]***

(iii) electrons move;
from Earth to the electroscope; ***[2]***

(c) (i) e.m.f. is the p.d. across cell when current is zero;
find intercept on *V*-axis; ***[2]***

(ii) r is $(-)$ gradient of graph ***or*** r=e.m.f./current when $V=0$ ***or*** value of R quoted at a given voltage;
relevant working shown on graph $\left(e.g.\ \frac{4.5}{3.8}=1.2\,\Omega\right)$ ***or*** use of $E=Ir+IR$; ***[2]***

(d) diagram showing resistor in series with device;
from graph, at 1.5 A, p.d. is 2.7 V ***or*** use of $E=I(R+r)$ to give total external resistance as $1.8\,\Omega$;
p.d. across $R=2.7-0.8=1.9\,\text{V}$ resistance of device $=\frac{0.8}{1.5}=0.53\,\Omega$;
resistance $=\frac{1.9}{1.5}=1.27\,\Omega$ resistance $=1.8-0.53=1.27\,\Omega$; ***[4]***

(e) $2P$;
P;
$\frac{1}{2}P$; ***[3]***

Part 2 Radioactivity

(a) (i) different forms of same element / nuclei having same proton number;
with different nucleon / mass numbers; ***[2]***

(ii) probability of decay (of nucleus) per unit time (ratio must be clear);
or
$\frac{dN}{dt} = -\lambda N$ with $\frac{dN}{dt}$, λ and N explained; ***[1 max]***

(b) ${}^{42}_{20}\text{Ca}$;
${}^{0}_{-1}\text{e}$ ***or*** ${}^{0}_{-1}\beta$; (*do not accept* e^{-}). ***[2]***
*Award **[1 max]** if any extra particle e.g. neutron is included in equation.*

(c) (i) evidence that half-life is 12.5 hours;
correct labelling of *t*-axis; (*at least three values required*) ***[2]***

(ii) line as "inverse" of given line, *i.e.* starts at zero, curves correct direction and flattens out reasonably; ***[1]***

(d) for this ratio, number of potassium atoms is $0.2\,N_0$;
time = 29 hours; ***[2]***