INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
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# MARKSCHEME

## November 2001

## PHYSICS

## Higher Level

## Paper 2

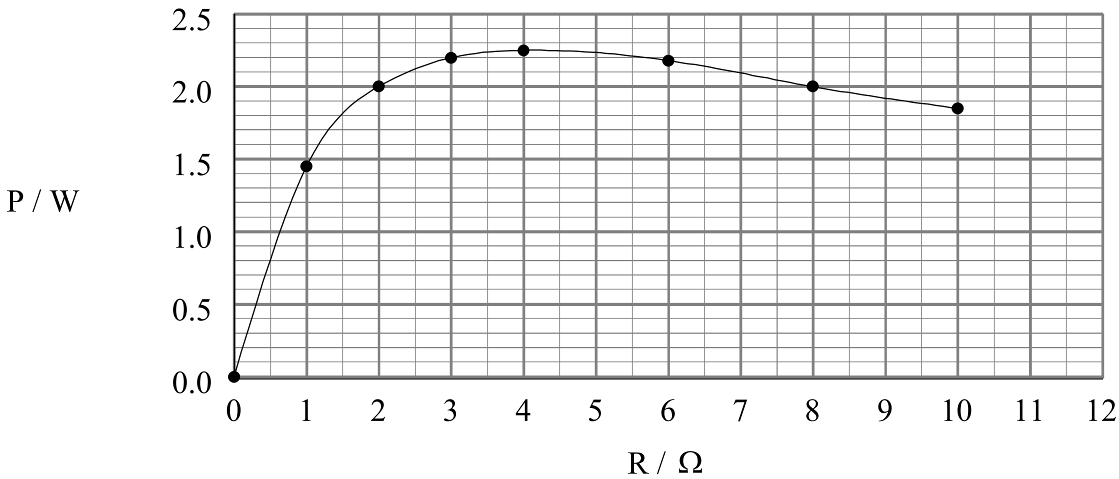
18 pages

## SECTION A

**A1.** (a) recognise to use $P = I^2R$; ***[1]***
correct substitution to give $P$ = 1.8 W; ***[1]***
***[2 max]***

(b) error in $I^2 = 4\,\%$; ***[1]***
error in $I^2R = 14\,\%$; ***[1]***
therefore absolute uncertainty = ± 0.3 W; ***[1]***
***[3 max]***

(c)




labelled axes with correct units; ***[1]***
suitable scale *(should fill at least half the grid)*; ***[1]***
data points *(zero point must be included)*; ***[1]***
best fit line; ***[1]***
***[4 max]***

(d) 4 Ω ( ± 1Ω) ***[1 max]***

(e) yes; ***[1]***
because of the large error in determining the actual maximum of the graph; ***[1]***
OWTTE;
***[2 max]***

**A2.** (a) (i) use $v = \sqrt{2gh}$ to get 4.0 m s$^{-1}$ ***[1 max]***

(ii) use $v = \sqrt{2gh}$ to get 3.5 m s$^{-1}$ ***[1 max]***

(iii) $\Delta p = m\Delta v = 0.2 \times 7.5$; ***[1]***
= 1.5 N s; ***[1]***
*(Award **[1]** for 0.1 N s and use e.c.f. in (b) below.)*

***[2 max]***

(b) (i) the total change in momentum *(accept impulse)* ***[1 max]***

(ii) total momentum = $\frac{1}{2}50 \times \Delta t = 1.5$ N s; ***[1]***
to give $\Delta t = 0.06$ s; ***[1]***
*e.c.f. from above gives $\Delta t = 0.004$ s;*

***[2 max]***

**A3.** (a) combine $F = mg_0 = G\frac{Mm}{{R_p}^2}$; ***[1]***

$GM = g_0{R_p}^2$; ***[1]***

substitute in $V = -G\frac{M}{R}$ to get $V = -\frac{g_0{R_p}^2}{R}$; ***[1]***

***[3 max]***

(b) (i) from the graph when $R = 2.5\times10^6$ m, $V = -9.8(\pm0.2)\times10^6$ J kg$^{-1}$; ***[1]***

substitute into $g_0 = \frac{V}{R_p}$ to give $g_0 = 3.9\,\mathrm{m\,s^{-2}}\left(\pm0.3\,\mathrm{m\,s^{-2}}\right)$; ***[1]***

***[2 max]***

(ii) distance from the centre $= 5.5\times10^6$ m
and ;$V$ at $5.5\times10^6\ \mathrm{m} = 4.2\times10^6\ \mathrm{J\,kg^{-1}}$ ***[1]***
change in potential $= (9.8-4.4)\times10^6\ \mathrm{J\,kg^{-1}} = 5.4(\pm0.4)\times10^6\ \mathrm{J\,kg^{-1}}$; ***[1]***
gain in PE of satellite $= 3000\times5.6\times10^6\ \mathrm{J\,kg^{-1}}$; ***[1]***
$= 1.7\times10^{10}$ J;
*If they use $3.0\times10^6$ m from the centre the answer is $5.4\times10^9$ J.*
*(Award **[2]** out of **[3]** for this answer.)*

***[3 max]***

**A4.** (a) $^{14}_{7}\text{N} + ^{1}_{0}\text{n} = ^{14}_{6}\text{C} + ^{1}_{1}\text{H}$ ***[1 max]***

(b) (i) since C-14 is radioactive it will transmute to another element OWTTE ***[1 max]***

(ii) use $A = A_0 e^{-\lambda t}$; ***[1]***

$$\lambda = \frac{0.7}{5600};$$ ***[1]***

$$t = \frac{5600}{0.7}\log_e \frac{13.2}{15.5};$$ ***[1]***

to give $t = 1300$ years; ***[1]***

Alternatively,

use $A = A_0 e^{-\lambda t}$ ***[1]***

$$\frac{A_0}{A} = e^{\lambda t} = \frac{15.5}{13.2} = 1.17;$$ ***[1]***

$$\lambda t = 0.16, \lambda t_{\frac{1}{2}} = \ln 2 = 0.69;$$ ***[1]***

$$t = \frac{0.16}{0.19} \times 5600 = 1300 \text{ years};$$ ***[1]***

*Whichever method, essentially award **[1]** for the right equation, **[2]** for a reasonable attempt at the arithmetic, and **[1]** for the correct answer.*

*If they try and attempt to answer by estimating the fraction of half-lives $\frac{2.3}{7.75} \times 5600 = 1700$ years then award a maximum of **[2]** - **[1]** for the idea and **[1]** for the 'correct' arithmetic.*

***[4 max]***

(c) the coal is 'older' than several half-lifes; ***[1]***
so activity is too weak to detect; ***[1]***
OWTTE;

***[2 max]***

## SECTION B

**B1. Part 1**

(a) (i) 400 g **[1 max]**

(ii) $Q = m\text{L} = 0.4 \times 2.3 \times 10^6$ (*i.e.* formula and correct substitution) **[1]**
$= 9.2 \times 10^5$ J ; **[1]**
**[2 max]**

(iii) rate $= \dfrac{\text{energy}}{\text{time}}$; **[1]**
$= \dfrac{9.2 \times 10^5}{900}$; **[1]**
$\simeq 1000$ W
**[2 max]**

(iv) because of all the energy losses to the surroundings OWTTE; **[1 max]**

(b) use $\dfrac{dQ}{dt} = -kA\dfrac{d\theta}{dx}$; **[1]**

correct substitution $1000 = \dfrac{200 \times 5 \times 10^{-2} \times d\theta}{6 \times 10^{-3}}$; **[1]**
to give $d\theta = 0.6\,^{\circ}\text{C}$; **[1]**
**[3 max]**

(c) Any sensible discussion of appropriate physics *e.g.* **[2]**
only a small amount of the base is actually in contact with the burner;
so there will be a layer of air between the burner and the base that accounts for most of the temperature drop (*or air is a poor conducto*r)
aluminum is a good conductor
flame has to be a higher temperature than base for energy transfer to take place;
**[2 max]**

(d) energy supplied to water $= 1000 \times 315$ J ; **[1]**
energy used to heat water $= 4200 \times 70$; **[1]**
and aluminium $= 0.25 \times s \times 70$ ; **[1]**
therefore $s = \dfrac{(1000 \times 315 - 4200 \times 70)}{(0.25 \times 70)} = 1200\,\text{J kg}^{-1}\,\text{K}^{-1}$; **[1]**
**[4 max]**

**B1. Part 2**

(a) no change; *[1]*
because temperature is constant; *[1]*
***[2 max]***

(b) 450 J; *[1]*
since there is no change in $dU$ then $dQ=dW$; *[1]*
OWTTE;
***[2 max]***

(c) $\Delta W = p\Delta V$; *[1]*
$p = 10^5, \Delta V = 3\times10^{-3}$; *[1]*
therefore $\Delta W = 300\,\text{J}$; *[1]*
***[3 max]***

(d) from $\Delta Q = \Delta U + \Delta W, -800 = \Delta U - 300$; *[1]*
to give $\Delta U = -500\,\text{J}$; *[1]*
*Note that the negative sign is necessary (or 'decreased by') so deduct* ***[1]*** *if no negative sign.*
***[2 max]***

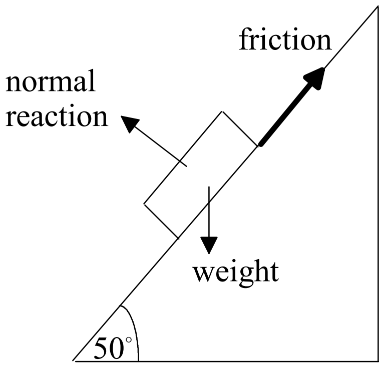
(e) the work done is zero; *[1]*
therefore energy absorbed is equal to change of internal energy from $\text{Y} \rightarrow \text{Z} = 500\,\text{J}$; *[1]*
***[2 max]***

(f) net work done by the gas; *[1]*
$= 0.5\times10^5 \times 3\times10^{-3} = 150\,\text{J}$; *[1]*
***[2 max]***

(g) total work done = 150 J, total energy absorbed = 950 J; *[1]*
$Eff = \frac{150}{950} = 0.16$; *[1]*
or by $Eff = \frac{Q_H - Q_C}{Q_H}$; *[1]*
$= \frac{(950-800)}{950} = 0.16$; *[1]*
***[2 max]***

**B2. Part 1**

(a)




*[1]* for each correctly drawn and named force ***[3 max]***

(b) (i) calculation of acceleration from $a = \frac{2s}{t^2}$; ***[1]***

to give $a = 2.47 \text{ m s}^{-2}$; ***[1]***

***[2 max]***

(ii) component of weight down the plane $= M\,g \sin 50^\circ$ ***[1]***

$= 7.51M$ ***[1]***

*(Do not penalise for omission of unit)*

***[2 max]***

(c) $F = \mu_k N$; ***[1]***

$= \mu_k Mg \cos 50^\circ = 6.31M\mu_k$ ; ***[1]***

*(Do not penalise for omission of unit)*

***[2 max]***

(d) accelerating force $= M\left(7.51 - 6.31\mu_k\right)$; ***[1]***

$= M \times 2.47$ (mass $\times$ acceleration) ***[1]***

to give $\mu_k = 0.80$; ***[1]***

***[3 max]***

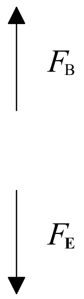
(e) recognise that $\mu_s = \tan\theta$; ***[1]***

to give $\mu_s = 0.84$; ***[1]***

***[2 max]***

**B2. Part 2**

(a)




electric; ***[1]***
magnetic; ***[1]***
***[2 max]***

(b) (i) electric force $F_E = qE$ ***[1 max]***

(ii) magnetic force $F_B = Bqv$ ***[1 max]***

(c) for no deflection $F_E = F_B$; ***[1]***

to give $v = \dfrac{E}{B}$; ***[1]***
***[2 max]***

(d) (i) at any point along the path the magnetic force is at right angles to the velocity of the ion; ***[1]***
and the speed of the ion is constant; ***[1]***
OWTTE;
*e.g. 'there is a force acting at right angles to the velocity of the ion and this will produce a constant centripetal acceleration since the velocity is constant'.*
*An answer such as 'the force is at right angles' would be worth **[1]**. Look for a bit more detail for **[2]**.*
***[2 max]***

(ii) $Bqv = \dfrac{Mv^2}{r}$; ***[1]***

to give $r = \dfrac{Mv}{Bq}$; ***[1]***
***[2 max]***

(e) diagram should show:

ion source and ion accelerator; ***[1]***
velocity selector; ***[1]***
region of uniform magnetic field; ***[1]***
separation of paths of isotopes; ***[1]***

description should:

mention the principle of crossed fields for velocity selection; ***[1]***
the reason for velocity selection *i.e.* $r$ will depend only on $M$; ***[1]***

*The diagram and description should be taken together and the marks need not necessarily be apportioned* ***[4]*** + ***[2]***. *The above scheme essentially shows what should be mentioned to get full marks.*

***[6 max]***

**B3. Part 1**

(a) let $d = \mathrm{k}v^2$; *[1]*
choose $v = 20,\ d = 60$ to give $\mathrm{k} = 0.15$; *[1]*
choose $v = 30,\ d = 135$ to give $\mathrm{k} = 0.15$; *[1]*
since k is the same $d$ is proportional to $v^2$; *[1]*
*(i.e. they should show that they understand the proportionality and then use **two** points to verify this proportionality.)*

***[4 max]***

(b) candidates could use a KE – work done argument or kinematic argument
*e.g.* $\Delta(\mathrm{KE}) = \frac{1}{2}mv^2 = Fd$; *[1]*
where $F$ is the braking force; *[1]*
if the braking force $F$ is constant then $d \propto v^2$; *[1]*

***or***

if $F$ is constant than $a$ is constant; *[1]*
so $v^2 = u^2 + 2ad$; *[1]*
$v = 0$ therefore $d \propto u^2$; *[1]*
***[3 max]***

(c) (i) from the graph $d = 60$ m; *[1]*
average speed $= 10\ \mathrm{m\,s^{-1}}$; *[1]*
$t = \frac{60}{10} = 6.0\,\mathrm{s}$; *[1]*

***or***

from the graph $d$=60 m; *[1]*
use $v^2 = u^2 + 2ad$ to give $a = 3.3\ \mathrm{m\ s^{-2}}$; *[1]*
use $v = u + at$ to give $t = 6.1$ s (6.0 s); *[1]*
***[3 max]***

(ii) use $v^2 = u^2 + 2ad$ to find $a$; *[1]*
to give $a = 3.3\ \mathrm{m\ s^{-2}}$; *[1]*
use $F = m\,a$ to give $F = 5000$ N; *[1]*
*If they have calculated a in (i) then this is easier for them!*

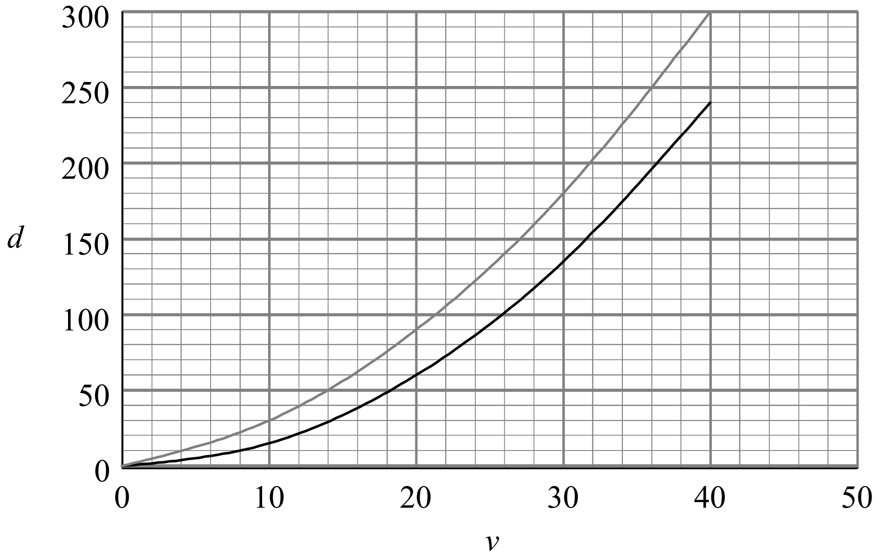
***or***

use $Fd = \frac{1}{2}mv^2$; *[1]*
$= \frac{1}{2}(1500)\times(20)^2$; *[1]*
to give $F = 5000$ N; *[1]*
***[3 max]***

(d) reaction time or thinking time; ***[1]***
explanation of what this is; ***[1]***
*(i.e. something like 'when a driver sees an incident that causes him to brake it takes some time before he reacts' receives **[2]** but just 'reaction time' receives **[1]**)*

***[2 max]***

(e)



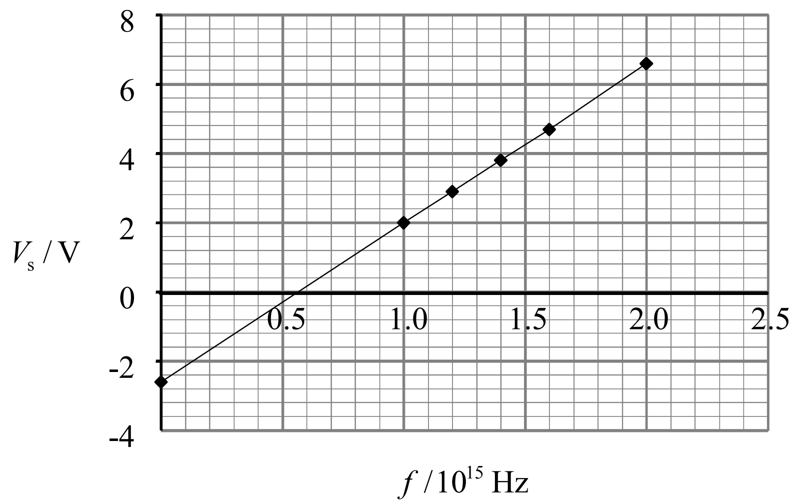

rough correct shape; ***[1]***
explanation: reaction time is constant; ***[1]***
therefore each point on the braking distance graph will be increased by an amount proportional to the speed; ***[1]***
OWTTE;

***[3 max]***

**B3. Part 2**

(a) *Answers will be open ended but a good answer should mention the following points:*
the Einstein theory says that light consists of photons and the energy of each photon is dependent on the frequency of the light; ***[1]***
a minimum amount of energy is required to remove an electron from a metal; ***[1]***
the frequency of red light is such that photons do not possess this minimum energy; ***[1]***
and so no electrons are emitted and no current will be registered; ***[1]***
UV photons have enough energy to emit electrons and so a current is registered; ***[1]***
***[4 max]***

(b)



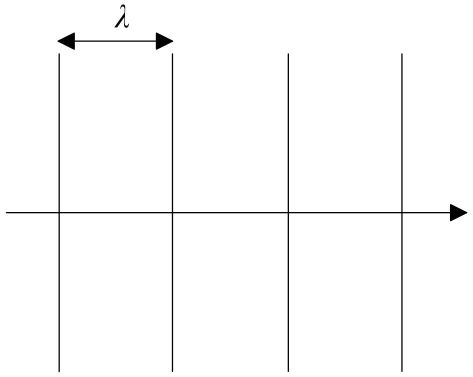

straight line graph ***[1 max]***
*(Do not deduct the mark if the graph has not been extrapolated to f = 0 but it must go to $V_s = 0$ for the mark.)*

(c) (i) recognise that $f_0$ is the intercept on the $f$ axis at $V_S = 0$; ***[1]***
$f_0 = 6.0\,(\pm 1.0) \times 10^{14}$ Hz; ***[1]***
***[2 max]***

(ii) recognise that the equation of the line is $Ve = hf - \phi$; ***[1]***
slope $= \frac{h}{e}$; ***[1]***
$= 4.1(\pm 0.3) \times 10^{-15}$
to give $h = 6.6(\pm 0.4) \times 10^{-34}$ J s; ***[1]***
***[3 max]***

(iii) work function found from $V$ intercept = 2.6 V ± 0.4V; ***[1]***
to give 2.6 eV (±0.4 eV); ***[1]***
*(Do not penalise for negative value)*
could also calculate from the value of $h$ above and $f_0$, $\phi = hf_0$; ***[1]***
= 2.6 eV; ***[1]***
***[2 max]***

**B4.** (a)




$\lambda$ on diagram ***[1 max]***

(b) $\lambda = 3$ cm ***[1 max]***

(c) (i) period = 0.1 s; ***[1]***
so in 0.05 s wavefront will move 1.5 cm (half a wavelength); ***[1]***
***[2 max]***

(ii) negative cosine graph ***[1 max]***

(d) each point on a wave front acts as a source of secondary 'wavelets'; ***[1]***
the envelope of waves from these point sources, in the forward direction, forms the new wave front; ***[1]***
OWTTE;
***[2 max]***

(d)

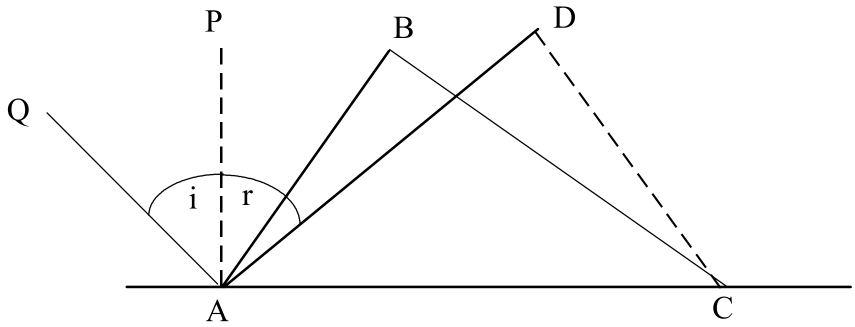



diagram should show incident angle $\angle$QAP and reflected angle $\angle$PAD correctly labelled; ***[1] + [1]***
and correct position of reflected wave front CD; ***[1]***
*explanation:* In the time that B reaches C the wavelet from A will have reached D; ***[1]***
since the waves travel in the same medium AD = BC; ***[1]***
and since $\angle ABC = \angle ADC = 90^\circ$; ***[1]***
then $\Delta ABC \equiv \Delta ADC$; ***[1]***
hence angle i = angle r; ***[1]***
(*i.e. clear diagram in conjunction with good explanation will receive* ***[8]****.)*
***[8 max]***

(e) (i) recognise that the refractive index is ratio of the speeds; ***[1]***
to give $n = 1.5$; ***[1]***
use $1.5 = \frac{\sin r}{\sin 35^\circ}$; ***[1]***
to give $r = 59^\circ$; ***[1]***
*(If they get i and r the wrong way round to give r = 22° then award **[2]** out of **[4]**.)*
***[4 max]***

(ii) the wave fronts will be totally reflected at the boundary; ***[1]***
since critical angle $= \sin^{-1}\left(\frac{1}{n}\right)$; ***[1]***
$= 42^\circ$; ***[1]***
hence waves are incident at an angle greater than the critical angle; ***[1]***
***[4 max]***

(f) (i) 3.35 m; ***[1]***
for destructive interference at Y the path difference between the waves must be half a wavelength (½ $\lambda$) ***[1]***
***[2 max]***

(ii) will decrease; ***[1]***
since $\lambda$ goes down; ***[1]***
and therefore path difference will be smaller; ***[1]***
OWTTE;
***[3 max]***

(iii) a sound of frequency 442 Hz; ***[1]***
with a beat frequency of 4 Hz; ***[1]***
*or something like 'a sound frequency 442 Hz which varies in intensity with a regular frequency of 4 Hz". Note that a qualitative answer scores zero marks.*
***[2 max]***