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Examiners' Report
January 2011

GCE Physics 6PH08 01

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6PH08 01

This paper aims to test the candidates' familiarity with practical techniques and procedures and it is expected that they will have completed a variety of practical tasks during their A level course. It also aims to provide progression from the AS Unit 7 and as such will often include more technological apparatus such as the Air Track in question 2. The techniques demanded by the questions should be practised using basic equipment and it is unlikely that candidates with limited practical experience will score very highly on this paper.

The paper is a written alternative to practical work and in writing the questions there is a deliberate attempt to align the assessment with the Unit 6 criteria which are shown on the coursework marking grids. It is likely to be helpful to read this report and the mark scheme with the criteria to hand to understand better how the assessment tasks are put together.

This paper follows the format of the first paper which was sat in June 2010 series. Candidates showed a broad familiarity with the tasks set and each mark was awarded to some candidates and, equally, each mark was not awarded on occasion. The questions provide a ramp of difficulty with a long question at the end which involves some planning; this is a new activity at AS and so some development of these skills is expected at this level. The questions are written to take into account the fact that candidates might not be familiar with the specific apparatus and that English might not be their first language.

Question 1

This question was very well done by almost all the candidates with many scoring full marks and it presented a relatively easy start to the paper.

The aim was to show the use of a high precision balance in finding a volume to a higher precision than by using a measuring cylinder. So there was a lot of emphasis on significant figures whilst the powers of ten needed looking after as well.

(i) Use these measurements to calculate the weight of water in the cylinder. (1)

$4.1408 - 2.2305 = 1.9103$ N

Weight of water = 1.9103N

(ii) The upthrust U on the key is given by

$$U = V\rho g$$

where V is the volume of the key and ρ is the density of the water.

Calculate the volume of the key. (2)

$V = \frac{U}{\rho g} = \frac{0.0263}{1000 \times 9.81} = 2.68 \times 10^{-6}$ m^3

$= 2.68$ cm^3

Volume = 2.68cm^3

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Examiner Comments

The candidate sets the work out in a logical fashion. The answer starts with the equation needed and then this is transposed before substituting in the numbers. It would be even better if the numbers had their units in the equation too.
There is no need at all to include the number 1000 since this is in the question, as are the units.

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Examiner Tip

Start your answer by writing out the equation you think will help you get your answer.

(i) Use these measurements to calculate the weight of water in the cylinder. **(1)**

weight of water = 4.1408 − 2.2305 = ~~1.9103 N~~ 1.9103 N

Weight of water = 1.9103 N

(i) The student now suspends the key in the water and notes that the balance reading increases to 4.1671 N. Calculate the upthrust. **(1)**

upthrust = 4.1671 − 4.1408 = 0.0263 N

Upthrust = 0.0263 N

(ii) The upthrust U on the key is given by

$$U = V \rho g$$

where V is the volume of the key and ρ is the density of the water.

Calculate the volume of the key. **(2)**

$V = \frac{U}{\rho g} = \frac{0.0263}{1019.5 \times 9.81} = 2.63 \times 10^{-6}\ m^3$

Volume = $2.63 \times 10^{-6}\ m^3$

(iii) She measures the mass of the key on its own as 9.38 g.

Calculate the density of the key. **(2)**

$\rho = \frac{m}{V} = \frac{9.38 \times 10^{-3}}{2.63 \times 10^{-6}} = 3567\ kg\,m^{-3}$

Density = $3567\ kg\,m^{-3}$

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Examiner Comments

Here the candidate shows a good grasp of what is needed with the working clearly shown. In b(ii) they divide by their value for the density, which is preferred. They would not be penalised for using 1000, given as a 'show that' in part (a).
The data is to 3 SF and so the final answer should be as well, hence they lose the final mark.

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Examiner Tip

Only use as many significant figures (SF) in your answer as there are SF in the data.

Question 2(a)

This question asked about the theory behind momentum conservation and expected a response that mentioned the absence of external forces. This was not done well, many candidates discussed energy, possibly thinking about an elastic collision even though this is not the case here.

(a) Using an air track reduces friction on the trucks. State why this is important in a momentum conservation experiment.

(1)

Friction is an external force for the interacting system of truck A and B. For momentum to be conserved, there should be no net external force ~~action~~ acting on the system, according to the principal of conservation of momentum.

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Examiner Comments

This shows the right idea.

(a) Using an air track reduces friction on the trucks. State why this is important in a momentum conservation experiment.

(1)

energy is lost as heat or due to friction. Momentum conservation ~~occ is~~ occurs when there are no external forces acting on it. So that speed of trucks do not slow down. So energy is not lost to other forms. So kinetic energy is constant in the system.

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Examiner Comments

This answer is a little too long and the candidate wanders off on to energy which is not what the question asks.

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Examiner Tip

Read your answer to make sure you have answered the question asked.

Question 2(b)

This asks the candidate to consider how they might practically ensure that something was horizontal. The mark scheme indicates a wide variety of methods, the more usual is to measure - using a rule *and* a set square - the height above the bench at both ends. But since this is an air track it was just as good to release a truck and see if it starts to move, candidates had to do it in two places to get the second mark. Here was an example of a question done better by those who had seen the apparatus.

Explain how you would show that the air track is horizontal before starting the experiment.

(2)

give a small push on truck A

the velocity at each light gate should be the same

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Examiner Comments

This gets one mark, how will they calculate the velocity from their *measurements*?

By using a set square and a meter rule to make sure it is parallel to the surface it is resting on.

By releasing ~~(A)~~ Truck A and observing if it will slide down or remain motionless.

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Examiner Comments

Here is a candidate who gives two methods, but each is only worth one mark.

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Examiner Tip

Giving two answers does not improve your chances of scoring the marks.

The trucks are allowed to move freely on the track. If the track is horizontal, they will not move.

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Examiner Comments

This does just enough to get both marks. They probably mean trucks A and B and so get the benefit of the doubt. They also mean 'rest freely', but they give enough of the right ideas.

Question 2(c)

This quaestion asks the candidate to think how the experiment *shows* the conservation of momentum. The more successful candidates used a mathematical argument although the mark scheme allows a discussion as well.

For momentum to be conserved, the momentum before collision must equal momentum after. (momentum = m x v)

$$m \times \frac{l}{t_1} = 2m \times \frac{l}{t_2} \qquad \left\{ v = \frac{d}{t} \Rightarrow \frac{l}{t} \right\}$$

$$\frac{1}{t_1} = \frac{2}{t_2} \Rightarrow \therefore t_2 = 2t_1$$

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Examiner Comments

This is very neat as it uses the information in the question without repeating it. The mathematical route must end with the conclusion as shown clearly here for the third mark. The candidate even explains why $v = l/t$.

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Examiner Tip

Longer answers are not often better answers.

Both trucks have the same mass. Explain why $t_2 = 2t_1$ if momentum is conserved.

(3)

$P_A = mV$ $P_B = mV$.   momentum is conserved.

$P_{AB} = 2mV$ p m is constant
then V is a half of truck A's
then t is put off
so $t_2 = 2t_1$

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Examiner Comments

Allowing for the notation, which is not the best, the candidate states that the velocity is halved. Then jumps to the conclusion with no indication of how they got there. Mention of the length of card, l, is a vital step here.

Question 2(d)

This is an exercise in data handling and many candidates did not use it very well. They were expected to find a mean value for the ratio and then compare that with the theoretical value. They could use either actual uncertainty - here 0.2 - or percentage difference. This question proved a good discriminator for the better candidates.

the mean of $\frac{t_2}{t_1} = \frac{2.1 + 2.3 + 1.9 + 2.0 + 2.2}{5} = 2.1$

~~which is approximately equal to 2~~ approximately equal to 2.

~~Because~~ The values are different as friction in the experiment.

So that's momentum conservation.

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Examiner Comments

The candidate works out the mean but then uses no more mathematical argument. There is a clear difference which they try to explain but without figures the argument is not convincing.

Use this data to discuss whether momentum can be considered to be conserved in this experiment.

(3)

~~[illegible]~~

the mean of $\frac{t_2}{t_1}$ is $\frac{2.1+2.3+1.9+2.0+2.2}{5} = 2.1$ is closed to 2,

and $\frac{2.1-2}{2} = 5\%$ is in the error range, so $t_2 = 2t_1$,

so it can ~~say be considered to~~ say that momentum is conserved in this experiment.

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Examiner Comments

Here the mean is calculated and then the percentage difference, but they should use that 5% to compare with the experimental uncertainty from the variation in the readings.

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Examiner Tip

If the percentage difference is bigger than the percentage uncertainty, the conclusion is not supported by the data.

the mean of $\frac{t_2}{t_1} = \frac{2.1+2.3+1.9+2.0+2.2}{5} = 2.1$

difference percentage $= \frac{2.1-2}{2} \times 100\% = 5\% < 10\%$

the momentum can be considered to be conserved.

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Examiner Comments

This mean of using the (correct) percentage difference is not valid. Comparing it with 10% is too arbitrary.

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Examiner Tip

Always use the data to evaluate the uncertainty.

Question 3

Here the candidate is asked to use the uncertainties in measurements to come to a conclusion about the value of a capacitor.

3 A student measures the energy stored in a capacitor of unknown capacitance.

She charges the capacitor to a potential difference V using a battery and then discharges the capacitor through a joulemeter which records the energy W stored in the capacitor. She uses two different batteries and records the following readings.

V/V	W/mJ			Mean W/mJ	C/mF
4.5	19.57	19.51	19.63	19.57	1.9
6.0	36.14	36.12	36.22	36.16	2.0

(a) (i) For each potential difference, calculate the mean energy W stored in the capacitor. Hence calculate the capacitance C using the formula $W = \frac{1}{2}CV^2$.

Add your values to the table.

(2)

For 4.5V, $C = \frac{2W}{V^2}$

$= \frac{2(19.57 \times 10^{-3})}{4.5^2}$

$= 1.9$ mF

For 6.0 V, $C = \frac{2(36.16)}{6.0^2}$

$= 2.0$ mF

(ii) Calculate the percentage difference between your two values of C.

(1)

% difference $= \frac{2.0 - 1.9}{\left(\frac{2.0 + 1.9}{2}\right)} \times 100\%$

$= 5.1$ %

Percentage difference = 5.1 %

(b) The uncertainty in the values of potential difference in the table is 0.1 V.

(i) Estimate the uncertainty in your mean value of W when using the 4.5 V battery.

(1)

Uncertainty = $\frac{1}{2}$ range

= $\frac{1}{2}$ (19.63 − 19.51)

= 0.06 mJ

Uncertainty = 0.06 mJ

(ii) Use these uncertainties to estimate the percentage uncertainty in the value of C obtained using the 4.5 V battery.

(2)

% uncertainty in C = $\left(2 \times \frac{0.1}{4.5} + \frac{0.06}{19.57}\right) \times 100\%$

= ~~4~~ 5%

Percentage uncertainty = 5%

(c) Explain whether the unknown capacitor could be a 2200 μF capacitor with a tolerance of 20%.

(2)

Range of capacitor = 2200 μF × $\frac{20}{100}$ = 440 μF

The unknown capacitor's capacitance is within (2200 μF ± 440 μF) range. It could be a 2200 μF capacitor with a tolerance of 20% as ~~it~~ ~~it within~~ the 1.9 mF value is within its range.

(Total for Question 3 = 8 marks)

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Examiner Comments

Here the first mark was for the values of W and the second mark was for the values of C. So the skill tested was processing data which the candidates handled very well. Any calculations shown below the table were not inspected closely.
The rest of the question is very well answered without great length. It is only spoiled at the very end when the candidate leaves it up to the exmainer to work out whether their value, 1.9, lies within the range.

3 A student measures the energy stored in a capacitor of unknown capacitance.

She charges the capacitor to a potential difference V using a battery and then discharges the capacitor through a joulemeter which records the energy W stored in the capacitor. She uses two different batteries and records the following readings.

V/V	W/mJ			Mean W/mJ	C/mF
4.5	19.57	19.51	19.63	19.57	1.93
6.0	36.14	36.12	36.22	36.16	2.00

(a) (i) For each potential difference, calculate the mean energy W stored in the capacitor. Hence calculate the capacitance C using the formula $W = \frac{1}{2}CV^2$.

Add your values to the table.

(2)

$\frac{19.57+19.51+19.63}{3}$ $= 19.57$ mJ

$19.57 = \frac{1}{2}CV^2$

$19.57 \times 2 = CV^2$

$19.57 \times 2 = 20.25C$

$1.93\text{mF} = C$

$\frac{36.14+36.12+36.22}{3}$ $= 36.16$ mJ

$\frac{36.16 \times 2}{36} = C = 2\text{mF}$

(ii) Calculate the percentage difference between your two values of C.

(1)

$\frac{1.93}{2.01} \times 100 = 96.5\%$

Percentage difference = 96.5%

(ii) Use these uncertainties to estimate the percentage uncertainty in the value of C obtained using the 4.5 V battery.

(2)

$W = \frac{CV^2}{2}$

$C = \frac{2W}{V^2}$

$\frac{\Delta C}{C} \times 100 = \left(\frac{\Delta W}{W} \times 100\right) + \left(2 \times \frac{\Delta V}{V} \times 100\right)$

$\frac{\Delta C}{C} \times 100 = \left(\frac{0.06}{19.57} \times 100\right) + \left(2 \times \frac{0.1}{4.5} \times 100\right) = 0.31\% + 4.44\% = 4.75\%$

Percentage uncertainty = 4.75%

(c) Explain whether the unknown capacitor could be a 2200 μF capacitor with a tolerance of 20%.

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Examiner Comments

This shows clearly again how the uncertainties are combined when the quantities are not linearly related.

Question 4(a)

This question covered practical work that is easily accessible, yet requires a treatment that is A level in demand.

Candidates lost marks by not stating the obvious. When describing measurements the method should be clearly listed. Here it was important to descibe heating the oil and then measuring the temperature as it cooled down. Many candidates lost their way in writing an answer - bullet points are the best way to keep on track.

Describe the measurements you would make to verify this relationship. Your description should include:

- a variable you will control to make it a fair investigation
- how you will make your results as accurate as possible.

(5)

A measured volume of cooking oil should be taken. Then clamp the thermometer and heat it up to a certain (high) temperature. The oil should be stirred continuously to ensure even distribution of heat. Next shut off the heat supply, note the temperature and start timing. Stirring should be carried out as well. At regular intervals, record the time and the corresponding temperature. Continue this procedure ~~for a~~ until a series of readings of temperature against time are taken. The temperature would fall and it ~~the~~ is this fall in temperature that is noted down.

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Examiner Comments

This answer explains clearly what needs to be done but misses out key detail, including what might be controlled, despite the big clue in the question.

(5)

First, the temperature reading at room temperature is recorded. This temperature is to be kept constant throughout the experiment. The thermometer is then dipped into the heated cooking oil until the reading reaches a certain value. This is the temperature of the oil. ~~The~~ stop watch is started as soon as a temperature reading for the oil is recorded. ~~The~~ Different values for temperature are recorded at regular time intervals as the cooking oil cools. Draw a table, with temperature differences ~~[illegible]~~ (from room temperature) in one column. Take the ~~values~~ natural logirithms of these values and plot ln Δθ against time. A straight line is obtained. Repeat the experiment and average to make the results accurate.

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Examiner Comments

This candidate includes the basic method but then wanders off into the data handling, away from the question about measurements. A good start though.

Question 4(b)(i)

Candidates are expected to show the logarithmic version of the equation and then say something else about why this makes a straight line.

(i) Explain why a graph of ln $\Delta\theta$ against t should be a straight line. **(1)**

$\ln\Delta\theta = \ln \Delta\theta_0 e^{-kt} = \ln\Delta\theta_0 - kt$

∴ ~~$\ln\Delta\theta = \ln\theta + kt$~~ $\ln\Delta\theta = \ln\Delta\theta_0 - kt$

∴ $\ln\Delta\theta$ against t should be a straight line

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Examiner Comments

This is not quite enough.

(i) Explain why a graph of ln $\Delta\theta$ against t should be a straight line. **(1)**

$\Delta\theta = \Delta\theta_0 e^{-kt}$

$\ln\Delta\theta = \ln\Delta\theta_0 + \ln e^{-kt}$

$\Rightarrow \ln\Delta\theta = -kt + \ln\Delta\theta_0$

$y = mx + c$

∴ $\ln\Delta\theta \propto t$ as 'k' and $\ln\Delta\theta_0$ remains constant, so it should straight line.

(ii) Use the column(s) provided for your processed data, and then plot a suitable graph.

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Examiner Comments

This does enough because it is clear that the value of *k* will be the negative of the gradient.

(i) Explain why a graph of ln $\Delta\theta$ against t should be a straight line.

(1)

$\ln(\theta - \theta_0) = e^{-kt}$

$y = mx + c$

The equation $\Delta\theta = \Delta\theta_0 e^{-kt}$ obeys the equation of st. line.

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Examiner Comments

Unfortunately this tells the examiner nothing

Question 4(b)(ii)-(iii)

This is the most standard part of any paper, there is always data to manipulate and put into a graph. The marking for this is the same every year so candidates should be able to improve their skills.

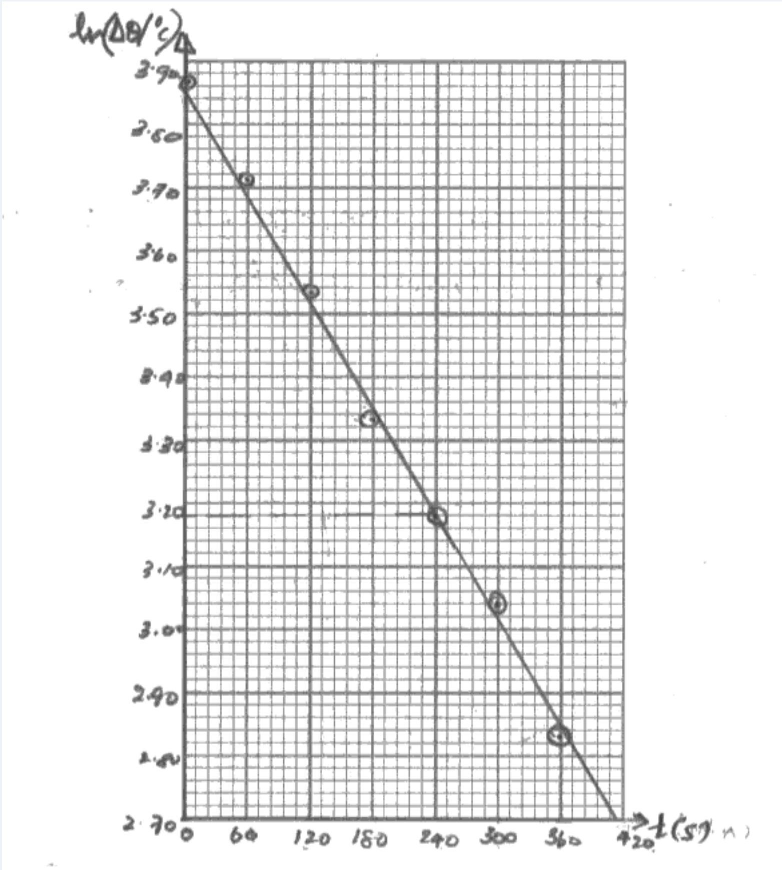
The data in the table should have enough SF to plot the graph accurately using the smallest divisions, this is usually 3 SF.

The graph should display the data to best advantage, a common error is to include the origin, it is often not helpful to do this.

The scale should enable the examiner to interpolate readings from the line. This is not possible if the scale is based on 3's or some other awkward division. Here 60's were allowed along the time axis but that is unlikely to occur much since the time was measured here in minutes.

(b) The following data were obtained using cooking oil. θ is the temperature at time t.
Room temperature = 22 °C

t/s	θ/°C	ln(Δθ/°C)	ln(Δθ₀/°C)	Δθ/°C	ln(Δθ/°C)
0	70	4.25		48	3.87
60	63	4.14		41	3.71
120	56	4.08		34	3.53
180	51	3.93		29	3.37
240	46	3.82		24	3.18
300	43	3.76		21	3.04
360	39	3.66		17	2.83



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Examiner Comments

This excellent graph might be a little steeper by moving the top intercept a little higher, but the data is clear. Candidates often draw the Best Fit line from the top point to the bottm point, this is seldom the best option.
The gradient calculation should have a negtaive value but the minus signs have been ignored. Also the traingle of calculation is too narrow and the unit has been ignored.

$k = $ ~~$\frac{3.87 - 3.18}{240 -}$~~ $\frac{3.18 - 3.87}{240 - 0} \rightarrow \frac{0.69}{240} = 2.88 \times 10^{3}$

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Examiner Tip

Note here the way to include the unit in the logarithm of a variable. In this way the axis shows pure numbers with no units.

(b) The following data were obtained using cooking oil. θ is the temperature at time t.
Room temperature = 22 °C

t/s	θ/°C	$\Delta\theta$ /°C	ln $\Delta\theta$
0	70	48	3.8712
60	63	41	3.7135
120	56	34	3.5263
180	51	29	3.3672
240	46	24	3.1780
300	43	21	3.6445
360	39	17	2.8332

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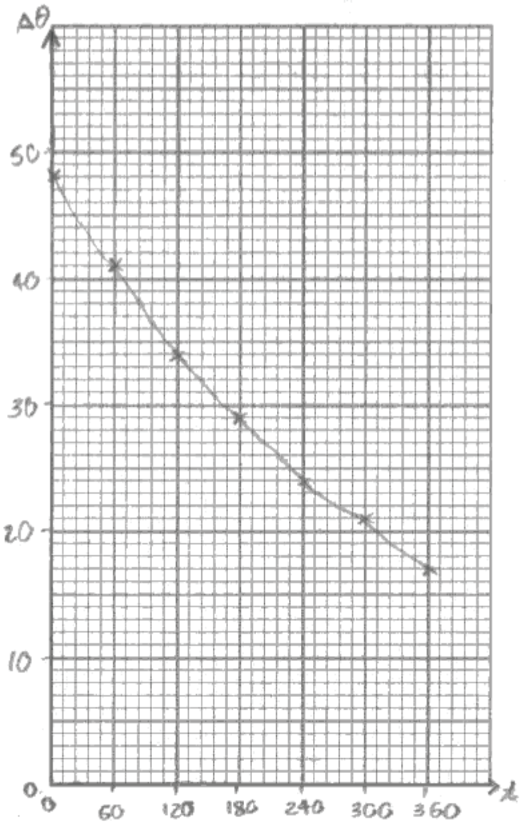
Examiner Comments

Despite calculating the log values the candidate plots Δθ against t. This is done fairly well and credit is given even though it is the wrong graph. This is positive marking since the candidate can score no marks in part (c).

(ii) Use the column(s) provided for your processed data, and then plot a suitable graph on the grid below to show that these data are consistent with $\Delta\theta = \Delta\theta_0\, e^{-kt}$.

(5)



(iii) Use your graph to determine a value of the constant k for the oil.

(3)

$e^{-kt} = 3.3619$

$k = 1.212$

$k =$ 1.212

Question 4(c)

This was another question that expected a practical answer but was often answered too vaguely. Greater precision depends on the instruments used and is not always the case.

Eliminating human error is never a sufficient reason without saying where that error comes from. In this case it is reading two scales at the same time, so simultaneous readings is the advantage here.

(c) Your teacher suggests using a temperature sensor and a data logger in place of the thermometer and stop clock.

State an advantage of using a temperature sensor and a data logger in this experiment.

(1)

with a sensor,
The temparature reading can be taken very quickly so that ~~it~~ it doesn't change whilst taking the reading

(Total for Question 4 = 15 marks)

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Examiner Comments

This gives enough of the right idea without actually using the word simultaneous which is the key word.

Paper Summary

A lot of marks are lost because candidates lose sight of the practical aspects of the questions. To have a better chance of higher marks candidates should

- do lots of practical work
- consider the uncertainty of every measurement they make
- practise data handling
- think about the use of Significant Figures
- ensure they read the question thoroughly
- ensure their answer always follows the question.

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