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MARKSCHEME

May 2008

PHYSICS

Higher Level

Paper 2

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Subject Details: Physics HL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[35 marks]** and **TWO** questions in Section B **[2 × 30 marks]**. Maximum total = **[95 marks]**.

1. A markscheme often has more marking points than the total allows. This is intentional. Do **no**t award more than the maximum marks allowed for part of a question.

2. Each marking point has a separate line and the end is signified 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 <u>underlined</u> are essential for the mark.

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

7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing ***OWTTE*** (or words to that effect).

8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. Indicate this with **ECF** (error carried forward).

10. Only consider units at the end of a calculation. Unless directed otherwise in the mark scheme, unit errors should only be penalized once in the paper. Indicate this by writing **–1(U)** at the first point it occurs and **U** on the cover page.

11. Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

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 writing **–1(SD)** at the first point it occurs and **SD** on the cover page.

SECTION A

A1. (a) (i) $\pm 0.5^\circ\text{C}$; ***[1]***

Do not accept $1^\circ C$.

(ii) actual uncertainty $= \pm 70\,\Omega$;

percentage uncertainty $= \left(\dfrac{70}{2600}\right) \times 100 = 3\%$; *(do not allow 2.7%)* ***[2]***

Do not apply SD–1 here since the question asks specifically for an estimate.

(b) (i) *at 20°C*: $1800\,\Omega$; ***[1]***

at 5°C: within range $3080\,\Omega \rightarrow 3220\,\Omega$;
within $3120\,\Omega \rightarrow 3180\,\Omega$; ***[2]***

(ii) use of tangent at correct position clear;
answer $64\,\Omega\,\text{K}^{-1}$ ***or*** $64\,\Omega\,^\circ\text{C}^{-1}$; *(allow $\pm 2\,\Omega\,K^{-1}$* ***or*** *$\pm 2\,\Omega\,^\circ C^{-1}$)*
<u>negative</u> sign; ***[3]***

(c) gradient of graph decreases as temperature rises / increases as temperature drops; *accept "gradient not constant".*
so relationship cannot be linear; ***[2]***

or

straight-line joining extreme points;
does not pass through "error boxes" of all points;

(d) product *RT* calculated correctly for two points;
product calculated correctly for third point;
conclusion: not same value so suggestion not correct; ***[3]***
*Award **[2 max]** if °C used instead of K.*

A2. (a) measure activity *A* of a sample containing the isotope;
determine (chemically) the number *N* of atoms <u>of the isotope</u> (from the measured mass of the isotope);
$A = \lambda N$ <u>and</u> $T_{\frac{1}{2}} = \dfrac{\ln 2}{\lambda}$; ***[3]***

(b) fraction $= \left(\frac{1}{2}\right)^{1.6}$ ***or*** fraction $= e^{-1.6\times\ln 2}$;
fraction $= 0.33$; ***[2]***

A3. (a) curved line, starts at V_1 and same pressure as given line;
always steeper than given line and finishing at V_2 and higher pressure than given line; ***[2]***
Accept any line linking V_1 and V_2 provided it is steeper than the first line.

(b) (i) upper line identified as G; ***[1]***

(ii) area between the lines shaded; ***[1]***

(c) *the gas*:
entropy decreases;
gas is at constant temperature and energy transferred to surroundings / (same number of moles of) gas molecules occupy reduced volume and therefore disorder (of gas) reduced;

the surroundings:
entropy increases; ***[3]***

A4. (a) <u>e.m.f.</u> induced proportional to/equal to;
rate of change of flux (linkage) / rate of flux cutting; ***[2]***

(b) (i) for e.m.f./current to be induced in secondary, flux must be changing <u>in the core</u>;
changing flux is caused by varying current in primary; ***[2]***

(ii) induced currents in core are kept small; *(do not allow reduced/prevented)*
to reduce heating/energy losses; *(do not allow mere "eddy current losses")* ***[2]***

(iii) use of $\frac{N_S}{N_P} = \frac{V_S}{V_P}$;
to give $N_P = 8600$ turns;
and $I_P \left(= \frac{42}{230} \right) = 180\,\text{mA}$; ***[3]***

SECTION B

B1. Part 1 Units and momentum

(a) fundamental units are defined / arbitrarily / as a standard / are reproducible;
derived units can be expressed in terms of the fundamental units; ***[1]***
Both responses required to award the mark.

(b) (i) $\text{m}\,\text{s}^{-1}$; ***[1]***

(ii) derived units of momentum are $\text{kg}\,\text{m}\,\text{s}^{-1}$ / units of R are the units of force;
derived units of R are $\text{kg}\,\text{m}\,\text{s}^{-2}$; ***[2]***
Response needs correct statement of derived units.

(iii) $\text{kg}\,\text{m}^{-1}$; ***[1]***
ECF from answer in (b)(ii).

(c) (i) momentum is mass × <u>velocity</u>; ***[1]***

(ii) impulse is force × time / change in momentum; ***[1]***
In each case allow an equation, with symbols explained.

(d) (i) $\Delta p = 450\ (18-13)$;
$= 2250\,\text{kg}\,\text{m}\,\text{s}^{-1}$ ***[1]***

(ii) idea of equating Δp to change in momentum of water;
$m = \frac{2250}{19} = 118\,\text{kg}\,(\approx 120\,\text{kg})$; ***[2]***

(iii) time of trolley in tank $= \frac{9.3}{15.5} = 0.60\,\text{s}$;

$a = \frac{(18-13)}{0.60}$ ***or*** $force = \frac{2250}{0.60} (= 3750\,\text{N})$;

$a = 8.3\,\text{m}\,\text{s}^{-2}$ $a = \frac{3750}{450} = 8.3\,\text{m}\,\text{s}^{-2}$; ***[3]***

or

$v^2 = u^2 + 2as$;

$a = \frac{13^2 - 18^2}{2\times 9.3}$;

$a = 8.3\,\text{m}\,\text{s}^{-2}$;

(e) (i) $E_{\mathrm{K}} = \frac{1}{2}mv^2$;
$= \frac{1}{2} \times 450 \times (18^2 - 13^2)$;
$= 35\,000\,\mathrm{J}$; ***[3]***

(ii) $E_K = \frac{1}{2} \times 118 \times 19^2$
$= 21000\,\mathrm{J}$; *(allow 22 000 J for use of m = 120 kg)* ***[1]***

(f) some water will be thrown “sideways”;
this will account for the difference in the kinetic energies;
this will not have any momentum in the forward direction / equal masses of water to left and right; ***[3]***

B1. Part 2 X-rays

(a) *Labelled diagram showing*:
evacuated envelope;
metal target;
heated filament;
anode and cathode clear; ***[4]***
Anode, cathode and heating of filament may be indicated by electrical symbols.

(b) (i) change temperature of cathode / cathode current;
increase temperature / current gives increase in intensity; ***[2]***

or

change (accelerating) voltage / atomic number of target;
increase voltage / atomic number gives increase in intensity;

(ii) change accelerating p.d. / anode-cathode p.d.;
increase p.d. gives shorter wavelength; ***[2]***

(c) whenever a charged particle is accelerated / interacts with matter, it radiates electromagnetic radiation;
accelerations of all different magnitudes so many different wavelengths produced; ***[2]***

B2. Part 1 Latent heat and specific heat

(a) (i) quantity of thermal energy/heat required to convert unit mass / mass of 1 kg of liquid to vapour/gas;
with no change of temperature / at its boiling point; ***[2]***

(ii) on vaporizing, potential energy of molecules/atoms increases;
on vaporizing, kinetic energy of molecules/atoms does not change;
only change in kinetic energy seen as change in temperature; ***[3]***
The term "vaporizing" or "phase change" should be present at least once to award full marks.

(b) (i) heater, variable resistor and power supply in series;
ammeter in series with heater, voltmeter in parallel with heater; ***[2]***

(ii) $P = VI$ used – not merely quoted;

$I = \frac{80}{9} = 8.9\,\text{A}$; ***[2]***

(iii) idea of $power \times time = mass \times latent\ heat$;
allowance made in equation for heat loss to atmosphere;
$(80 - 35) \times 60 = (1.89 - 0.70) \times L$;
$L = 2300\,\text{J g}^{-1}$; ***[4]***
*Award **[3 max]** for use of two powers and a reference to heat loss to atmosphere/environment to explain the difference in numerical values of L.*
*Award **[2 max]** for use of two powers and taking an average.*
*Award **[1 max]** for use of one power only.*

(c) (i) $\text{mass} = (650 - 350) \times 6 \times 1 = 1800\,\text{g}$; ***[1]***

(ii) $\text{energy} = 1.8 \times 4.2 \times 10^3 \times (100 - 18)$;
$= 6.2 \times 10^5\,\text{J}$ ***[1]***
Award mark for the substitution, not the final answer.

(iii) $\text{cost} = \frac{6.2 \times 10^5 \times 365 \times 3.5}{1.0 \times 10^6}$;
$= 790$ cents; ***[2]***

B2. Part 2 Force fields

(a) (i) *at A*: constant;
at B: decreasing; ***[2]***

(ii) field line gives the direction of the force (on mass or charge);
if lines touched (or crossed), particle would move in two directions at the same time and this is impossible; ***[2]***

(iii) pattern is the same in all four quadrants *i.e.* symmetry;
correct pattern in one quadrant;
field directions correct; ***[3]***

(b) (i) must be a force normal to direction of motion / some reference to circular motion;
so field is magnetic; $\left\{\right.$ *Do not award if there is no reasoning or reasoning is fallacious or misleading.* ***[2]***

(ii) particles are oppositely charged; ***[1]***

(iii) $r = \dfrac{mv}{Bq}$;
speed is decreasing / particle losing energy;
hence radius is decreasing; $\left\{\right.$ *Do not award if there is no reasoning or reasoning is fallacious or misleading.* ***[3]***

B3. Part 1 Wave phenomena

(a) (i) C shown where graph line cuts *x*-axis; ***[1]***

(ii) time period $= 0.30\,\text{ms}$;
use of $v = f\lambda$ <u>and</u> $f = \dfrac{1}{T}$ ***or*** $v = \dfrac{\lambda}{T}$;
$\lambda = 380 \times 0.30 \times 10^{-3} = 0.11\,\text{m}$; ***[3]***
ECF if time period misread.

(b) (i) superposition of two waves / *OWTTE*;
of same frequency and amplitude travelling in opposite directions; ***[2]***

(ii) stationary/standing wave is set up in the tube;
heaps form at the (displacement) nodes / powder pushed away from antinodes; ***[2]***

(iii) wavelength $= (2 \times 9.3 =)\, 18.6\,\text{cm}$;
speed $= (1800 \times 0.186 =)\ 330\,\text{m}\,\text{s}^{-1}$; ***[2]***
ECF if value of wavelength wrong.

(c) heaps further apart means longer wavelength;
hence speed increases (as temperature rises); $\Big\{$ *Do not award if there is no reasoning or reasoning is fallacious or misleading.* ***[2]***

(d) (i) when two waves meet;
resultant <u>displacement</u> found by summing individual displacements;
to give maximum displacement / displacement greater than that of an individual wave; ***[3]***

(ii) line in correct position, labelled C; ***[1]***

(iii) line in correct position, labelled D; ***[1]***

(e) use of $\lambda = \dfrac{ax}{D}$ and $a = 4.0 \times 10^{-2}\,\text{m}$;

$$\lambda = \frac{4.0 \times 10^{-2} \times 1.2}{1.5};$$

$\lambda = 3.2 \times 10^{-2}\,\text{m}$; ***[3]***
ECF if value of "a" wrong ***[2 max]***.

B3. Part 2 Nuclear decay

(a) emission of particles and/or e.m. radiation from unstable nucleus;
not affected by temperature/environment / is spontaneous process;
constant probability of decay (per unit time) / is random process;
activity/number of unstable nuclei in sample reduces exponentially;
daughter nucleus is (energetically) more stable; ***[3 max]***

(b) (i) fission; ***[1]***

(ii) **N.B.** *positions may be marked on line or on x-axis.*
U shown near right-hand end of line;
Sr and Xe shown between U and the peak with Sr to the left of Xe; ***[2]***

(iii) total binding energy of uranium $= 1189 + 784.8 - 187.9$;
$= 1785.9\,\text{MeV}$;

binding energy per nucleon $= \left(\frac{1785.9}{235} = \right) 7.60\,\text{MeV}$; ***[3]***

Allow unit as MeV or MeV per nucleon.
Accept answer in Joules e.g. $1.22 \times 10^{-12}\,J$.

(iv) binding energy is zero because neutrons are separate particles; ***[1]***

B4. Part 1 Gravitation

(a) (i) direction is changing and so there is an acceleration;
there must be a resultant force on the satellite / force is provided by gravitational attraction; ***[2]***

(ii) object and satellite have the same acceleration;
acceleration is towards centre of planet;
so no reaction force between object and satellite; ***[3]***

(b) (i) potential energy $\frac{-(GMm)}{(R+h)}$; ***[1]***

(ii) in orbit, $\frac{mv^2}{(R+h)} = \frac{(GMm)}{(R+h)^2}$ ***or*** expressed in words;
use of $E_K = \frac{1}{2}mv^2$;
$E_K = \frac{\frac{1}{2}(GMm)}{(R+h)}$; ***[3]***

(c) (total energy = potential energy + kinetic energy)
total energy is $\frac{-(GMm)}{2(R+h)}$;
as total energy is reduced, $\frac{(GMm)}{2(R+h)}$ increases;
hence h decreases; $\left\{\right.$ *Do not award if there is no reasoning or reasoning is fallacious or misleading.*
E_K increases and v increases; ***[4]***

(d) friction reduces the total energy of the satellite;
causing height to decrease and speed to increase;
less height, greater frictional force;
because atmosphere denser;
frictional force causes heating effect;
as height decreases heating effect increases / heats up more;
if satellite small, sufficient heating to cause destruction; ***[4 max]***
Do not allow "heats up as height decreases".

B4. Part 2 Linear and circular motion

(a) (i) spacing of the dots is increasing / *OWTTE*; ***[1]***

(ii) three further dots;
spacing increases by two squares between any two dots; ***[2]***

(iii) $\text{distance} = 37.6\,\text{m}$; ***[1]***

(b) (i) travels $(2.2 \times 4 =)\ 8.8\,\text{m}$ between drops;
$\text{speed} = \left(\frac{8.8}{0.80} =\right) 11\,\text{m s}^{-1}$; ***[2]***

(ii) in each $0.80\,\text{s}$, speed increases by $\frac{(0.4 \times 4)}{0.80} = 2.0\,\text{m s}^{-1}$;
$\text{acceleration} = \left(\frac{2.0}{0.80} =\right) 2.5\,\text{m s}^{-2}$; ***[2]***

or

in (2×0.80) seconds, distance traveled is $3.2\,\text{m}$;
$a = \frac{2(\Delta s)}{t^2} = \frac{2 \times 3.2}{(1.6)^2} = 2.5\,\text{m s}^{-2}$;
Allow a different choice of appropriate time interval to give correct answer.

(c) (i) friction force between tyres and road;
acts towards centre of circle; ***[2]***

(ii) centripetal force provided by friction between passenger and seat;
this force is below centre (of gravity) of person;
so causes a turning effect on the person;
hence upper part of body moves “outwards”; ***[3 max]***

or

centripetal force provided by friction between passenger and seat;
so, (initially) causes a turning effect on the lower part of the body;
by inertia upper body continues in a straight line;
hence upper part of the body moves “outwards”;