MARKSCHEME

NOVEMBER 2004

PHYSICS

Standard Level

Paper 2

General Marking Instructions

Subject Details: Physics SL 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 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.
- 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.

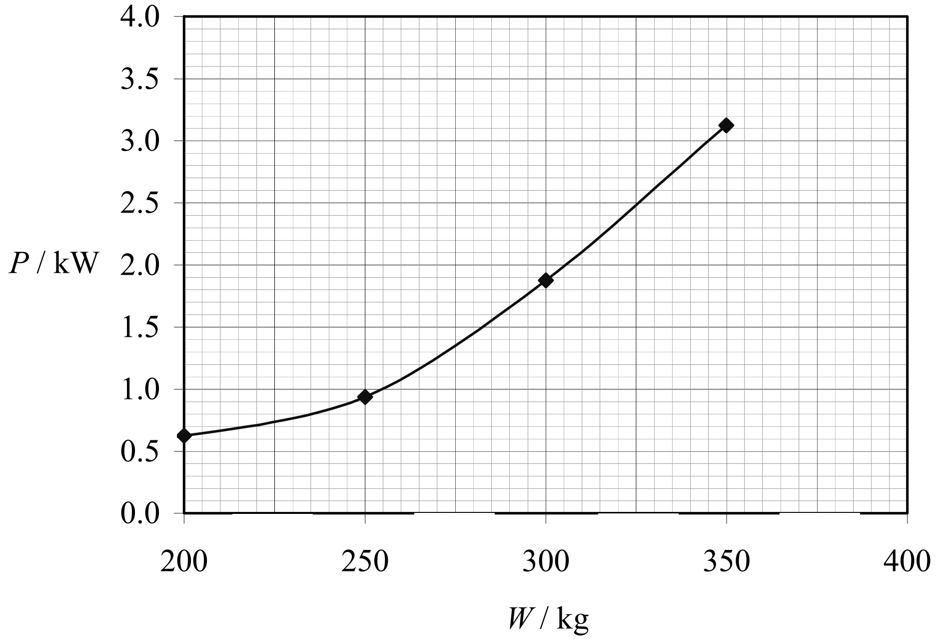
SECTION A

A1. (a) (i) 2.0 kW; (± 0.10 kW) ***[1]***

(ii) $F = \frac{P}{v}$;

$= 1000\,\mathrm{N}$; (± 50 N) ***[2]***

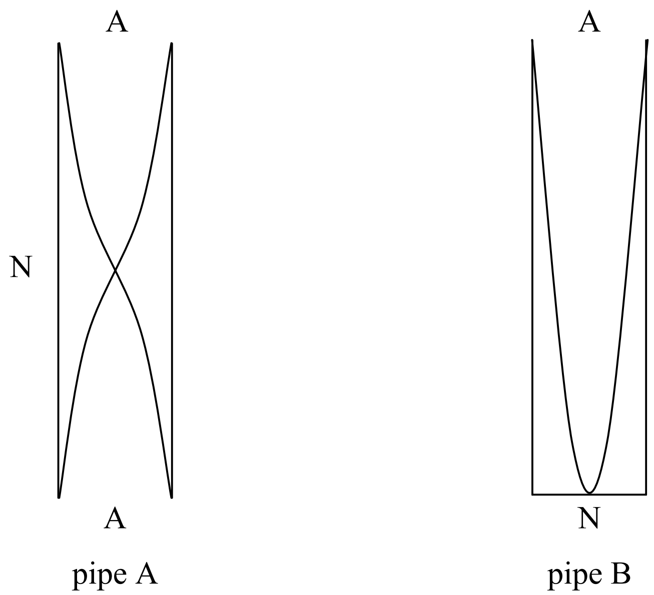
(b) (i)



sensible use of grid and suitable P scale; *(at least half of grid used)*
labelled P axis with correct units;
data point (200, 0.65);
data point (250, 0.95);
data points (300, 1.9), (350, 3.1);
Allow ± 0.2 kW.
line of best fit; ***[6]***

(ii) 2.6 kW; (±0.1 kW) *(watch for ecf)* ***[1]***

A2. (a)



(i) correct wave shape for pipe A;
correct wave shape for pipe B; ***[2]***

(ii) correct marking of A and N for pipe A;
correct marking of A and N for Pipe B; ***[2]***

(b) (i) for pipe A, $\lambda = 2L$, where L is length of the pipe;
$c = f\lambda$ to give $L = \dfrac{c}{2f}$;
substitute to get $L = 0.317$ m; ***[3]***

(ii) for 32 Hz, the open pipe will have a length of about 5 m;
whereas the closed pipe will have half this length, so will not take up as much space as the open pipe / *OWTTE*; ***[2]***
*The argument does not have to be quantitative. Award **[1]** for recognition that low frequencies mean longer pipes and **[1]** for the same frequency, closed pipes will be half the length of open pipes. The fact they need less space can be implicit.*

A3. (a) (i) $h = \frac{v^2}{2g}$;

to give $h = 3.2\,\text{m}$; ***[2]***

(ii) 0.80 s; ***[1]***

(b) time to go from top of cliff to the sea $= 3.0 - 1.6 = 1.4\,\text{s}$;

recognise to use $s = ut + \frac{1}{2}at^2$ with correct substitution, $s = 8.0 \times 1.4 + 5.0 \times (1.4)^2$;

to give $s = 21\,\text{m}$; ***[3]***

Answers might find the speed with which the stone hits the sea from $v = u + at$*, (*$42\,\text{m}\,\text{s}^{-1}$*) and then use* $v^2 = u^2 + 2as$.

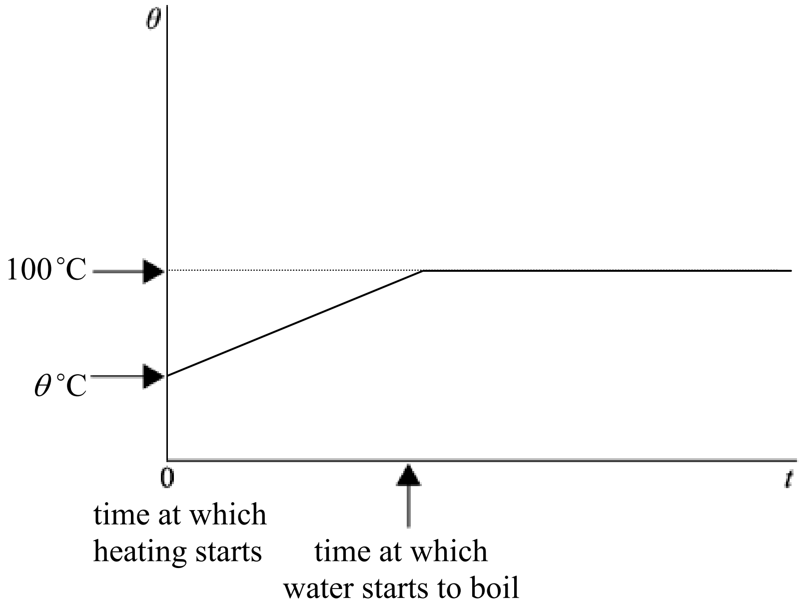
SECTION B

B1. Part 1 Specific heat capacity and specific latent heat

(a) specific heat capacity is the amount of energy required to raise the temperature of unit mass through 1 K; ***[1]***

(b) raising the temperature means increasing the KE of the molecules;
there are different numbers of molecules of different mass in unit mass of aluminium and water (accept different densities) and therefore different amounts of energy will be needed / *OWTTE*; ***[2]***

(c) (i)



general shape (but constant θ range must be clear); ***[1]***

(ii) $\theta \rightarrow 100\,^{\circ}\text{C}$:
the KE of the molecules is increasing;

$100\,^{\circ}\text{C}$:
when the water starts to change phase, there is no further increase in KE;
the energy goes into increasing the PE of the molecules;
so increasing their separation;
until they are far enough apart to become gas / their molecular bonds are broken / until they are effectively an infinite distance apart / *OWTTE*; ***[5]***

(d) (i) total energy supplied $= 400 \times 600 = 2.4 \times 10^{5}$ J ; ***[1]***

(ii) energy required to raise temperature of water $= 0.30 \times 80 \times 4.2 \times 10^{3} = 1.0 \times 10^{5}$ J ;
energy available to convert water to steam $= (2.4 - 1.0) \times 10^{5} = 1.4 \times 10^{5}$ J ;
mass of water converted to steam $= \dfrac{(1.4 \times 10^{5})}{2.3 \times 10^{6}} \approx 60\,\text{g}$; ***[3]***

(iii) energy is lost to the surroundings *(must specify where the energy is lost)* / water might bubble out of pan whilst boiling / anything sensible; ***[1 max]***

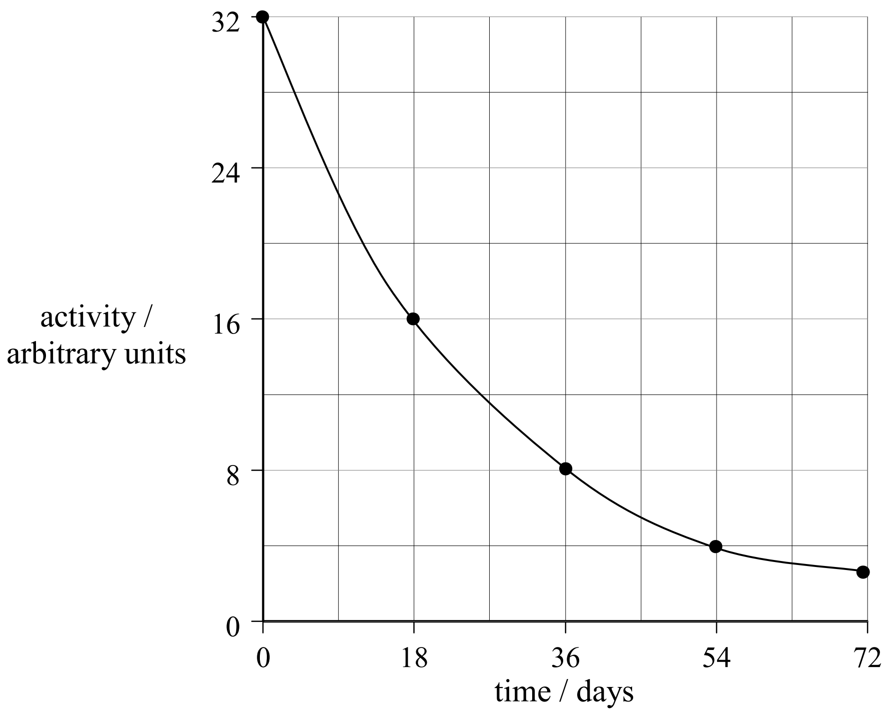
Part 2 Radioactivity and nuclear energy

(a) (i) isotope: nuclei of elements with different number of neutrons; *[1]*
Accept same Z different A / OWTTE.

(ii) time for the activity to halve in value / time for the number of nuclei to transmute to nuclei of another element / *OWTTE*; *[1]*

(b) (i) ${}^{227}_{86}\mathrm{Ac} \rightarrow {}^{227}_{90}\mathrm{Th} + \beta^{-}(\mathrm{e}^{-})$; *[1]*

(ii)



correct data points;
sensible attempt at line of best fit; *[2]*

(iii) 5.0 (±1); *[1]*

(iv) Geiger tube plus counter;
count for given time and divide count by time to get activity; *[2]*
Or if candidates use Geiger tube plus ratemeter, ***[1]*** *then some other detail is needed such as source must be placed close to the GM tube* ***[1]****.*

(c) mass defect $= 227.0278 - (223.0186 + 4.0026) = 0.0066\,\mathrm{u}$;
$= 6.148\,\mathrm{MeV\,c^{-2}}$;
therefore energy of $\gamma = 6.148 - 5.481 = 0.667\,\mathrm{MeV}$; *[3]*

B2. Part 1 Estimating energy changes for an escalator

(a) ***Note****: for part (i) and (ii) the answers in brackets are those arrived at if 19.3 is used as the value for the height.*

(i) height raised $= 30\sin 40 = 19\,\text{m}$;
gain in $\text{PE} = mgh = 700 \times 19 = 1.3 \times 10^4\ \text{J}\ (1.4 \times 10^4\ \text{J})$; ***[2]***

(ii) $48 \times 1.3 \times 10^4\ \text{J} = 6.2 \times 10^5\ \text{J}\ (6.7 \times 10^5\ \text{J})$; ***[1]***

(iii) the people stand still / don't walk up the escalator
their average weight is 700 N / ignore any gain in KE of the people; ***[1 max]***

(b) power required $= \dfrac{(6.2 \times 10^5)}{60} = 10\,\text{kW}\ (11\,\text{kW})$;

$Eff = \dfrac{P_{\text{out}}}{P_{\text{in}}},\ P_{\text{in}} = \dfrac{P_{\text{out}}}{Eff}$;

$P_{\text{in}} = 14\ \text{kW}\ (16\ \text{kW})$; ***[3]***

Part 2 Electric circuits

(a) (i) when connected to a 3 V supply, the lamp will be at normal brightness;
and energy is produced in the filament at the rate of 0.60 W;
Look for the idea that 3 V is the operating voltage and the idea of energy transformation.
or
when connected to a 3 V supply, the lamp will be at normal brightness;
and the resistance of the filament is 15 Ω / the current in the filament is $0.20\,\text{A}$; ***[2 max]***

(ii) $I = \dfrac{P}{V}$;
to give $I = 0.20\,\text{A}$; ***[2]***

(b) (i) at maximum value, the supply voltage divides between the resistance of the variable resistor, internal resistance and the resistance of the filament;
i.e. response must show the idea of the voltage dividing between the various resistances in the circuit. Do not penalise if responses do not mention internal resistance here.
at zero resistance, the supply voltage is now divided between the filament resistance and the internal resistance of the supply; ***[2]***

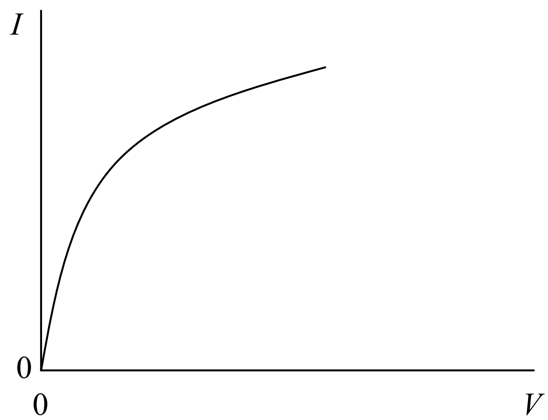
(ii) when resistance of variable resistor is zero, $\text{e.m.f.} = Ir + V_{\text{lamp}}$;
$3.0 = 0.2r + 2.6$;
to give $r = 2.0\,\Omega$; ***[3]***

(c) (i) $3.3\,\Omega$; ***[1]***

(ii) $13\,\Omega$; ***[1]***

(d) at the higher pd, greater current and therefore hotter;
the resistance of a metal increases with increasing temperature;
OWTTE; ***[2 max]***

(e)



correct approximate shape (*i.e.* showing decreasing gradient with increasing *V*); ***[1]***

(f) parallel resistance of lamp and YZ is calculated from $\frac{1}{R}=\frac{1}{4}+\frac{1}{12}$;

to give $R = 3.0\,\Omega$;

3.0 V therefore divides between $3.0\,\Omega$ and $12.0\,\Omega$;

to give pd across the lamp $= 0.60\,\text{V}$;

Give relevant credit if answers go via the currents i.e.

calculation of total resistance $= 15.0\,\Omega$;

total current $= 0.20\,\text{A}$;

current in lamp $= 0.15\,\text{A}$;

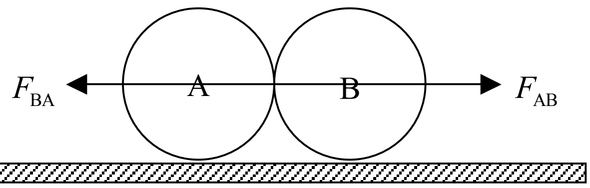
pd across lamp $= 0.15 \times 4 = 0.60\,\text{V}$; ***[4 max]***

B3. Part 1 Conservation of momentum and energy

(a) when two bodies A and B interact, the force that A exerts on B is equal and opposite to the force that B exerts on A;
or
when a force acts on a body an equal an opposite force acts on another body somewhere in the universe; ***[1 max]***
*Award **[0]** for "action and reaction are equal and opposite" unless they explain what is meant by the terms.*

(b) if the net external force acting on a system is zero;
then the total momentum of the system is constant (or in any one direction, is constant); ***[2]***
*To achieve **[2]** answers should mention forces and should show what is meant by conserved. Award **[1 max]** for a definition such as "for a system of colliding bodies, the momentum is constant" and **[0]** for "a system of colliding bodies, momentum is conserved".*

(c)



arrows of equal length;
acting through centre of spheres;
correct labelling consistent with correct direction; ***[3]***

(d) (i) *Ball B:*
change in momentum $= Mv_B$;
hence $F_{AB}\Delta t = Mv_B$; ***[2]***

(ii) *Ball A:*
change in momentum $= M(v_A - V)$;
hence from Newton 2, $F_{BA}\Delta t = M(v_A - V)$; ***[2]***

(e) from Newton 3, $F_{AB} + F_{BA} = 0$, ***or*** $F_{AB} = -F_{BA}$;
therefore $-M(v_A - V) = Mv_B$;
therefore $MV = Mv_B + Mv_A$;
that is, momentum before equals momentum after collision such that the net change in momentum is zero (unchanged) / *OWTTE*; ***[4]***
Some statement is required to get the fourth mark i.e. an interpretation of the maths result.

(f) from conservation of momentum $V = v_B + v_A$;
from conservation of energy $V^2 = v_B{}^2 + v_A{}^2$;
if $v_A = 0$, then both these show that $v_B = V$;
or
from conservation of momentum $V = v_B + v_A$;
from conservation of energy $V^2 = v_B{}^2 + v_A{}^2$;
so, $V^2 = (v_B + v_A)^2 = v_B{}^2 + v_A{}^2 + 2v_A v_B$ therefore v_A has to be zero; ***[3 max]***
Answers must show that effectively, the only way that both momentum and energy conservation can be satisfied is that ball A comes to rest and ball B moves off with speed V.

Part 2 Electric charge at rest

(a) the force exerted per unit charge;
on a small positive (test) charge; ***[2]***
Accept either "small" or "test" or both.

(b) (i) substitute for $r = a\sqrt{2}$;
into $E = \dfrac{kQ}{r^2}$ to get $E = \dfrac{kQ}{2a^2}$; ***[2]***

(ii) $\downarrow$; ***[1]***

(iii) E for each component $= \dfrac{kQ}{a^2}$;
add vectorially;
to get $E_{tot} = \sqrt{2}\,\dfrac{kQ}{a^2}$; ***[3]***
*Award **[1]** if not added vectorially i.e.* $E_{tot} = 2\dfrac{kQ}{a^2}$