Pearson Edexcel

Examiners' Report
June 2023

International Advanced Level Physics WPH16 01

ResultsPlus

Introduction

The IAL paper WPH16 Practical Skills in Physics II assesses the skills associated with practical work in Physics and builds on the skills learned in the IAL paper WPH13. This paper assesses the skills of planning, data analysis and evaluation which are equivalent to those that A level Physics candidates in the UK are assessed on within written examinations. This document should be read in conjunction with the question paper and the mark scheme which are available at the Pearson Qualifications website, along with Appendix 10 in the specification.

In this specification, it is expected that candidates will carry out a range of Core Practical experiments. The skills and techniques learned from carrying out these experiments will be examined in this paper, but the Core Practical experiments themselves are not assessed. Candidates who do little practical work will find this paper more difficult as many questions rely on applying the learning to novel as well as other standard experiments.

It should be noted that, whilst much of the specification is equivalent to the previous specification, there are some notable differences. Candidates are expected to know and use terminology appropriately, and use standard techniques associated with analysing uncertainties. These can be found in Appendix 10 of the specification. In addition, new command words may be used which challenge the candidates to form conclusions. These are given in Appendix 9 of the specification, and centres should make sure that candidates understand what the command words mean.

The paper for June 2023 covered the same skills as in previous series and was therefore similar in demand.

Question 1 (a)

This question was set in the context of using a water flow device to monitor the flow rate of water in a river. Although this was an unfamiliar context, the use of an oscilloscope to measure time is found in Core Practical 6: Speed of Sound.

In part (a) candidates had to describe a simple method to determine the volume flow rate of water leaving the water tank. It was clear that some candidates did not take account of the depth of water remaining constant as some described measuring the internal volume of the water tank. In addition, some candidates described measuring *h* which was unnecessary. Of those that scored marks, the majority stated how to calculate the volume flow rate and that a time should be measured. In general, candidates were not specific about needing to measure the time for a **fixed** volume or the volume for a **fixed** time.

(a) Describe a simple method to determine the volume flow rate of the water moving out of the tube.

(3)

Measure the time taken for the water to fill a fixed volume of water, this could be a beaker of $100 cm^3$ ~~of~~ or a measuring cylinder of $100 cm^3$. Measure the time taken to fill the water using a stop watch. Ensure to repeat the experiment and calculate a mean time for each value of h. This will reduce random error. Flowrate is given by volume / time taken. The answer will be in $cm^3 s^{-1}$

~~vol~~ $\text{flow rate} = \frac{\text{volume}}{\text{time}}$

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Examiner Comments

This response scored 3 marks. The first two marks on lines 1 and 2, and the final mark at the bottom of the response. The additional detail in the middle is correct but not necessary for the question, however on other responses this may have been given credit.

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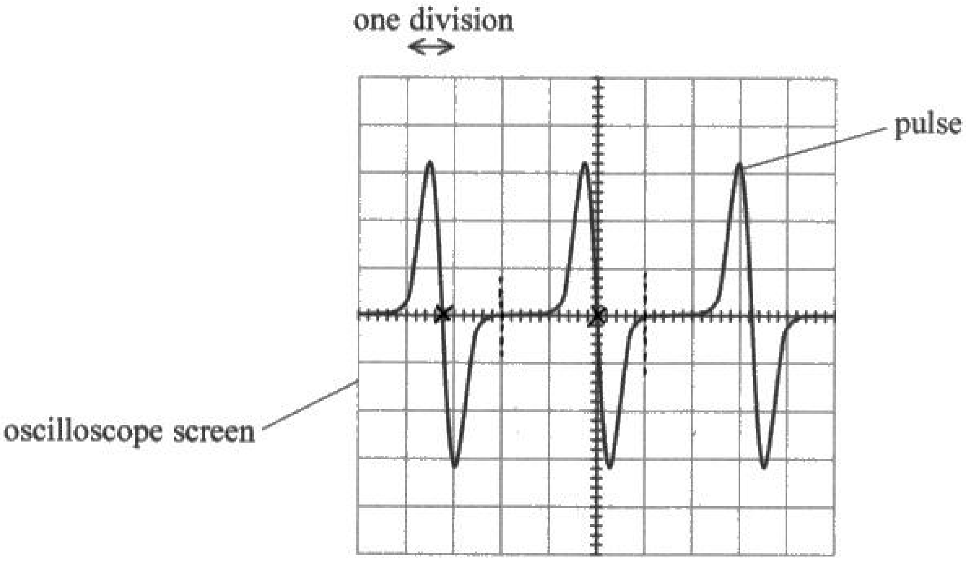
Examiner Tip

Simple methods only need short statements of the variables to be measured and, in this case, what to do with the measurements.

Question 1 (b)

In part (b) candidates had to calculate the frequency of the pulses displayed on the oscilloscope screen. In general, candidates were more successful than in previous series. However, the most common error was not determining the time period accurately. Some candidates only measured from the point the trace left the horizontal axis to where it returned, ignoring the space in between pulses. Some candidates attempted to determine the time for multiple pulses then divided by the number of pulses rather than the number of gaps in between. It was clear from some diagrams that candidates attempted to extrapolate from a peak to the horizontal axis, which lead to inaccurate values. Candidates should also note that all working must be shown to be awarded marks.



The horizontal axis represents time.

The time scale was set to 50 ms per division.

Calculate the frequency *f* of the pulses.

(3)

$\frac{1}{T} = f$ $\quad 5 - 1.8 = 3.2$ divisions

$3.2 \cdot (50 \cdot 10^{-3}) = 0.16$ s

$\frac{1}{0.16} = f$

$f = 6.25$ Hz

$f =$ 6.25 Hz

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Examiner Comments

This response scored 3 marks. The candidate had clearly marked on the horizontal axis where the measurements were being taken from and included all working.

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Examiner Tip

Use places where the trace crosses the horizontal axis to measure time accurately.

Question 1 (c)

Part (c) proved to be problematic for many candidates. This part required candidates to describe a method to investigate how *f* varied with volume flow rate. As with part (a) many candidates described measuring *h* which was not necessary. In addition, many then followed with a graph of *f* against *h* which would not answer the question. Some also described how to measure *f* which was not needed as this was tested in part (b). In general, candidates appeared not to take notice of how many marks the question was worth and therefore wasted time by including irrelevant detail. In addition, many responses went beyond the lines given. Another common error was not being specific about measuring *f* and **known values** of volume flow rate.

(c) Describe how the student could investigate how *f* varies with the volume flow rate of the water.

(3)

The student could change the volume flow rate by changing h at regular intervals. This will change the frequency as well. Measure the frequency and volume flow rate for at least 5 different ~~re~~ values of h. repeat ~~eo~~ each experiment 3 times and find mean. ~~Plo~~ Finally plot a graph of frequency against volume flow

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Examiner Comments

This response scored 3 marks. The first mark was scored on lines 3 and 4 and the second mark on line 2. The final mark can be seen on line 6 but appears to go out of the clip. The additional information was unnecessary.

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Examiner Tip

Check how many marks the question is worth. Usually one mark is awarded for each piece of relevant information that answers the question.

Question 1 (d)

Finally, in part (d) the candidates were told that the water flow device was connected to a data logger and used to monitor the flow of water in a river overnight. Candidates were asked to give two reasons why a data logger was appropriate for this task. As is usual for this type of question, candidates give standard answers, such as simultaneous measurements and high sampling rates, without considering the context of the investigation. Those that scored marks either stated that the device would not need monitoring or that the data logger could take measurements for a long period of time. Note that stating "a data logger would be able to record overnight" was not accepted as this was given in the question.

Give **two** reasons why a data logger is an appropriate piece of equipment to use for this task.

(2)

Data logger records information automatically without the need to keep in check. It loggs water flow and time taken ~~log~~ and hence, the frequency over a long period of time.

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Examiner Comments

This is an unusual response that scores 2 marks. The first mark is scored on lines 1 and 2. Note that "records information automatically" alone would not have scored the mark, but it was the sense of not needing to monitor the data logger that scores the mark. The second mark is scored on lines 3 and 4.

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Examiner Tip

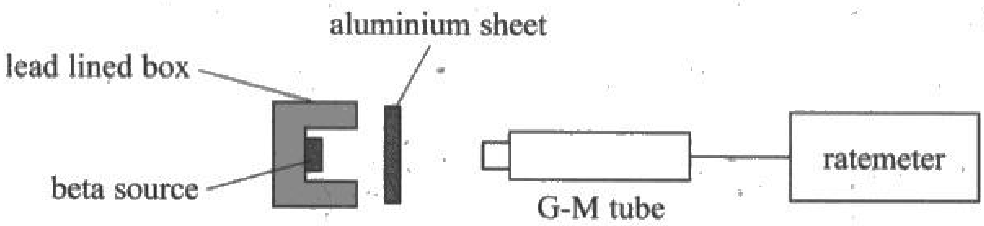
Think about the context in which a data logger is being used.

Question 2 (a)

This question assessed planning skills within the context of investigating the absorption of beta particles in aluminium. The techniques used in this practical can be found in Core Practical 15: Gamma Radiation.

In part (a) candidates had to state two safety precautions for the investigations. As is usual for this question some candidates focused on using personal protective equipment, which is not needed for a laboratory beta source. In addition, some candidates stated that the source should be placed in a lead lined box when not in use, but the diagram already showed the source in such a container. Using shielding was also a common response, therefore it appears some candidates had not interpreted the diagram correctly. Candidates should also be careful in their spelling of **tongs** as spellings that result in a different word are not accepted.

2 The absorption of beta particles in aluminium can be investigated using the apparatus shown.



(a) State **two** safety precautions for this investigation.

(2)

Handle radio active source with tongs. keep a safe distance from the source, limit exposure time.

ResultsPlus Examiner Comments

This response scores 2 marks. Note that the question asked for two safety precautions and this candidate gave three. In this case all three were correct so there is no penalty. However, candidates that give more responses than the number specified risk marks being lost if one of the responses is incorrect or contradicts another response.

ResultsPlus Examiner Tip

When a question asks for a specific number of responses only give that number, so in this case only give two safety precautions.

Question 2 (b)(i)

In part (b)(i) candidates had to explain how a graph of ln *C* against *x* could be used to test the validity of the exponential relationship given. This type of question should be very familiar however there may be a slightly different emphasis that candidates should be aware of. The first mark was for performing a correct log expansion of the given formula. There are only two forms this can take, either a power law such or an exponential function. However, some candidates did not complete this successfully. For the second mark candidates have to compare their log expansion with $y = mx + c$, which is standard for this type of question. The comparison must be **explicit**, ie the order of the log expansion must match the order of terms of the equation of a straight line. It should be noted that where two forms of the expansion are given, it is the final one that is used as the comparison. In some cases, candidates wrote $y = c - mx$ or missed out the operators, both of which were not credited. Candidates then had to identify the gradient correctly as $-m$. Some candidates missed the – sign, and some referred to "*m*" rather than state "the gradient is". Finally, the question asked why the graph could be used to test the validity of the relationship, therefore a comment stating why this is the case was necessary.

(b) A student planned to test whether beta particles are absorbed by aluminium according to the relationship

$$C = C_0 e^{-\mu x}$$

where
C is the count rate when the thickness of the aluminium sheet is x
C_0 is the count rate with no aluminium sheet
μ is a constant.

(i) Explain why a graph of $\ln C$ against x could be used to test the validity of this relationship.

(2)

$\ln C = \ln C_0 - \mu x$ is in the form of $y = mx + c$

$-\mu$ is gradient which is constant

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Examiner Comments

This is a common response worth one mark. Although this candidate did correctly identify the gradient as being constant, the order of the terms of the equation of a straight line does not match the order of the expansion. This expansion is in the form *y* = *c* + *mx*.

ResultsPlus
Examiner Tip

To make the comparison explicit, ensure the order of the expansion matches the order of equation of a straight line.

Question 2 (b)(ii)

Part (b)(ii) was the familiar planning question. Candidates should be aiming to write a method for the investigation described in the question that could be followed by a competent physicist. Although marks were not awarded for linking ideas, candidates often used vague language, or their descriptions did not follow logically. The best answers were structured and concise, leading to a method that could be followed easily. Unusually, this question was not answered well despite the similarity to the core practical, and often responses lacked sufficient detail. In addition, some candidates wasted time by describing the graph to plot which had already been given in part (b)(i), and how to handle the source safely which was tested in part (a).

The mark scheme for this type of the question can vary owing to the context of the experiment however they all follow a similar structure. The first four marks were for describing how to obtain sufficient and valid data to test the validity of the relationship. Of these, candidates most often scored the marks for measuring the thickness with a micrometer and using at least five different values of thickness. However, some candidates decided that a metre rule was appropriate to measure the thickness of the aluminium sheet. In addition, some stated that different thicknesses should be used without stating how many. Some candidates also stated that the distance should be measured with a metre rule, then did not state explicitly that it should be kept constant. Occasionally candidates then went on to vary the distance, which is an entirely different investigation.

The final three marks were for techniques to improve accuracy. Measuring and subtracting the background count was a popular response. It was unusual to see responses referring to techniques to measure the thickness of the aluminium sheet accurately despite this being a common question in past series.

(ii) Devise a plan to obtain the data required to test the validity of this relationship.

(6)

Measure the thickness, x using a verner calliper. at different Positions and orientations and calculate the mean. Measure the count rate for a long period of time. Vary x, thickness to get atleast 5 sets of values. Measure the ~~co~~ Initial count rate when the aluminium sheet is removed. to get C_0. Measure the background count rate and Subtract the background count rate from the count rate. to avoid Systematic error. Plot a graph of $\ln C$ against x to check If it is a Straight line.

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Examiner Comments

This is a clear response worth 5 marks. Line 1 scores the first mark. Unusually, this candidate included how to measure the thickness accurately in line 2 to be awarded the fifth mark. The second and third marks on lines 3 and 4. Finally, the seventh mark is scored on lines 7 and 8.

ResultsPlus
Examiner Tip

Think about how to collect sufficient and valid data that answers the question. If the question has already asked about safety and a graph there is no need to include it again.

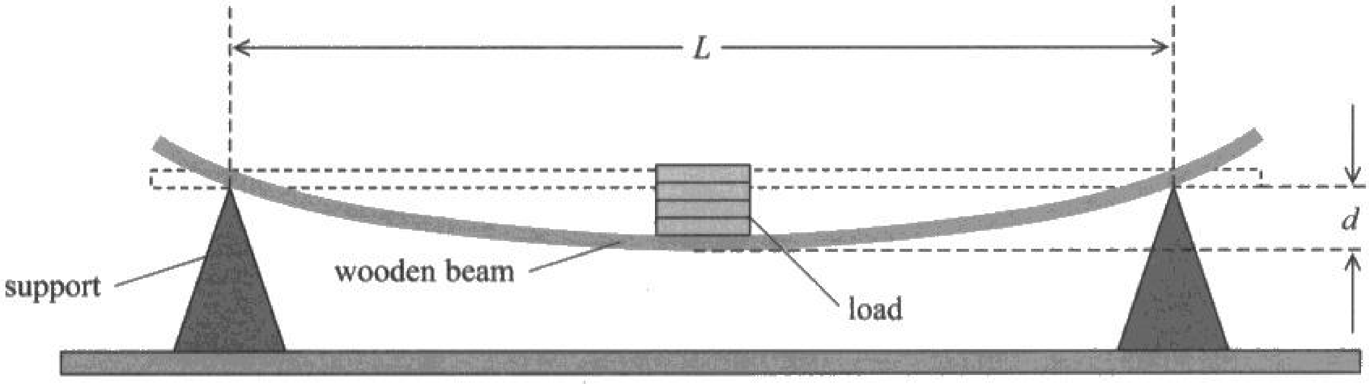
Question 3 (a)

This question involved plotting and analysing the graph for an investigation involving the bending of a wooden beam. A question involving a graph appears in each series and the mark scheme follows a common format. Therefore, there is plenty of opportunity to practise this skill and consult Examiner's Reports to correct common errors. A good candidate should be able to access most of the marks and most candidates should score some marks.

In part (a) candidates had to describe an **accurate** method to determine a **single value** of the distance *d* using a 15 cm ruler. The first mark was for describing how to obtain a value for *d* which many candidates did not do. Those that described this sometimes forgot to subtract the two values, or placed the ruler at the support for one measurement and did not specify that it would be moved to the centre of the beam when the load was added. The final two marks were for techniques to improve the accuracy of the measurements. As this was a **single** value, repeating and calculating the mean was not accepted. Of these marks, ensuring the ruler was vertical and reading perpendicularly to the scale were most awarded. However, some candidates either did not specify a set square or similar or used the word "perpendicular" without stating with respect to the bench. Some candidates were awarded this mark from a drawing on the diagram. A small number of candidates described creative uses of the 15 cm ruler, including using it as a horizontal marker.

3 A student investigated the bending of a flexible wooden beam.

The student placed a load on the wooden beam. The centre of the beam was displaced by a distance d as shown.



(a) Describe an accurate method to determine a single value of d using a 15 cm ruler.

You should include any additional apparatus.

(3)

Measure distance at centre of L. Measure height from table ~~top~~ to wooden beam without any mass and use a set square to ensure ruler is vertical when taking measurements. Read scale perpendicularly to avoid parallax error and then add mass and measure distance from table to wooden beam again and find the differences between the two measurements to obtain d.

ResultsPlus Examiner Comments

This response scores 3 marks. The method is clear and would lead to an accurate value for *d*.

ResultsPlus Examiner Tip

Ensure that you can describe techniques for using common pieces of apparatus.

Question 3 (b)(i-iii)

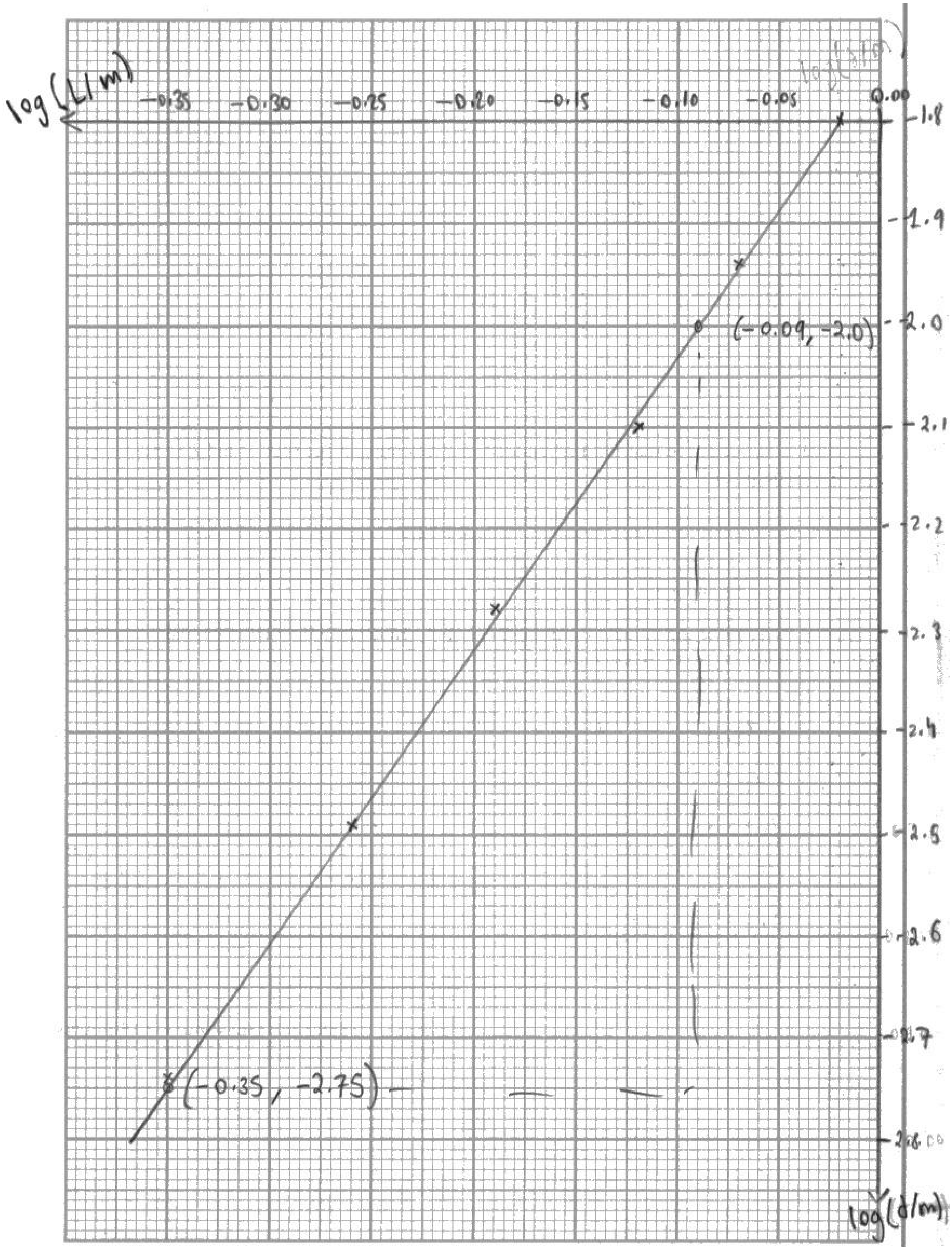
Part (b)(i) assessed the candidates' ability to process data and plot the graph of log *d* against log *L*. The first two marks were for processing the data correctly. It is expected that candidates use base 10, however as the logarithms for both variable are required other bases were not penalised. On rare occasions, candidates gave one set of values to base 10 and used natural logs for the other set of values. To gain these marks, the values must be **correct** and given to a **consistent** number of decimal places sufficient to plot a graph accurately on standard graph paper. For logarithms candidates should give **two** decimal places although **three** is accepted and was more valid for this graph. The most common errors here were truncating rather than rounding, using an inconsistent number of decimal places in processed data, or using too many decimal places.

The third mark was for placing the axes the correct way around and labelling with the correct quantity. Some candidates inverted the axes, i.e., they plotted log *L* against log *d*. Candidates should note that the question is always written in the form "plot *y* against *x*". This also often lead to mistakes in later parts. The most common mistake is not using the correct format for labelling a log axis, either by missing out the brackets or units or both. The correct form is log (quantity/unit), eg log (*d* / m). Some candidates converted their *d* and/or *L* values, presumably to avoid negative numbers, however some then did not use the correct unit in the axis label. As the graph involved negative numbers, candidates often inverted their axes. This was accepted provided both were inverted. In addition, candidates placed their axes on the left of the grid and at the bottom of the grid. These were also accepted but often lead to mistakes later in the question.

The fourth mark was for choosing an appropriate scale. At this level, the candidates should be able to choose the most suitable scale in **values of 1, 2, 5 and their multiples of 10** such that **all** the plotted points occupy **over half the grid in both directions**. Candidates should realise that although the graph paper given in the question paper is a standard size the graph does not have to fill the grid. In most cases a landscape graph is unnecessary. Candidates at this level should also realise that scales do not have to start from zero, and this was the most common error. Scales based on 3, 4 (including 0.25) or 7 are awkward and not accepted. Candidates should also be encouraged to label every major axis line, i.e. every 10 small squares, with appropriate numbers, so that examiners can easily see the scale used. A minority of candidates tried to use the values of log *L* as their scales.

The fifth mark is for accurate plotting. Candidates should be encouraged to use neat crosses (´ or +) rather than dots when plotting points. Candidates were not awarded this mark if they used large dots that extended over a small square or used an awkward scale. Mis-plots were common owing to the negative scales. Candidates should be encouraged to check a plot if it lies far from the best fit line.

The final mark is for the best-fit line. This mark was awarded often as the data used did not produce a significant scatter. Often candidates will join the first and last points instead of judging the scatter of the data points which can lead to errors. Where candidates were not awarded this mark it was either because the line was too thick, i.e. over half a small square, discontinuous, or had a clear bend. In addition, some lines did not reach the last data point. Candidates should be encouraged to use a 30 cm ruler for this examination.



log(L/m)
−0.35
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
−1.8
−1.9
−2.0
−2.1
−2.2
−2.3
−2.4
−2.5
−2.6
−2.7
−2.8
(−0.09, −2.0)
(−0.35, −2.75)
log(d/m)

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Examiner Comments

This is a clear example that scores all 6 marks. The log values were all correct and all given to 2 decimal places. The axis labels are in the correct format and the scales are sensible. Note that the *y* axis starts from 1.8. The data points are all correct and the candidate used neat crosses. The best fit line is straight, continuous, covers the range of data points and has an even spread of data points on either side of the line. Note that this candidate has drawn a triangle on the graph for the gradient calculation.

ResultsPlus
Examiner Tip

Practise drawing a variety of graphs under time constraints.

In part (b)(ii) candidates were asked to determine the gradient of the graph. There were several common errors seen. The first mark is for using a **large triangle** to calculate the gradient of the graph. Unusually, some candidates inverted their gradient. Many candidates used the first and last points, or other data points from the table. This is only acceptable if the data points lie **exactly** on the best fit line. Candidates should be encouraged to find places where the best-fit line crosses an intersection of the grid lines near the top and bottom of the best-fit line and **to mark these as a triangle on the graph**. Those that used awkward scales were often only successful when sensible values were used. The final mark could be awarded from an incorrect gradient, but often candidates used too many or too few significant figures. Occasionally, candidates forgot that the data was negative, which resulted in an incorrect gradient.

(iii) It is suggested that for a given load, the relationship between d and L is of the form

$$d = kL^r$$

where r and k are constants.

Determine the value k from the graph and hence write the mathematical relationship between d and L.

(3)

$\log(d) = r \log L + \log k$ $\quad$ L x, d y $(-0.09, -2.0)$

$r = 2.88$

~~log(-2~~

$-2 = 2.88 \cdot (-0.09) + \log k$

$\log k = -1.7408$

$k = 10^{-1.7408}$ $\quad$ $k = 0.0181635$

$\therefore$ $d = 0.018 L^{2.88}$

ResultsPlus Examiner Comments

This response follows on from the graph above and scores all three marks. The candidate chose sensible points where the line crossed intersections of the grid lines to form their triangle. The triangle covers at least half of the plotted data points and the Δy and Δx are the correct way round. The final value is within range and given to an appropriate number of significant figures.

ResultsPlus Examiner Tip

Mark the gradient triangle on the graph to avoid mistakes in extrapolating the data.

In part (b)(iii) candidates had to determine the mathematical relationship. Most scored at least one of the first two marks. Many read the value of log *k* correctly from the graph, or correctly calculated the value using the gradient and a data point from the best fit line. It was here that those candidates who placed their *y* axis on the left of the page made a mistake in determining the *y* intercept as they extrapolated the line to the axis drawn. In addition, some tried to estimate a *y* – intercept by extending the axis beyond the grid lines, or stated that this was the value of *k*. Some candidates that calculated the *y* intercept got confused with the negative data. Many scored the second mark by converting the log value, but some candidates used the incorrect antilog function. The final mark was for placing these values in the mathematical relationship to a sensible number of significant figures. Many candidates did not attempt this.

(iii) It is suggested that for a given load, the relationship between d and L is of the form

$$d = kL^r$$

where r and k are constants.

Determine the value k from the graph and hence write the mathematical relationship between d and L.

(3)

$\log(d) = r\log L + \log k$ $\quad$ $(\underset{x}{\overset{L}{-0.09}}, \underset{y}{\overset{d}{-2.0}})$

$r = 2.88$

~~log L = 2~~

$-2 = 2.88 \cdot (-0.09) + \log k$ $\quad$ $\therefore$ $d = 0.018L^{2.88}$

$\log k = -1.7408$

$k = 10^{-1.7408}$ $\quad$ $k = 0.0181635$

ResultsPlus
Examiner Comments

This response follows on from the graph above where the candidate started the *y* axis from 1.8 which meant that the *y* intercept could not be obtained from the graph. Instead, the candidate used a data point from the best fit line and the gradient to calculate the *y* intercept. This candidate cleverly used a data point used in the gradient calculation. This response scores all three marks.

ResultsPlus
Examiner Tip

Practise using both methods to obtain a *y* intercept.

Question 4 (a)(i)

This question involved determining a value for the density of a fluid using the oscillations of a weighted test tube. This involved the techniques used to measure time period which candidates encounter in Core Practical 16: Oscillations. In addition, the analysis of uncertainties is common to all past papers therefore candidates should be encouraged to analyse uncertainties on a regular basis, either whilst making measurements or using past papers. Candidates should read Appendix 10 of the specification and **include all working** as marks are awarded for the method.

Part (a)(i) was a familiar question in which candidates had to describe two techniques to determine the time period of the oscillation. In general, candidates scored well on this question. Many candidates stated “repeat and calculate a mean” however this was not accepted as this was given in the question. Other common responses included using light gates and data loggers. These are not measuring techniques but are **modifications** and were not given credit. Candidates should also check the number of marks being awarded as many responses went beyond the lines given.

(a) The student measured the time period T of the oscillations using a stopwatch. She repeated the measurement of T and calculated a mean.

(i) Describe **two** other techniques she should use to determine T.

(2)

Use of markers at the position the spheres are in equilibrium.

start the stopwatch after a few oscillations to minimise random error.

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Examiner Comments

This response scored two marks. Note that this candidate only gave the two responses which were asked for. References to minimising errors are irrelevant as this is a "describe" question not an "explain" question, however these were treated as neutral responses.

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Examiner Tip

Learn the techniques for measuring time period with a stopwatch and only give the number of techniques the question asks for.

Question 4 (a)(ii)

Part (a)(ii) involved calculating a mean and uncertainty from a set of data. The first mark was for the correct value of the mean given to the **same number of decimal places as the measurements**. Many candidates gave too many decimal places or did not divide the mean by five to obtain *T*. The second two marks were for the uncertainty calculation. The candidates **must show** the uncertainty calculation for the second mark, and this is awarded for calculating the **half range or furthest from the mean**. Some candidates calculated the percentage uncertainty. The final mark was for the correct uncertainty given to the same number of decimal places as the mean.

(ii) She recorded the following measurements.

$5T$ / s	3.43	3.36	3.28	3.49

Calculate the mean value of T and its uncertainty in seconds.

(3)

$$\bar{T} = \frac{3.43 + 3.36 + 3.28 + 3.49}{5 \times 4} = 0.68\,s$$

$$U_T = \frac{3.49 - 3.28}{5 \times 2} = 0.02\,s$$

Mean value of T = 0.68 s ± 0.02 s

ResultsPlus
Examiner Comments

This is a clear response scoring all three marks. Note that the calculation for the uncertainty is awarded a mark so it is important to include all working.

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Examiner Tip

Ensure that the number of decimal places for the mean matches the data given.

This is a common response where the candidate did not divide by 5 to obtain the time period so could not be awarded the first mark. However, both uncertainty marks were still available provided the uncertainty for the calculated mean was given.

(ii) She recorded the following measurements. oscillation

$5T$ / s	3.43	3.36	3.28	3.49

Calculate the mean value of T and its uncertainty in seconds.

(3)

$$\text{Mean} = \frac{3.43 + 3.36 + 3.28 + 3.49}{4}$$

$$= 3.39 \text{ s}$$

$$\Delta \Rightarrow \frac{\text{max} - \text{min}}{2} = \frac{3.49 - 3.28}{2}$$

$$= 0.105 \approx 0.11$$

Mean value of T = 3.39 s ± 0.11 s

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Examiner Comments

This response scores the two uncertainty marks. The half range is clearly calculated and the uncertainty for that mean value is given to the same number of decimal places as the mean.

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Examiner Tip

Ensure the number of decimal places for the uncertainty matches the number of decimal places for the mean.

Question 4 (b)

In part (b) candidates had to **explain** why vernier calipers were a suitable instrument to measure a diameter of 2 cm. The question also encouraged the candidate to include a calculation which was intended to give them a clue as to what was expected. However, despite this, and similar questions appearing in previous series, this was poorly answered. There were some answers, such as “vernier calipers are suitable for this measurement” or “vernier calipers have a small resolution”. Some candidates tried to compare to a metre rule, eg “smaller resolution than a ruler”. The first mark was for stating the resolution of standard vernier calipers, ie 0.1 mm. Some candidates used 0.01 mm, or other values, or did not include a unit. As this is an **explain** question this could not be inferred from a calculation. Other terms are accepted for resolution however **precision** and **accuracy** are not accepted. In addition, some candidates confused resolution with uncertainty. It is expected that the uncertainty in a **single** measurement is **half** the resolution. This was also a common error in the calculation of the percentage uncertainty in the second mark. Some candidates did calculate this correctly, however they then did not make a suitable statement. Some candidates compared this to an arbitrary percentage, eg 5% or 1% which was not accepted. Some candidates compared this to the percentage uncertainty for a ruler, which was acceptable if done correctly.

(b) The student estimated that the diameter of the test tube was approximately 2 cm.

Explain why vernier calipers are a suitable instrument to measure the diameter.

Your answer should include a calculation.

(2)

vernier ~~cap~~ calipers have a resolution of 0.1 mm

$u\% = \frac{0.05}{2 \times 10} \times 100\% = 0.25\%$ the percentage uncertainty is relative low. so it's a suitable instrument.

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Examiner Comments

This response scores two marks.

ResultsPlus
Examiner Tip

When planning experiments, practise justifying why a particular instrument is suitable for a measurement.

This candidate uses the term "precision" instead of "resolution".

(b) The student estimated that the diameter of the test tube was approximately 2 cm.

Explain why vernier calipers are a suitable instrument to measure the diameter.

Your answer should include a calculation.

(2)

Precision of vernier calliper is ~~0.1mm or~~ 0.01 cm, so it uncertainity is 0.005 which is very small. Hence the percentage uncertainity of the diameter is $\frac{0.005}{2} \times 100 = 0.25\%$ which is ~~very~~ ~~a~~ very small hence it is a suitable instrument.

ResultsPlus Examiner Comments

This response scores one mark for the percentage uncertainty calculation and the comment.

ResultsPlus Examiner Tip

Check the meaning of the terms resolution, precision and accuracy in the Glossary of Appendix 10 of the specification.

This candidate did not state the resolution of the vernier caliper. This is an "explain" question therefore this must be explicit and cannot be inferred from a calculation.

(b) The student estimated that the diameter of the test tube was approximately 2 cm.

Explain why vernier calipers are a suitable instrument to measure the diameter.

Your answer should include a calculation.

(2)

% uncertainty of vernier calipers $= \frac{\frac{1}{2} \times 0.01}{2\text{cm}} \times 100 = 0.25\%$

The percentage uncertainty ~~of the~~ of measuring using vernier calipers is small therefore vernier calipers are a suitable instrument to measure the diameter.

ResultsPlus
Examiner Comments

This response scores one mark for the percentage uncertainty calculation and comment.

ResultsPlus
Examiner Tip

Ensure that you explain why the percentage uncertainty has that value by referring to the resolution of the instrument.

Question 4 (c)(i-iii)

In part (c)(i) they were asked to **show that** the density of the liquid was about 1200 kg m^{-3}. Generally, candidates scored well on this part. For a **show that** question, all working must be shown, and candidates should give their final answer to at least one more significant figure than the value. It should be noted that a sensible number of significant figures is expected in a practical paper, so the mark may not be awarded if there are too many.

(i) Show that ρ is about 1200 kg m^{-3}.

$D = 2.38\text{ cm} \pm 0.01\text{ cm}$
$T = 0.61\text{ s} \pm 0.01\text{ s}$
$m = 48.95\text{ g}$

(2)

$$\rho = \frac{16\pi m}{T^2 D^2 g}$$

$$= \frac{16 \times \pi \times 48.95 \times 10^{-3}}{(0.61)^2 \times (2.38 \times 10^{-2})^2 \times 9.81}$$

$$= 1189.9 = 1190\ \text{kg m}^{-3}$$

ResultsPlus
Examiner Comments

This response scores two marks. The candidate chose to rearrange the formula before making the substitution which is accepted provided it is correct. All the powers of 10 are correct and a sensible number of significant figures are given.

ResultsPlus
Examiner Tip

To be awarded a "use of" mark the values from the question must be substituted into the correct place in the formula.

In part (c)(ii) they were asked to **show that** the percentage uncertainty in the density was about 4%. Candidates used two methods of solving this, either by combining percentage uncertainties, or by using the maximum and minimum method. Those that used percentages were often more successful. Those that used the maximum and minimum method often did not show their working for these values. Again, the number of significant figures is important in a practical paper, particularly for uncertainties, and only two or three significant figures was accepted.

(ii) Show that the percentage uncertainty in ρ is about 4%.

(3)

% U of m = considered negligible

% U of $T^2 = \left(2 \times \frac{0.01}{0.61}\right) \times 100 = \cancel{3.28}\ 3.28$

% U of $D^2 = \left(2 \times \frac{0.01}{2.38}\right) \times 100 = 0.84$

$\therefore$ Percentage uncertainty in ρ = 3.28 + 0.84

= 4.12 %

[shown]

ResultsPlus
Examiner Comments

This response scores three marks. The calculation is clearly laid out in steps and the final answer is given to a sensible number of significant figures.

ResultsPlus
Examiner Tip

Ensure you know how to calculate and combine percentage uncertainties.

In this example the candidate shows the calculation in one step, which is accepted provided it is clear.

(ii) Show that the percentage uncertainty in ρ is about 4%.

(3)

$u\%\,\rho = \cancel{u\%\,D^{2} + u\%\,T^{2}}$ $\quad u\%\,\rho = 2 \times u\%\,D + 2 \times u\%\,T$

$$= 2 \times \frac{0.01}{2.78} \times 100 + 2 \times \frac{0.01}{0.61} \times 100$$

$$= 4.12\,\%$$

ResultsPlus
Examiner Comments

This response scores three marks.

ResultsPlus
Examiner Tip

Ensure all working is clearly laid out.

Finally, in part (iii) candidates were given the density glycerol and had to **deduce whether** the liquid could be glycerol. This is a standard type of question used in every series but there were some that did not attempt this or just made a vague statement with no calculation. The command word **deduce** means that a calculation is needed, and **whether** means a conclusion is required. Candidates can use different methods, but they **must show their working** as marks are awarded for the method, and the final value may differ slightly owing to different levels of rounding. The first method was calculating the limits for the measured density using the calculated percentage uncertainty. This was generally done well as some candidates used the show that value. The most common error here was calculating the limits of the stated density rather than the measured density. A smaller number used the percentage difference method. This is an accepted method but can produce more errors, most notably using the calculated value or the mean of the measured and quoted values in the denominator. A smaller number used the maximum and minimum method. For all methods, the final mark was for a correct conclusion. As in previous series, the main error with the conclusion was not explicitly making a comparison between relevant values.

(iii) The density of glycerol is $1260\,\text{kg}\,\text{m}^{-3}$.

Deduce whether the liquid could be glycerol.

(2)

$\frac{104.12}{100} \times 1190 = \cancel{1239}\ 1240$

$\frac{95.88}{100} \times 1190 = 1140$

range $\rightarrow$ $1140 - \cancel{1239}$ 1240

since glycerol does not fall in the range, the liquid cannot be glycerol.

ResultsPlus Examiner Comments

This response scores two marks. This candidate calculated both limits which wasn't necessary as the quoted value was greater than the upper limit, however the limits are correct, and the comment is sufficient to score the marks.

ResultsPlus Examiner Tip

Check which limit you need to calculate by comparing the calculated value to the quoted value.

This candidate uses the percentage difference method.

(iii) The density of glycerol is 1260 $kg\,m^{-3}$.

Deduce whether the liquid could be glycerol.

(2)

$\% U = 4.12\%$

$\% D = \frac{(1260-1190)}{1260} \times 100$

$= 5.56\%$

Since the % D is greater than the % V then the liquid could not be glycerol

ResultsPlus
Examiner Comments

This response scores two marks. The percentage difference is correct, and the comment is sufficient to score the marks.

ResultsPlus
Examiner Tip

When using the percentage difference method, ensure the value being compared to is in the denominator.

Paper Summary

Candidates will be more successful if they routinely carry out and plan practical activities for themselves using a wide variety of techniques. These can be simple experiments that do not require expensive, specialist equipment. In particular, they should make measurements on simple objects using vernier calipers and micrometer screw gauges and complete all the Core Practical experiments given in the specification.

In addition, the following advice should help to improve the performance on this paper.

- Learn what is expected from different command words, in particular the difference between describe and explain.
- Use the number of marks available to judge the number of separate points required in the answer.
- Be able to describe different measuring techniques in different contexts and explain the reason for using them.
- Show working in all calculations.
- Choose graph scales that are sensible, i.e. 1, 2 or 5 and their powers of ten only so that at least half the page is used. It is not necessary to use the entire grid if this results in an awkward scale, i,e. in 0.25, 3, 4 or 7. Grids can be used in landscape if that gives a more sensible scale.
- Plot data using neat crosses (´ or +), and to use a 30 cm ruler to draw best fit lines. Avoid simply joining the first and last data points without judging the spread of data.
- Draw a large triangle on graphs using sensible points. Labelling the triangle often avoids mistakes in data extraction.
- Learn the definitions of the terms used in practical work and standard techniques for analysing uncertainties. These are given in Appendix 10 of the IAL specification.
- Revise the content of WPH13 as this paper builds on the knowledge from AS.