Examiners' Report
June 2017

IAL Physics 6 WPH06 01

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Introduction

The IAL paper WPH06 Experimental Physics assesses the skills associated with practical work in Physics. In particular it addresses the skills of planning, data analysis and evaluation. As the questions can be set in a wide variety of familiar and unfamiliar contexts, those candidates who have carried out a range of experiments using different apparatus and techniques will find the paper more accessible.

This document should be read in conjunction with the question paper and mark scheme which are available on the Pearson Qualification website.

Question 1 (a)

As in previous series, Question 1 assesses the candidates' ability to handle uncertainties at the level expected of an A2 candidate. This question was set in an unfamiliar context of determining the viscosity of oil flowing through a pipe where the candidates were given data including the measurement of the internal diameter of the pipe.

Parts (a)(i) and (a)(ii) focused on the candidates' ability to choose a suitable measuring instrument and justify that choice. It became clear that many candidates across the grade range had either misunderstood the question and assumed the measurement given was of an external diameter, or had not tried to measure an internal diameter as they assumed that a micrometer screw gauge was needed. The type of micrometers used in most centres could not be used to measure an internal diameter therefore these answers were not credited.

Of those who chose a Vernier caliper, the most common error was to not comment on the percentage uncertainty in the measurement. Although a travelling microscope was not expected to be seen, those that did state this were given full credit.

The final part of this question asked the candidates to describe a suitable technique. Those candidates who chose a micrometer often fell short here as many of them would describe measuring the external diameter and extracting the thickness of the material which, for a 1 cm diameter, would be impossible. This part of the question required the candidate to make it clear that the diameter should be measured at different orientations of the pipe and an average found. Some candidates may have been successful in this but then lost the mark by implying measurements along the pipe. This suggested that the candidates were using their knowledge of measuring the diameter of a wire, such as in the Young modulus experiment, and not thinking about the context of the question.

(i) State a suitable instrument for this measurement.

(1)

varnier

~~F~~ ~~vattnier~~ calliper

(ii) Explain your choice of instrument.

(2)

Has the precision of 0.01mm.

1cm → 10mm

$\%U = \frac{0.01}{10} \times 100 = 0.1\%$, which small % Uncertainty

(iii) State the measuring technique you would use with this instrument to obtain an accurate value for the internal diameter of the pipe.

(1)

Measure the diameter at different lenghts of the pipe.

ResultsPlus

Examiner Comments

Although this candidate had correctly justified the use of a Vernier caliper, the use of the instrument implied an external diameter. In addition there is no indication of an average being calculated. This candidate scored 3 out of the 4 marks available.

ResultsPlus

Examiner Tip

When justifying the use of an instrument, include both a calculation of the percentage uncertainty and a comment about the value.

Question 1 (b) (c)

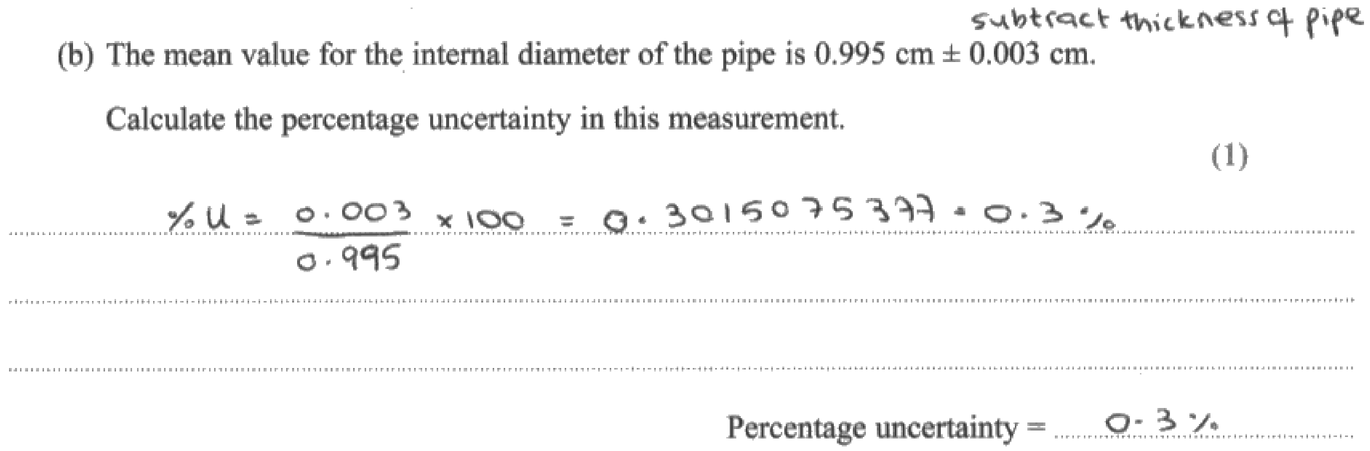
These parts of Question 1 concerned determining a value of the viscosity of oil flowing through the pipe given the measurement of the mean diameter along with values for the other variables, with its associated percentage uncertainty.

In part (b), most candidates were able to calculate the percentage uncertainty in the diameter. On occasion candidates calculated an answer that was double what was expected implying the whole range being used which was not credited. At this stage, the use of significant figures was not assessed.

In part (c)(i) the candidates were asked to show that the units for viscosity were correct. Most candidates did this well although there were some that made mistakes with the algebra or used cm, which is not a base unit. It was expected that the candidates would use the formula provided however those candidates that had used Stokes' law were credited.

Part (c)(ii) involved calculating the viscosity using the data provided. In general this was done well but the main errors were either not halving the diameter or using an incorrect power of 10 for the radius. In addition some candidates used a 1 cm measurement which was not accepted. This part of the question also prompted the candidates to consider the correct number of significant figures.

Finally the candidates had to calculate the percentage uncertainty in this value. Better candidates found this straighforward but for those who used the correct method the most common error was to use three significant figures. The uncertainties in the data were given to one or two significant figures so only one or two significant figures in the final answer were credited. In some cases, candidates thought that the percentage uncertainty in the diameter should also be halved for the radius when they should be the same. Often E grade candidates find this a challenge and often simply add the percentage uncertainties to arrive at the final answer.



subtract thickness of pipe

(b) The mean value for the internal diameter of the pipe is 0.995 cm ± 0.003 cm.

Calculate the percentage uncertainty in this measurement.

(1)

$\% U = \frac{0.003}{0.995} \times 100 = 0.3015075377$ • 0.3 %

Percentage uncertainty = 0.3 %

$\frac{V}{t} = \frac{\pi P r^4}{8 \eta L}$ $\therefore$ $\eta = \frac{\pi P r^4 t}{8 V L}$ $\Rightarrow$ P is measured in Nm^{-2},

t in s and V in m^3, L in m $\therefore$ $\eta = \frac{Nm^{-2} \times m^4 \times s}{m^3 \times m}$

$\hookrightarrow$ Units $\eta = \frac{Nm^{-2} s \times m^4}{m^4} = Nm^{-2} s$

(ii) Calculate a value for η.

(2)

$$\eta = \frac{\pi P r^4 t}{8 V L} = \frac{\pi (695)\left(\frac{0.995}{2} \times 10^{-2}\right)^4 \times \left(\frac{1}{8.5 \times 10^{-6}}\right)}{8 \times 2.00}$$

$$\eta = \frac{0.157357 7336}{16} = 9.83485835 \times 10^{-3}$$

$\eta =$ $9.83 \times 10^{-3} \, Nm^{-2} s$

~~not 2x~~

(iii) Calculate the percentage uncertainty in η.

(2)

% U in η = % U in P + 4 × % U in r + % U in $\frac{V}{t}$ + % U in L

% U in $\eta = 0.7 + 4 \times 0.3 + 3.5 + 0.5$

$= 5.9\%$

Percentage uncertainty = 5.9 %

ResultsPlus

Examiner Comments

This candidate scores full marks for this question and has set out the answers well showing a full working of each section. This is good practice as marks can be awarded for method even if the final answer is incorrect. In addition, the “show that” section is laid out such that the algebra is easy to follow.

ResultsPlus

Examiner Tip

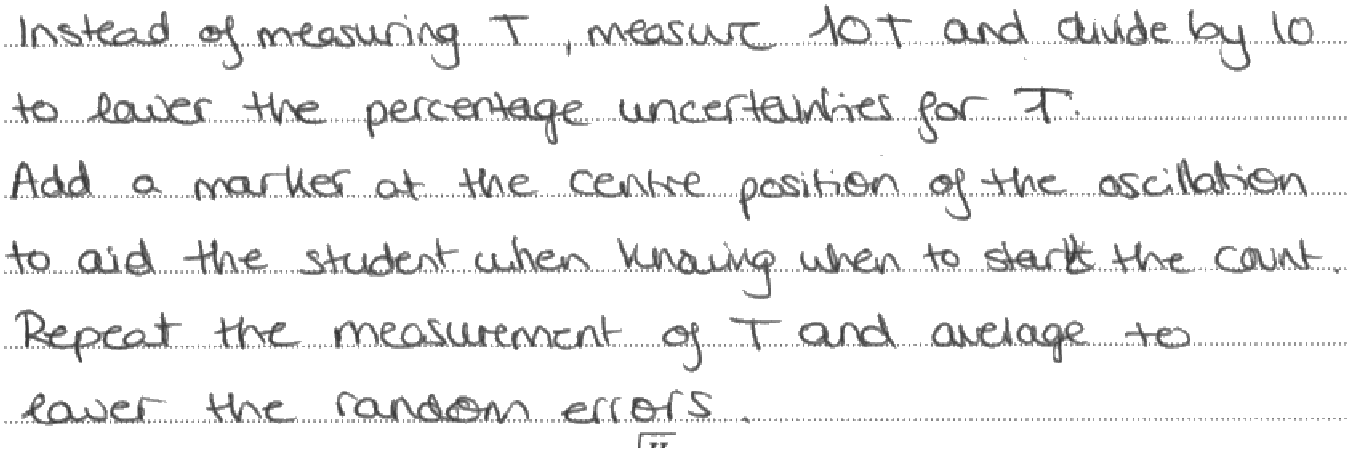
When calculating the total percentage uncertainty of a variable raised to a power, the percentage uncertainty of the variable is multiplied by that power.

Question 2 (a)

This question focused on planning an oscillation type experiment. It was set within a more unusual context although this did not seem to trouble the candidates.

In this part, the candidates had to list the techniques they would use to ensure the measurement of the time period was as accurate as possible. It was clear that some candidates were distracted by the inclusion of the ruler as a measuring instrument which meant that many candidates needed to use extra space.

Although many candidates mentioned the use of a timing marker many did not specify that it should be at the centre of the oscillation. The mark for this was the one most often not achieved. In contrast the majority of candidates were very clear about timing multiple oscillations however, in some cases, they were not clear enough in describing how they would find a value for *T*. Some simply stated that they would find an average which was not explicit enough to gain the mark. Many also stated that they would repeat the experiment to obtain a mean value. However, in some cases it was not obvious whether they would repeat at each length or they quoted “repeat and mean” which is too vague.



Instead of measuring T , measure 10T and divide by 10
to lower the percentage uncertainties for T.
Add a marker at the centre position of the oscillation
to aid the student when knowing when to start the count.
Repeat the measurement of T and average to
lower the random errors.

ResultsPlus

Examiner Comments

This candidate scores full marks for this question. The position of the marker is very clear in this case as is specifying the number of oscillations to be timed. This candidate also suggests reasons for each of these techniques which was not asked for in this case.

ResultsPlus

Examiner Tip

These are standard techniques for measuring the time period of an oscillation - ensure that you know and understand standard measuring techniques.

Question 2 (b)

This part of the question was completed successfully by the majority of candidates. Here they were required to describe which graph they would draw which simply required the candidate to state the two variables in the correct form and the associated gradient. Those that presented a sketch of the graph were given full credit. Of those who were unsuccessful it was a consequence of using an extra variable, such as T^2 against *IL*. In addition some candidates made mistakes in squaring. The second part asked how they would calculate a value for *K* which meant they had to state exactly how it would be calculated from the gradient they had stated. Those candidates that tried to use a logarithmic relationship were generally unsuccessful with this question as they failed to realise that the intercept would be needed to calculate *K* and this was a complex relationship.

$T = 2\pi\sqrt{\frac{IL}{K}}$ $\quad\quad T^2 = 4\pi^2 \cdot \frac{IL}{K}$

$T^2 = \frac{4\pi^2 I}{K} \cdot L$

plot a graph of T^2 against L since $\frac{4\pi^2 I}{K}$ is the gradient which is a constant.

obtain the value for the gradient where gradient = $\frac{4\pi^2 I}{K}$

hence $\cancel{I = \frac{\text{gradient} \times k}{4\pi^2}}$

$k = \frac{4\pi^2 I}{\text{gradient}}$

ResultsPlus

Examiner Comments

This is an example of a standard answer that scores full marks. A graph of *T* against √*L* would also be acceptable.

ResultsPlus

Examiner Tip

Only use a log-log graph when the power is unknown.

Question 2 (c)

This part of the question examined the candidates' ability to consider a possible improvement to the experiment. It was clear that many candidates were not familiar with a light gate set up as they presented answers that included taking multiple measurements, plotting graphs automatically etc. Candidates should be considering the use of dataloggers within the context of the measurements being made which, in this case, was to reduce the effects of reaction time on the uncertainty in the measurement of *T*. It was also evident that the candidates could not express themselves easily here as some used the phrases "human error" or "reaction error" which were not accepted.

- eliminate ~~reduces~~ reaction time
- giving a lower % uncertainty
- a lot of readings can be taken and used t- find the mean value.

ResultsPlus

Examiner Comments

This candidate scored both marks for this question for the first two lines.

- More readings can be taken in a given time
- Avoid human reaction time when measuring T
- A graph is automatically drawn

ResultsPlus

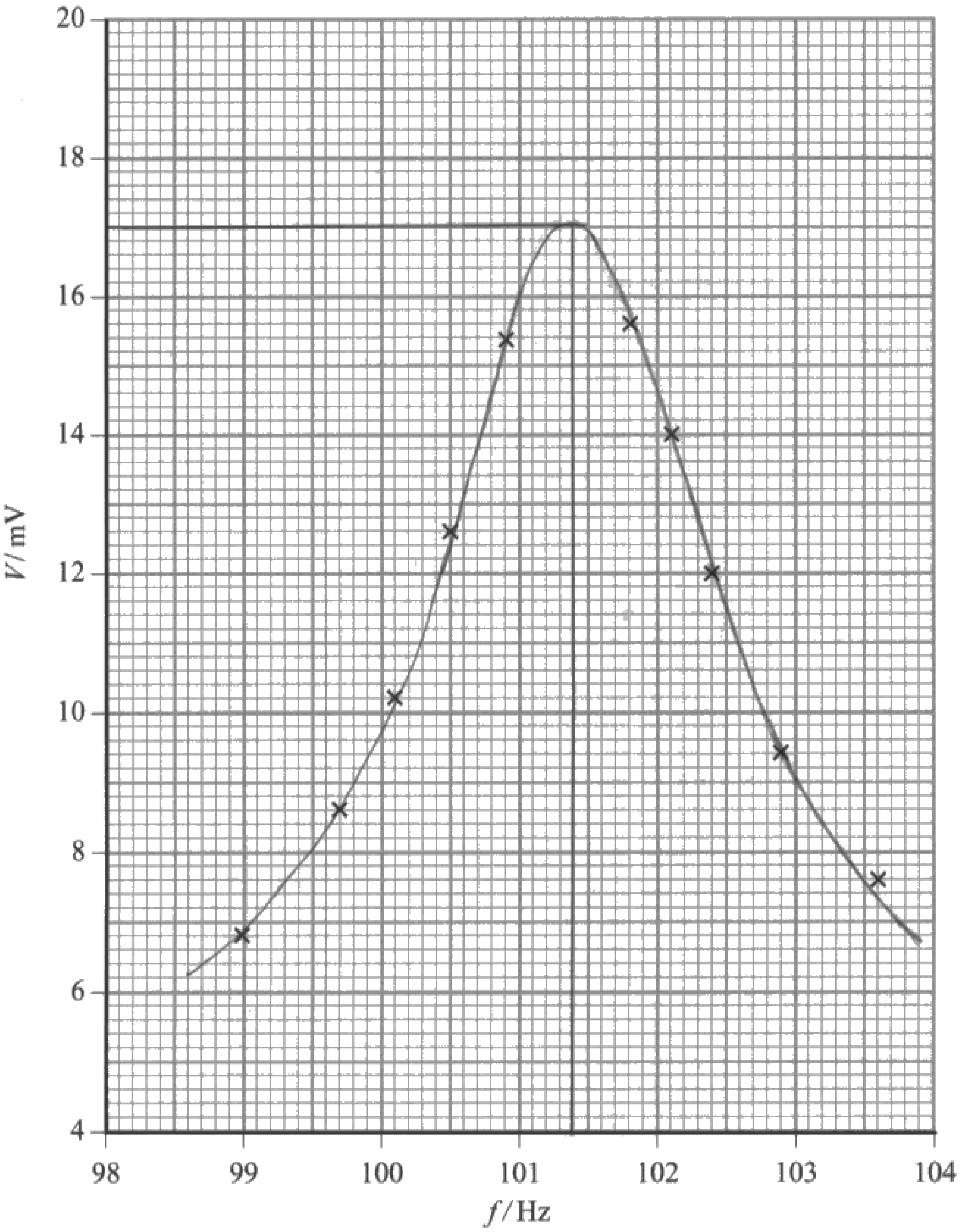
Examiner Comments

Although this candidate did score one mark for the middle line, the other two lines suggest that the candidate had not thought about the context of the experiment properly. The use of "more readings in a given time", or a high sampling rate, is more suitable for experiments that happen in a short time or require more data to show detail in a graph. Plotting a graph automatically does not improve the accuracy of the measurement so is not an accepted answer.

Question 3

This question involved an unfamiliar resonance experiment and tested the candidates' ability to draw a resonance curve using the data. The curve was then used to find the resonant frequency of the system.

In general the candidates coped very well with this although there were those that insisted on drawing straight best fit lines, either by drawing a triangle or two intersecting lines. Most candidates did read values from the peak of the graph well using the scales but the main error was not giving the correct units for the potential difference. The final part asked the candidates to consider how taking more data over a certain range would improve the final accuracy of f_0. Most candidates simply restated the question without realising that it would allow a more accurate best fit line to be drawn around the peak.



15×10^{-3} V

(iii) State the resonant frequency f_0 of the bottle.

(1)

101.4 Hz

(b) The student takes more readings in the range 100 Hz to 102 Hz.

Suggest how this would increase the accuracy of the value of f_0 obtained.

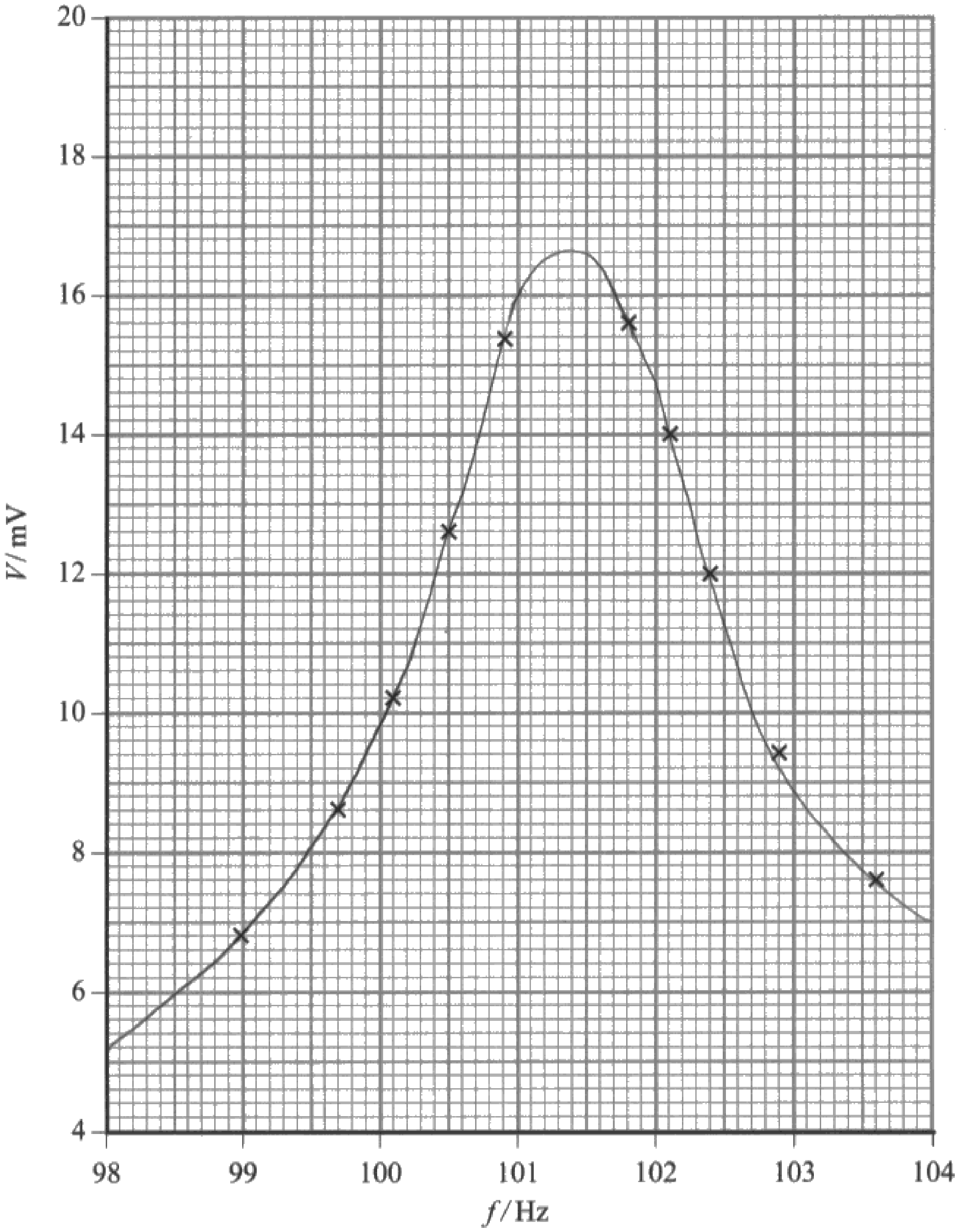
(1)

(show the turning point more clearly). more sets of data will improve the accuracy of the curve. between 100Hz - 102Hz (the peak) . so the maximum position will be show by the curve more accuratly .

ResultsPlus

Examiner Comments

This candidate scored 2 marks for the graph and 1 mark for the correct reading of the resonant frequency but unfortunately misread the peak potential difference. Note that the final part of the question could be expressed in a number of ways. Here the candidate relates the peak to the accuracy of the curve so scores the final mark giving 4 in total.


20
18
16
14
12
10
8
6
4
V / mV
98
99
100
101
102
103
104
f / Hz

(1)

~~16.6mV~~ 16.6mV

(iii) State the resonant frequency f_0 of the bottle.

(1)

101.4HZ

(b) The student takes more readings in the range 100 Hz to 102 Hz.

Suggest how this would increase the accuracy of the value of f_0 obtained.

(1)

Taking more readings can add more figures on the graph, plot more points. ~~The~~ It is clear that value of fo is between 100HZ to 102Hz, so when more ~~po~~ points plotted, the graph shape will be more clear, so it increase the accuracy.

ResultsPlus

Examiner Comments

This candidate was more successful in reading the graph and scores full marks. Note that in the final part the candidate refers to the resonant frequency being in this range and the shape of the graph.

Question 4 (a)

This question involved a standard determination of half-life of a radioactive isotope along with standard techniques involved with using radioactive sources.

This part of the question asked the candidates to consider why a background count is subtracted so tested the candidates on their knowledge of types of uncertainty. It was surprising how many candidates did not know that there are only two types of uncertainty, random or systematic. On occasion it was evident that the candidate was trying to present systematic as an answer as the words “system” or “systemic” were seen. Unfortunately this could not be credited as these words have their own specific meaning. A number of candidates also state “zero error” which is not a type of uncertainty but a source of uncertainty. A zero error is usually associated with a measuring instrument not a background count. There were also a number of other errors presented.

Question 4 (b)

In this part of the question the candidates had to consider a control variable other than the background count. Many candidates did better on this part although some candidates assumed it was the counter or ratemeter that did the detecting rather than the Geiger-Muller tube. In addition, some candidates thought that the time interval was a control variable rather than a technique.

Question 4 (c)

This part of the question posed little difficulty for the majority of candidates since the radioactive decay law is familiar to those who have studied radioactivity. In general, even weaker candidates were able to manipulate the equation into a straight line form but a surprising number were still not explicit enough in comparing this to *y* = m*x* + c. The better candidates were able to express this well and often went further by being explicit about the variables as well as the gradient.

$A = A_0 e^{-\lambda t}$ The graph is of the

$\underset{\overset{\uparrow}{y}}{\ln A} = \underset{\overset{\uparrow}{c}}{\ln A_0} \; \underset{\overset{\uparrow}{m}}{(-\lambda)} \times \underset{\overset{\uparrow}{x}}{t}$ form $y = mx + c$.

The gradient is $-\lambda$ which is a constant so graph is a straight line.

ResultsPlus

Examiner Comments

This candidate scores both marks and shows clear links between the variables and the equation. This can be done in a variety of ways.

(2)

$\ln A = \ln A_0 - \lambda t$

$Y = b + ax$

$-\lambda$ is the gradient

ResultsPlus

Examiner Comments

Although this is a minimalist answer this still scores both marks. The candidate has clearly lined up the equation with the straight line form and is explicit about the gradient. It should be noted that in the comparison with *y* = m*x* + c other letters are acceptable for the gradient and intercept.

ResultsPlus

Examiner Tip

Clearly link the equation with a straight line form.

Question 4 (d-f)

This is the data handling question that requires students to process data and plot a graph to determine a constant. In this question candidates were presented with the activity of a radioactive sample decaying over a period of 160 s. It was the decay constant of the isotope that the candidates were asked to determine.

Part (d) of this question involved processing the data and plotting the graph. The vast majority of candidates were able to calculate the natural logarithm of the activity but there were a number that only gave values to two significant numbers where three was expected. In general the graph was plotted well but weaker candidates were more likely to present an unprocessed graph.

As with previous series the units for the graph caused some confusion. A logarithm should have no units therefore both the quantity and unit should appear in the bracket, e.g. $\ln(A/\mathrm{s}^{-1})$.

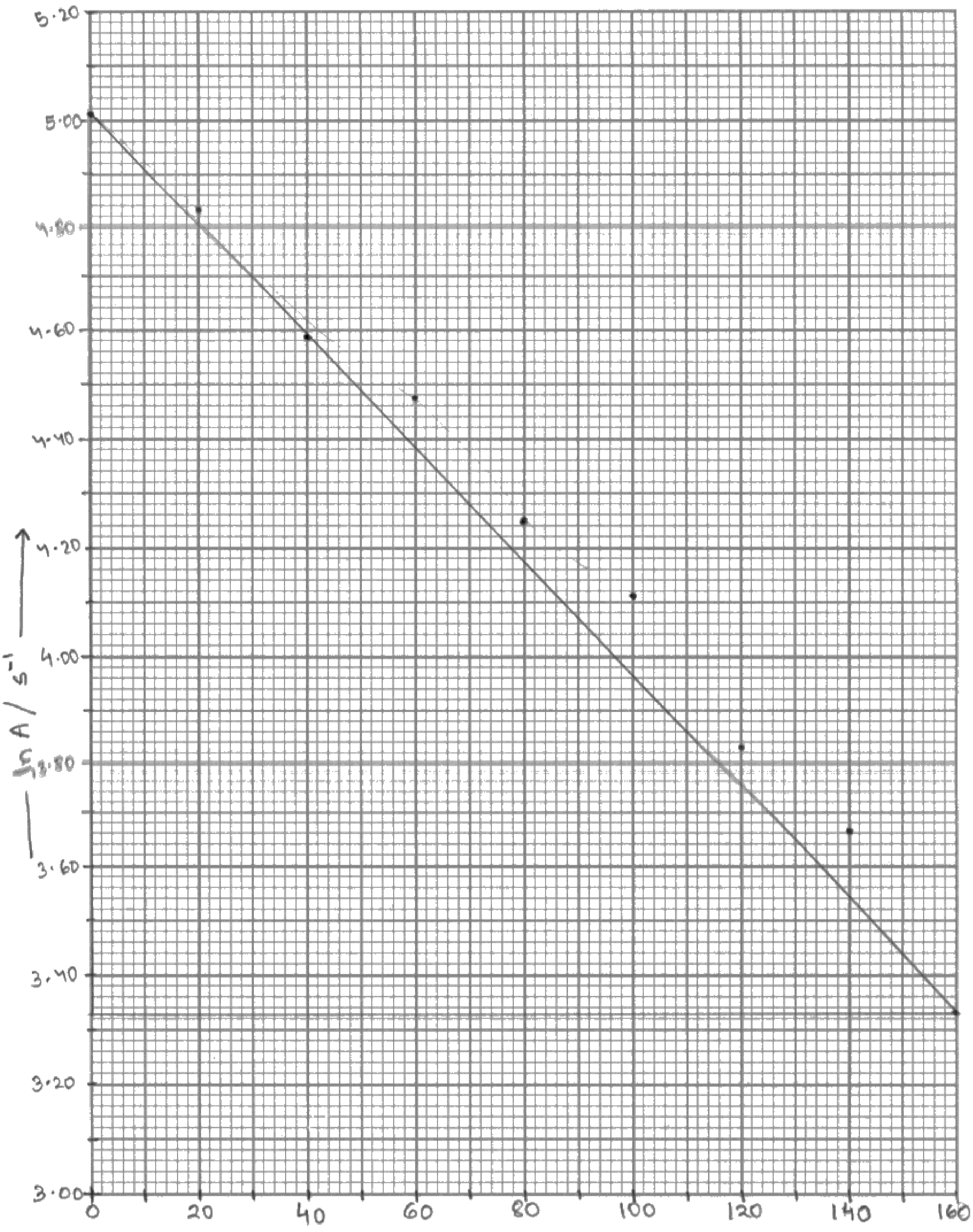
Scales were often chosen well however it should be noted that those candidates that used a scale of 0.25 per large square made more mistakes when plotting or interpolating the graph. Candidates should be encouraged to use scales in 1, 2 or 5 and their multiples of 10 only. In addition weaker candidates tended to use a *y*-axis that began at zero, hence the plots did not cover more than half the page resulting in a graph that was too small.

The plotting of points was done well however centres should encourage candidates to use a distinct cross (+ or ×) to denote the plot. If a dot is used then this can lead to an ambiguous plot. It is expected that the plot should be within one millimetre of the expected value to be considered an accurate plot therefore dots larger than 1 mm may not acceptable.

There were a number of best fit lines for this graph owing to the scatter of the points however the most common mistake was joining up the first and last points so there was an uneven number of plots on both sides of the line.

In part (e) the candidates were asked to calculate a value for λ using the graph. The majority managed to interpolate values from their graphs and use a large triangle however there was some confusion over the negative gradient. In addition many did not give a unit for λ or gave a unit of s^{-2}, indicating that they were unaware that a logarithm is dimensionless, or gave a unit of m. In addition some did not give it to three significant figures. There were some cases where the candidates tried to use the radioactive decay law which could not receive full credit.

In part (f) the candidates were to use their value for λ to calculate a value for the half life of the sample. Despite the previous errors in units for λ most candidates gave a unit of s for the half life. The final part asked the candidates to comment on the accuracy of their answer given a known value. Although most candidates were able to calculate a percentage difference they were less successful with the related comment. In this case they had to realise that their percentage difference was small, or not, and relate that to the accuracy. Some candidates tried to relate this to a supposed experimental uncertainty of 10% which, whilst acceptable, may not be accurate so was not credited. A comparison to 5% is more statistically valid and was given credit. There were also a number that just gave vague comments.


5·20
5·00
4·80
4·60
4·40
4·20
4·00
3·80
3·60
3·40
3·20
3·00
ln A / s⁻¹
0
20
40
60
80
100
120
140
160

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Examiner Comments

This example of part (d) shows common errors that candidates often make. The graph appears to be drawn correctly at first glance, however the units on the *y* axis are incorrect. This should be of the form ln(A/s^{-1}). The scales were well chosen by this candidate as the plots are spread over half the page and each large square is a multiple of 2. Although the plots are accurate this candidate joined the first and last points to form the best fit line leaving too many data points above the line. This graph scores 2 out of 4.

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Examiner Tip

Choose scales that are easy to read, such as values of 1, 2 or 5 and their multiples of 10.

(e) Use the graph to determine a value for λ.

(4)

$$\text{Gradient} = \frac{5{\cdot}011 - 3{\cdot}332}{-160}$$

$$= -0{\cdot}0105$$

$$\therefore \lambda = 0{\cdot}0105$$

λ = 0·0105

ResultsPlus

Examiner Comments

In part (e) the candidate chose two data points from the best fit line, which is acceptable provided that the points do lie on the line. Unfortunately, although the gradient was correct it was not shown as negative. In addition no unit was given for the final answer so the candidate scores 2.

(f) The half-life of a radioactive isotope is given as $t_{1/2} = \frac{0.69}{\lambda}$.

(i) Calculate a value for the half-life of protactinium-234.

(1)

$\frac{0.69}{0.0105} = 65.7$ or 1.095 minutes

Half-life = 1.095 minutes ~~65.7 seconds~~

(ii) The half-life for this isotope is quoted as 1.2 minutes.

Comment on the accuracy of your answer.

(2)

$\% D = \frac{1.2 - 1.095}{1.2} \times 100\% = 0.09\%$

% D is small enough to be compared to expected % uncertainity of my value of $t_{1/2}$. So, the accuracy of my answer is high.

(Total for Question 4 = 16 marks)

TOTAL FOR PAPER = 40 MARKS

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Examiner Comments

Finally in part (f), the candidate correctly calculates the half-life with the correct unit and scores 1. However, the calculation of the percentage difference was incorrect as there was no multiplication by 100 and, since the comment depended on this correct calculation, the candidate fails to score any marks despite stating a well worded comment.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- When choosing the most suitable measuring instrument for a given context, consider how the instrument is to be used as well as the percentage uncertainty.
- When calculating a final percentage uncertainty check the number of significant figures required; often this will be one or two. Likewise, the number of significant figures in the final answer of a calculation should be the same as the data used.
- Be specific when describing experimental techniques, for example, when describing where a timing marker should be placed in an oscillation experiment.
- When choosing an appropriate straight-line graph to plot, only use a log-log graph when the power is unknown, for example when a power law is being tested.
- Scales for graphs should be chosen so that the plotted points cover at least half the page. However, choose a scale that is easy to read, for example, scales that increase in 1, 2 or 5 and their multiples of 10, rather than trying to fill the page with an awkward scale. Scales based on multiples of 3, 4 and 7 lead to the most plotting and interpolating errors.
- Units on graphs should reflect those given in the results table. If a logarithm is applied to a variable then this will have no unit, for example, ln(A/s).
- When a gradient is negative, ensure that the negative sign is used in the answer.
- To be successful in this paper, candidates should practise using apparatus and techniques in a variety of contexts. In addition practising planning a variety of experiments will also help develop these skills.

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