# MARKSCHEME

## May 2006

## PHYSICS

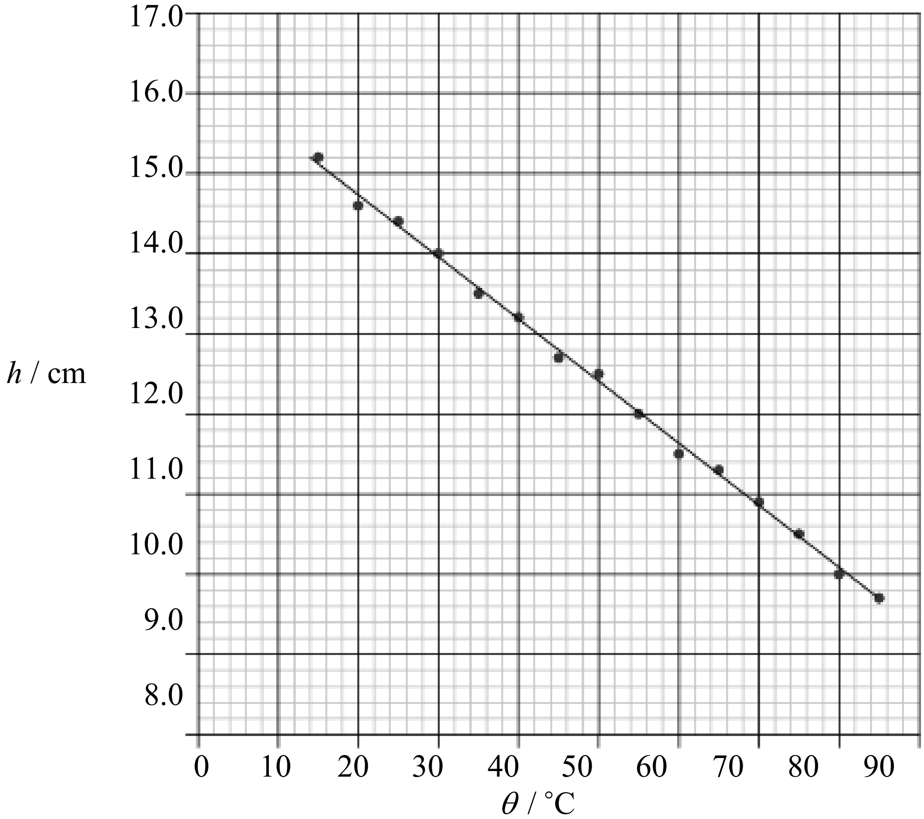
## Standard Level

## Paper 2

16 pages

**SECTION A**

**A1.** (a)




(i) sensible line of fit with reasonable distribution of points either side of line; ***[1]***

(ii) $h_0 = 16.2(\pm 0.2)\,\text{cm}$; ***[1]***

(b) this is a straight-line graph so has equation of the form $y = mx + c$;
$h = h_0(1 - k\theta)$ gives $h = h_0 - h_0 k\theta$;
$m = -h_0 k$;
$c = h_0$; ***[4]***
*essentially look for*:
*stating equation of a straight-line graph, showing that* $h = h_0(1 - k\theta)$ *can be written in this form, identifying m and c.*

(c) $k = \dfrac{\text{gradient}}{h_0}$; *If credit for* $m = -h_0 k$ *has not been given in* ($b$) *then it can be given if this statement is correct.*

gradient $= 0.077\ (\pm 0.003)$;

therefore, $k = \dfrac{0.077}{16.2}$;

$\approx 4.8 \times 10^{-3}\ \text{deg C}^{-1}$

***Or***

Allow use of a point on line of best fit i.e. choice of data point from line of best fit;
correct substitution into $h = h_0(1 - k\theta)$;
correct rearrangement essentially showing that $k = \dfrac{1}{\theta}(1 - \dfrac{h}{h_0})$; ***[3]***

*Accept range of answers for the gradient between* $4.9 \times 10^{-3}$ *and* $4.6 \times 10^{-3}$.

(d) *estimate*:

$h = \dfrac{\text{gradient}}{r}$;

gradient $= 1.5\,(\pm 0.2) \times 10^{-5}$;

$r = \dfrac{1.5 \times 10^{-5}}{25} = 6.0\,(\pm 0.8) \times 10^{-7}\ \text{m}$;

*comment*:
this is very small so it is unlikely that capillary action is the only mechanism / *OWTTE* / this assumes that the direct proportion holds for values of $h$ up to $25\ \text{m}$ / *OWTTE*; ***[4]***

*Accept ECF based on estimate only if comment is reasonable and consistent. If numerical value is correct, then award the mark for a plausible explanation (e.g. reference to molecular forces) as to why this is a reasonable value.*

**A2.** (a) there are no positions;
the lamp is effectively in series with $100\,\text{k}\Omega$ no matter what the position of S;
this means that the pd across it will always be close to zero (very small) / never reach 6 V;

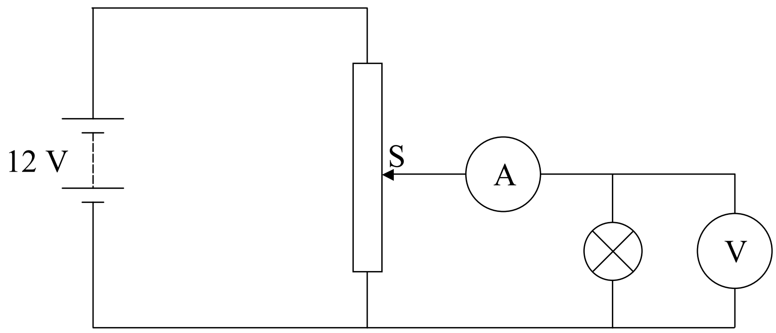
***Or***

there are no positions;
the resistance of the filament is much smaller that $100\,\text{k}\Omega$;
so (nearly) all the potential of the battery appears across the variable resistance; ***[3]***
*Award **[1]** max for correct answer with no argument or incorrect argument. Anthropomorphic answers such "battery has a lot of resistance to overcome" score **[1]** max. Must mention that voltmeter is effectively in series with battery to get full marks.*

(b) $I = \dfrac{V}{R}$;

$= \dfrac{12}{15} = 0.80\,\text{A}$; ***[2]***

(c)




correct position of ammeter;
correct position of voltmeter (either to the right <u>or</u> left of the lamp); ***[2]***

**A3.** (a) towards the centre of Earth; ***[1]***

(b) gravity/gravitational/centripetal; ***[1]***

(c) $T = 24 \times 3600 = 8.64 \times 10^4\,\text{s}$;

substitute into $a = \dfrac{4\pi^2 R}{T^2} = \dfrac{4\pi^2 \times 4.2 \times 10^7}{(8.64)^2 \times 10^8}$;

$= 0.23\,\text{m}\,\text{s}^{-2}$; ***[3]***

**SECTION B**

**B1.** (a) the amount of energy / heat required to raise the temperature of 1 kg of a substance through 1 K;

***Or***

Amount of energy needed to increase the temperature of a unit mass by one degree. ***[1]***

(b) the internal energy is the total energy of the molecules of a substance;
the greater the specific heat (the more energy required to raise unit mass through 1 K this) means that to increase the temperature by the same amount, more energy most be given to substance A than to substance B (so internal energy is greater) / *OWTTE*; ***[2]***
*Award **[0]** for correct answer with incorrect or no explanation.*

(c) (i) so that the metal reaches the temperature of the boiling water; ***[1]***

(ii) $Q_{\mathrm{M}}$ = mass of metal × specific heat capacity of metal × fall in temperature of metal; ***[1]***

(iii) $Q_{\mathrm{W}}$ = mass of water × specific heat capacity of water × rise in temp of water; ***[1]***

(iv) because energy is lost to the surroundings; ***[1]***

(d) (i) (energy is transferred) by conduction through the insulation of the element / *OWTTE*;
(energy is then transferred) by the bulk motion of the water / convection through the water / *OWTTE*;
the element will also radiate some energy which will be absorbed by the water / *OWTTE*; ***[3]***

(ii) energy supplied by heater in $1\,\mathrm{s} = 7.2\times10^{3}\,\mathrm{J}$;
energy per second = mass per second × sp ht × rise in temperature;
$7.2\times10^{3}$ = mass per second $\times 4.2\times10^{3}\times 26$;
to give mass per second = 0.066 kg / flow rate = 0.066kg $\mathrm{s}^{-1}$; ***[4]***

(iii) energy is lost to the surroundings;
flow rate is not uniform; ***[2]***
*Do not allow "the heating element is not in contact with all the water flowing in the unit". Accept answers that imply that there will be a temperature gradient between element and wall of pipe. Do not accept answers such as "element will not heat water uniformly".*

(iv) $P = VI, I = \frac{P}{V}$;

$= \frac{7.2\times10^{3}}{240} = 30\,\mathrm{A}$; ***[2]***

(v) when operating at $7.2\,\text{kW}$ the element is at a higher temperature / hotter than when first switched on;
therefore, resistance is greater (and so current is smaller) / *OWTTE*;

***Or***

element is cold / *OWTTE* when first switched on;
therefore, smaller resistance than when hot (and so current is larger); ***[2]***

(e) (i) $P = \frac{V^2}{R}$;

$\frac{240^2}{R_{240}} = \frac{110^2}{R_{110}}$;

$\frac{R_{110}}{R_{240}} = \left(\frac{110}{240}\right)^2$;

$= 0.21$

***Or***

from $P = VI$

$240I_2 = 110I_1$ to give $I_2 = \frac{11}{24}I_1$;

$I_2^{\ 2}\ R_2 = I_1^{\ 2}R_1$;

$\frac{R_1}{R_2} = \frac{I_2^{\ 2}}{I_1^{\ 2}} = \left(\frac{11}{24}\right)^2$;

$= 0.21$ ***[3]***

(ii) to get equivalent power, heating elements must have lower resistance;
therefore, they have to be physically larger so more expensive / take up more space;

***Or***

smaller voltage supply needs larger current;
so thicker cables therefore, more expensive / take up more space; ***[2]***

**B2. Part 1 Momentum**

(a) if the total (or net) external force acting on a system is zero / for an isolated system;
the momentum of the system is constant/momentum before collision equals momentum after collision; ***[2]***
*Award **[1]** for "momentum before (collision) = momentum after (collision)".*

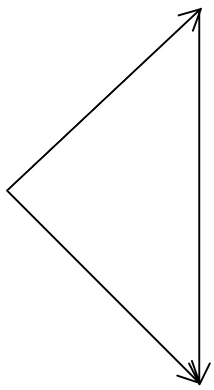
(b) (i) (a collision in which) kinetic energy is not lost / kinetic energy is conserved; ***[1]***

(ii) the momentum of the puck is not conserved since a force acts on it during collision / *OWTTE*;
the rink is attached to the Earth and momentum is given to the Earth such that the change in momentum of the puck is equal to the change in momentum of the Earth / *OWTTE*;

***Or***

the momentum of the Earth and puck are conserved / *OWTTE*;
the change in momentum of the puck is equal and opposite to the change in momentum of the Earth; ***[2]***
*This is a discussion so more than bald statements are required e.g. identification of system and some explanation.*

(c)



vector 5.0 cm long;
at right angles to initial vector as shown;
*By eye is sufficient.*
resultant vector as shown;
stated length $= 7.1(\pm 0.2)\,\text{cm}$ equivalent to $0.71(\pm 0.2)\,\text{N s}$;
*Length should be checked.*

***Or***

Second vector at right angles to first;
And of equal length;
Difference shown as a vertical vector;
Of magnitude $\sqrt{0.5^2+0.5^2}$ ;
$=0.71\ \text{N s}$ ***[4]***

*Caution: Many students are obtaining instead the <u>sum</u> of the two momenta rather than the difference. In this case the numerical answer is the same for the magnitude so watch out.*

(d) $F=\dfrac{\Delta p}{\Delta t}=\dfrac{0.71}{12\times10^{-3}}=59\ \text{N}$ ;
this is the average force and from the graph it can be seen that $F=2F_{\text{av}}$ ;
therefore, $F=120\ \text{N}$ ;

***Or***

area under graph is $\Delta p=0.71\ \text{N s}$ ;
area is $\dfrac{1}{2}F_{\max}\Delta t$ ;
and so $F_{\max}=\dfrac{2\times0.71}{12\times10^{-3}}=120\ \ \text{N}$ ; ***[3]***

**Part 2 Radioactive decay**

(a) (i) isotopes of elements are chemically identical but have different atomic masses / *OWTTE* / same number of protons in the nucleus but different number of neutrons / *OWTTE*; ***[1]***

(ii) the time it takes for the activity to halve / the time it takes for half the number of radioactive atoms to decay / *OWTTE*; ***[1]***

(iii) proton/ ${}^{1}_{1}\mathrm{H} / \mathrm{p}^{+}$; ***[1]***

(b) (i) no more C-14/carbon dioxide is taken in when a tree is dead;
the amount of C-14 determines the activity (of the charcoal);
since C-14 is radioactive the amount present (in the charcoal) decreases with time / *OWTTE*; ***[3]***

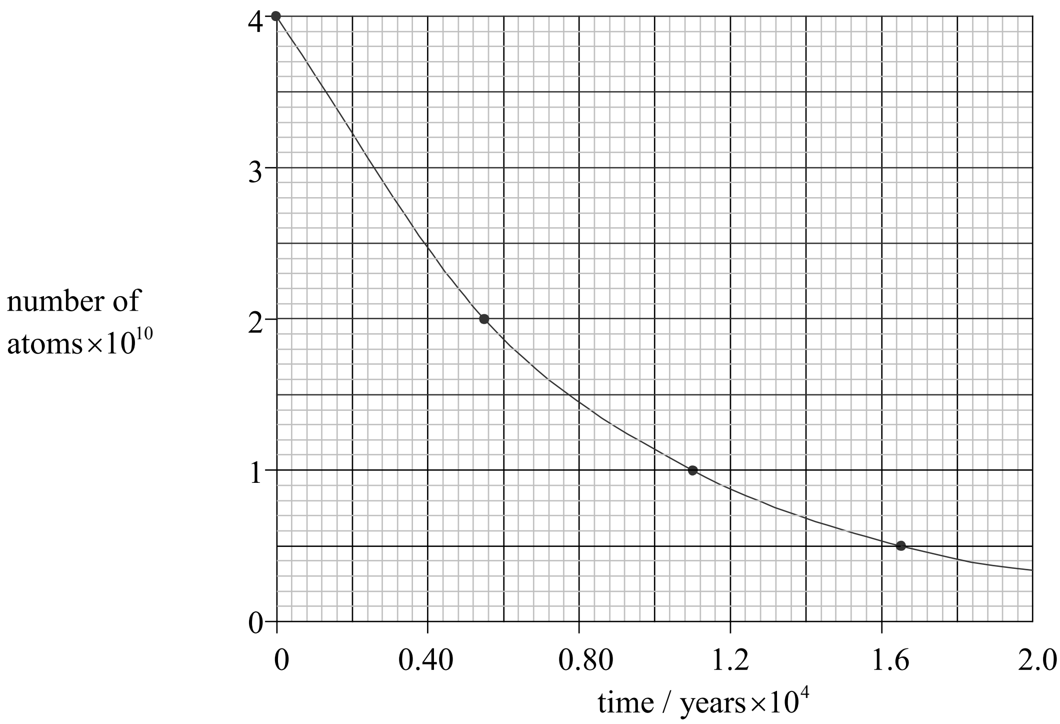
(ii) 14 g of C-14 contains $6.03\times10^{23}$ atoms;
therefore, $10^{-12}$ contains $\dfrac{6.03\times10^{23}\times10^{-12}}{14}\approx 4\times10^{10}$; ***[2]***

***Or***

Mass of atom = $14\times1.661\times10^{-27}$ kg ;
So number of atoms in $1\times10^{-12}$ g is

$$\frac{1\times10^{-12}\times10^{-3}}{14\times1.661\times10^{-27}};$$
$$=4\times10^{10}$$

(c)




four data points covering 3 half-lives; } *The data points at $4.00 \times 10^{10}$ and $0.50 \times 10^{10}$ must be shown.*

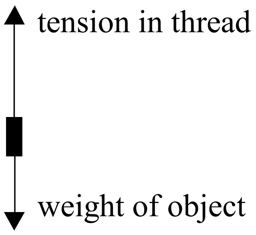
correct plotting of data points;
line of best fit to $1.8 \times 10^4$ years; ***[3]***

(d) (i) number of atoms $= \dfrac{1.9 \times 4 \times 10^{10}}{9.6} \approx 0.8 \times 10^{10}$; ***[1]***

(ii) from the graph age $= 1.3\,(\pm 0.2) \times 10^4$ years; ***[1]***
*Allow ECF from (c) and from (d)(i).*

**B3. Part 1 Electric motor**

(a) (i)




tension in thread;
weight (of object) / mg;
tension length > weight length; ***[3]***

(ii) $a = \frac{2s}{t^2}$;

$= \frac{2 \times 0.84}{(2.2)^2} = 0.35\,\text{m}\,\text{s}^{-2}$;

$T - mg = ma$;

$T = m(g + a) = 0.015 \times 10.35 = 0.16\,\text{N}$; ***[4]***

(b) (i) measure the time it takes the object to go successive distances of say 10 cm / any realistic length given <u>or</u> implied;
if the times are equal then speed is constant / *OWTTE*; ***[2]***

(ii) increase in potential energy $= 0.015 \times 10 \times 0.84 = 0.13\,\text{J}$;

rate of working = power input $= \frac{0.13}{3.4} = 0.037\,\text{W}$; ***[2]***

(iii) power input to motor $= VI = 6.0 \times 0.045 = 0.27\,\text{W}$;

$Eff = \frac{P_{out}}{P_{in}} = \frac{0.037}{0.27} = 0.14$ ***or*** $14\%$; ***[2]***

**Part 2 Waves**

(a) the direction in which energy (of the wave) is propagated;
for a transverse wave it is at right angles to the direction of vibration of the particles (of the medium through which the wave is travelling);
for a longitudinal wave the direction of energy propagation is in the same direction as the vibration of the particles; ***[3]***
*Accept answers based on diagrams for full marks provided direction of energy transfer and direction of oscillation are clear on the diagram.*

(b) (i) longitudinal;
it is likely that the hammer will set the atoms of the rod to vibrate in the same direction as the direction of the motion of the hammer / *OWTTE*; ***[2]***
*Award **[0]** if no explanation or poor explanation.*

***Or***

hammer would not experience a rebounding force (if wave were not longitudinal) /OWTTE;
some reference to direction of propagation of energy being along the length of the rod;

(ii) $s = 3.00\,\text{m}$;
$v = \frac{s}{t} = \frac{3.00}{6.00\times10^{-4}} = 5.00\times10^{3}\,\text{ms}^{-1}$; ***[2]***
*Watch out for incorrect answers based on* $v = f\lambda$ *and*
$f = \frac{1}{6\times10^{-4}} = 1667\,\text{Hz}$ *! It can give the correct numerical result with a completely wrong argument.*

(iii) the hammer blow/pulse sets the rod vibrating;
the vibration of the rod causes the air molecules in contact with the rod to vibrate;
thereby setting up a longitudinal wave in the air / creates the sound / *OWTTE*; ***[3]***

(iv) $\lambda = 2l = 3.00\,\text{m}$;
$f = \frac{v}{\lambda} = \frac{5.00\times10^{3}}{3.00} = 1.67\times10^{3}\,\text{Hz}$; ***[2]***