CAMBRIDGE TECHNICALS

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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

APPLIED SCIENCE

05847–05849, 05879, 05874

Unit 3 January 2022 series

Version 1

Contents

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

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Unit 3 series overview

The techniques presented in this unit underpin the work of scientists in the collection, analysis and presentation of data and information.

Candidate responses indicate growing strengths in data collection and presentation. Knowledge and understanding are generally secure when transferring data from tables to charts, performing simple calculations involving mean, median and mode or interrogating keys. Most candidates also gain at least half of the marks for developed calculations involving variance and standard deviation.

Understanding is less secure when selecting data from different sources to draw conclusions, justify conclusions or recognise conflicting evidence. Deducing the units of an equation from the dimensions of the numerator and denominator and application of the notation ± to calculate a range are weaknesses.

Selection of data for substitution into equations for quantitative chemical analysis is a particular area for improvement.

Candidates who did well on this paper generally did the following:	***Candidates who did less well on this paper generally did the following:***
• clearly showed their methods of calculations • followed the rubric instructions to select and use data from different sources correctly • demonstrated precision in plotting, labelling and drawing lines of best fit on graphs • recognised that different types of response are expected from questions with different command words • discussed both the trend and the source of error in the Level of Response question • discriminated between definitions of different sources of error and the difference between accuracy and precision.	• showed less attention to detail when plotting, labelling and drawing lines of best fit on graphs • ignored rubric instructions or did not locate and select data from identified sources • attempted to apply general knowledge to situations that required comparison of data sources.

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Question 1 (a)

1 The title page of a publication in a science journal is shown in **Fig. 1.1**.

The contents are fictional.

Laboratory Technology Reports
Volume 11, September 2016, Pages 11 – 32

An evaluation of different chromatography techniques: manual and automated.

Friedrich B. Bauer [a], Burkhard A. Fischer [a], Lucia C. Garcia [b], Pablo González [b], Jurgen D. Koch [a], Paula R. López [b], Ella A. Neumann [a], Hans R. Schmidt [a], Frieda W. Weber [a], Amelia T. Wolff [a]

[a] Scientific Gymnasium of Technology, Germany

[b] Instituto de Investigaciones Tecnologicas, Spain

Received 11 January 2016, Revised 20 February 2016, Accepted 10 April 2016, Available online 12 April 2016.

Fig. 1.1

(a) State the name of the journal that this work was published in.

.... **[1]**

Most candidates were able to name the journal.

Key point call out

Candidates should only give the name of the journal and not include any other details such as the volume number, month of publication, etc.

Question 1 (b) (i)

(b) **(i)** State the year that this scientific investigation was published.

.... **[1]**

All candidates identified the year of publication.

Question 1 (b) (ii)

(ii) Determine the approximate number of months between the paper submission date and when it was finally accepted for publication.

.... **[1]**

A common error was 4 months.

Question 1 (c)

(c) Explain how you can tell that this work was a collaboration between two research groups.

....

.... **[1]**

Most candidates identified groups in Spain or Germany, some referred to 'a' and 'b'.

Question 1 (d)

(d) State the name of the country where most of the authors worked.

.... **[1]**

Most candidates identified Germany.

Question 1 (e)

(e) One advantage of an online publication is that the findings can be made available to the wider scientific community very quickly.

Explain how **Fig. 1.1** shows that this is true.

.... **[1]**

Very few candidates used the data in Fig. 1.1 to determine that the paper was available 2 days after it was accepted. A common error was to refer back to the response given in Question 1 (b) (ii).

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Question 1 (f) (i)

(f) This article was published in a peer-reviewed journal.

(i) Describe what 'peer review' means.

....

....

....

.... **[2]**

Many candidates referred to the idea of checking (for review) but were unable to describe a peer in a scientific context. We needed to see a reference to another scientist, researcher or expert to award this mark. The majority of candidates did not gain full marks.

Key point call out

Candidates need to be taught that peer review occurs prior to publication. Or they need to qualify that the scientist doing the review should be an expert in the same field.

Question 1 (f) (ii)

(ii) State why peer review is important.

.... **[1]**

Few candidates gave a clear answer to this question. Marks were generally given for references to ensuring the validity of the work.

Key point call out

Candidates need to be taught that if a fellow expert is able to draw the same conclusions from the data then the work is validated.

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Question 2 (a)

2 Amari is a student who is interested in astronomy.

He finds the infographic in **Fig. 2.1** displayed in a science museum.

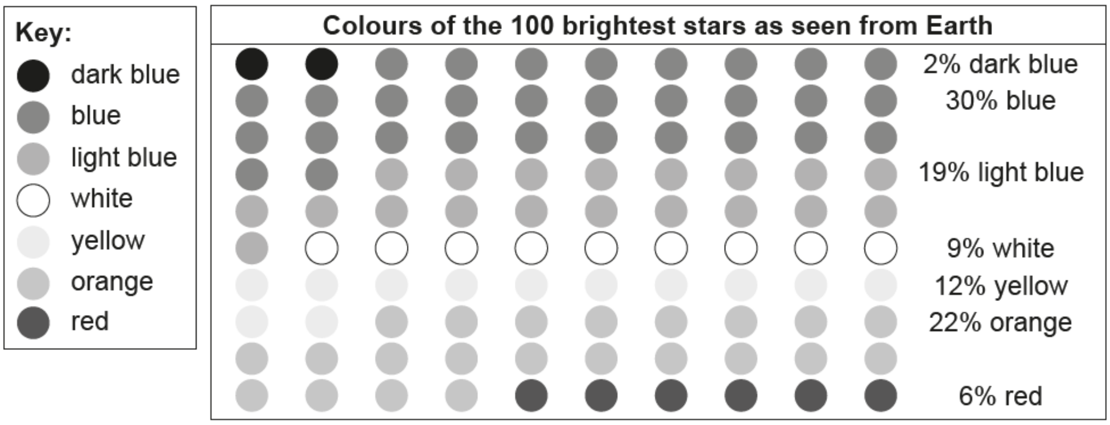

Fig. 2.1

(a) On **Fig. 2.2**, draw and label a bar chart of the percentage data shown in **Fig. 2.1**, in the order of colour shown.

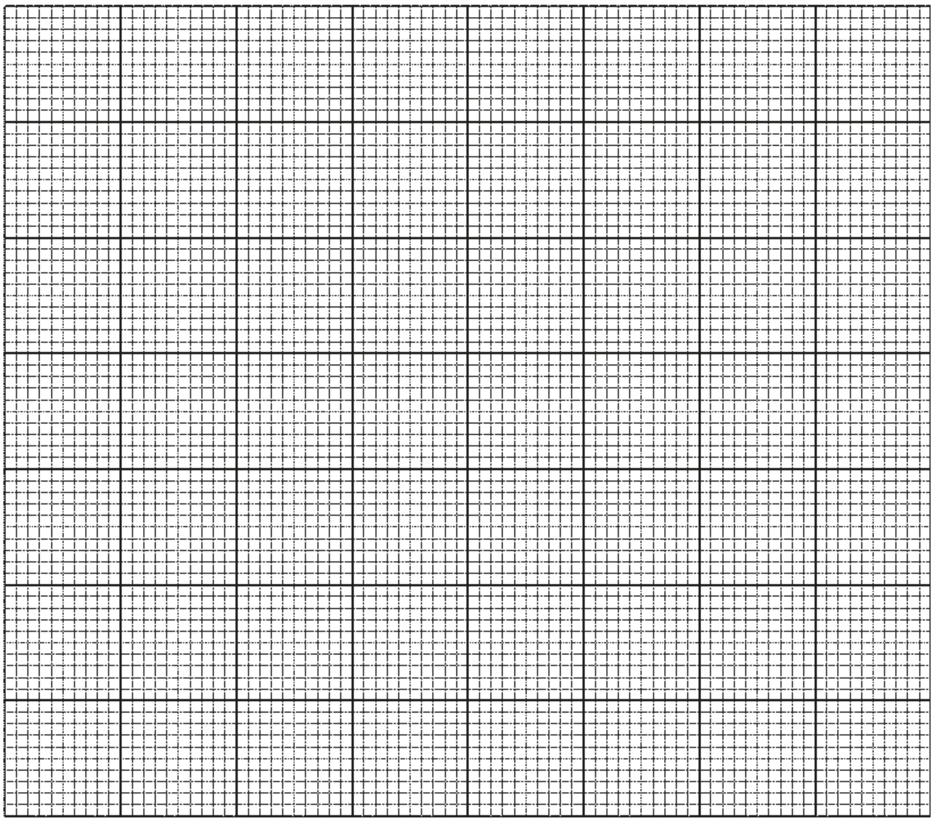

Fig. 2.2

[3]

Candidates who used an appropriate scale, e.g. 10 large squares = 5 were very unlikely to make plotting errors and were able to draw all bars to the correct height. A few candidates did not label one or both of the axes appropriately. Candidates must be taught that a bar chart displays discontinuous data (i.e. not a histogram) and that there must be gaps between the bars.

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Question 2 (b) (i)

(b) Amari finds some more information about stars and their colours.

Fig. 2.3 shows the range of wavelengths produced by three different stars:

- a G-type star with a temperature of 5000 °C
- a K-type star with a temperature of 4000 °C
- a M-type star with a temperature of 3000 °C.

The peak of each curve is the wavelength at which each type of star emits most of its light.

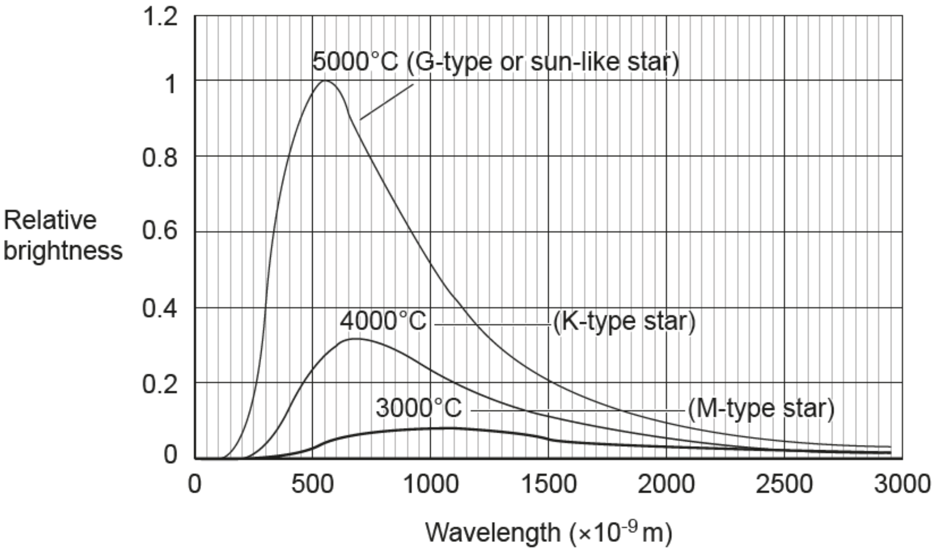

Fig. 2.3

Table 2.1 shows the range of wavelengths for the colours of the visible part of the electromagnetic spectrum.

Colour	Wavelength range (m)
red	(635 to 700) × 10^{-9}
orange	(590 to 635) × 10^{-9}
yellow	(560 to 590) × 10^{-9}
green	(520 to 560) × 10^{-9}
cyan	(490 to 520) × 10^{-9}
blue	(450 to 490) × 10^{-9}

Table 2.1

(i) Draw two vertical lines on **Fig. 2.3** to indicate the range of wavelengths of the visible part of the electromagnetic spectrum.

[1]

Only the more successful candidates were able to locate the values 450 and 700 on the x-axis and draw vertical lines from these points.

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Question 2 (b) (ii)

(ii) Amari thinks it is possible to deduce the average colour of the stars in **Fig. 2.3**.

Which **two** statements are reasons why Amari **cannot** deduce the average colour of these stars?

Tick (✓) **two** boxes.

A single colour is a range of wavelengths.	☐
Colour is discontinuous but wavelength is continuous.	☐
Colour is continuous but wavelength is discontinuous.	☐
Stars emit a range of wavelengths.	☐
The wavelength ranges are irregular.	☐

[2]

The stem of this question is quite demanding for candidates to interpret. However, there are only two true statements in this list (1 and 4). Option 5 is a plausible distractor – but only if the candidate is using the data in Table 2.1 and not in Fig. 2.3 as per the rubric.

?	**Misconception**	Candidates selecting options 2 or 3 have misconceptions about the meaning of continuous and discontinuous data.

Question 2 (b) (iii)

(iii) Determine the wavelength and colour of the maximum relative brightness of the G-type star in **Fig. 2.3**.

Wavelength = ... $\times 10^{-9}$ m

Colour = ...

[2]

Most candidates were able to use the graph to select this data.

?	**Misconception**	A common error was to give a wavelength range indicating that the candidate used the table instead of the graph.

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Question 2 (b) (iv)

(iv) Suggest why the G-type star appears to be white.

....

.... **[1]**

Key point call out

The command word here is 'suggest'. This means that a correct interpretation of the data must gain credit.

?	**Misconception**	Recognising that the G-star emits a mixture of different colours/wavelengths was enough to gain credit here (although this is also true for M and K stars). It was clear from many responses that candidates were trying to use general knowledge rather than the information provided.

Question 2 (c) (i)

(c) **(i)** Amari thinks that red stars are cooler than blue stars.

Explain why Amari is correct.

Use information from **Fig. 2.3** and **Table 2.1** to support your answer.

....

....

....

.... **[2]**

	AfL	Question 2 (c) (i) and (c) (ii) assess learning outcome 5 (LO5): **be able to draw justified conclusions from data.** This includes identification of conflicting evidence. Very few candidates gained any marks in these questions as they did not use the data provided. It was clear from many responses that candidates were trying to use general knowledge. Many candidates did not attempt these questions.

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Question 2 (c) (ii)

(ii) Amari then concludes that most of the stars near Earth are hotter than the sun.

Suggest why Amari could be correct, and suggest why he could also be incorrect.

Use information from **Fig. 2.1** and **Fig. 2.3** to support your answers.

Reason Amari could be correct

....

....

....

....

Reason Amari could be incorrect

....

....

....

....

[4]

Only a few candidates gained a mark using Fig. 2.1 for counting 51% of (most) stars as blue.

The trend using Fig. 2.3 shows higher temperatures when stars are brightest in the bluer/shorter wavelengths.

No candidates recognised that while Fig. 2.1 provides information about the *brightest* stars Amari's conclusion is about the *nearest* stars.

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Question 3 (a) (i)

3 Layla measures the e.m.f. of seven AAA batteries.

She connects each battery across the terminals of a digital multi-meter and records the e.m.f.

Her results are shown in **Table 3.1**.

Battery	e.m.f. (V)
1	1.60
2	1.48
3	1.57
4	1.60
5	1.60
6	1.44
7	1.58

Table 3.1

(a) Using the data in **Table 3.1**:

(i) Find out the mode and median of the e.m.f. values.

Mode = ... V

Median = ... V
[2]

Most candidates gained both marks.

Question 3 (a) (ii)

(ii) Calculate the mean e.m.f.

Give your answer to **3** significant figures.

Mean = ... V **[3]**

Most candidates gained 3 marks. A few did not give a 3 s.f. answer.

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Question 3 (b)

(b) Calculate the variance, s^2, and standard deviation, s, of the e.m.f values.

Use the equation:

$(n - 1) \times s^2 = \Sigma (X_i - \overline{X})^2$

- n = number of samples
- X_i = e.m.f. of each individual cell
- $\overline{X}$ = mean e.m.f. calculated in **(a)(ii)**.

s^2 = ...

s = ...

[6]

Marks were given for each process in the calculation. Most candidates made minor errors in summation either in the sum of X – mean or the sum of the squares of these values. A common error was to divide by 7 instead of (n – 1 = 6).

A calculated value from these steps, even with errors still gained a fourth marking point and recognition of this value as the variance by recording it on the answer line gained a fifth mark.

Many candidates who recorded an s^2 = value on the answer line however were unable to find the square root of this value.

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Question 3 (c) (i)

(c) Layla measures the e.m.f. of the batteries again, in millivolts, mV.

Her new results are shown in **Table 3.2**.

Battery	e.m.f. (mV)
1	1614
2	1618
3	1516
4	1618
5	1591
6	1619
7	1619

Table 3.2

Layla concludes that:

'there are two batteries in **Table 3.1** whose e.m.f values are due to measurement error'.

(i) Identify the two batteries.

Battery number .... and battery number ....

[1]

It was clear from most of the candidates' responses that they were using the data in Table 3.2 instead of Table 3.1 to answer Question 3 (c) (i).

Comparison of both tables shows that batteries 2 and 6 have very different values from the others in Table 3.1. They are much closer in value to the others when they are re-measured as shown in Table 3.2.

Key point call out

Candidates must take great care to select data from the correct sources indicated in the stem of the question.

Question 3 (c) (ii)

(ii) Explain your answer to **(c)(i)**. Use ideas about precision in your answer.

....

....

.... **[2]**

As most candidates referred to batteries 3 and 5 (by using Table 3.2) in their answer to Question 3 (c) (i), they were still able to gain a mark for an idea of precision.

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Question 3 (d)

(d) Draw lines to connect each experimental analysis term with its correct definition.

Experimental analysis term	**Definition**
Accuracy	The closeness of agreement between measured values obtained by repeated measurements.
Measurement error	Error due to measurements varying in an unpredictable way.
Precision	Error due to measurements differing from the true value by a consistent amount.
Random error	The closeness of the instrument reading to the true value.
Systematic error	The difference between a measured value and the true value.

[5]

Many candidates gained 5 marks. The most common error was determining which term was defined as 'the difference between a measured value and the true value'.

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Question 4 (a) (i)

4 Felix is investigating changes in the rate of flow of water.

Fig. 4.1 is a diagram of the apparatus he uses.

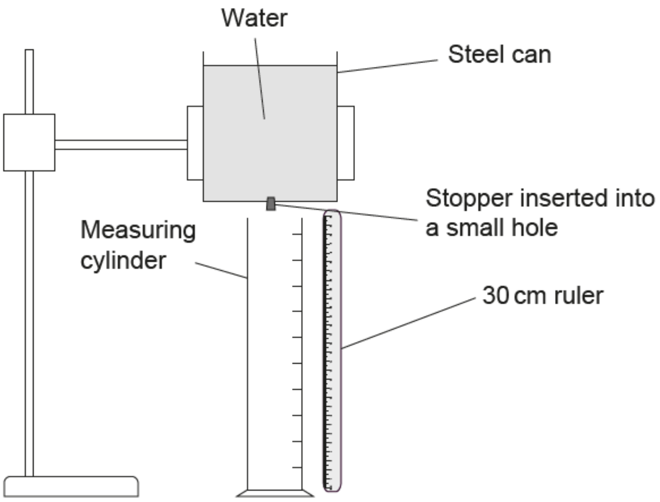

Fig. 4.1

- Felix removes the stopper from the steel can and starts a stopwatch.
- Felix records the time taken for the water level inside the measuring cylinder to reach a height of 2.0 cm, 4.0 cm and so on up to 14.0 cm.

(a) The time, t_1, when the water level reaches a height, h_1, of 12.0 cm is 251 s.

The time, t_2, when the water level reaches a height, h_2, of 14.0 cm is 330 s.

The diameter, d, of the measuring cylinder is 7.1 cm.

(i) Calculate the change in height, Δh, and the time taken, Δt, for the change in height.

$\Delta h = (h_2 - h_1)$ = ... cm

$\Delta t = (t_2 - t_1)$ = ... s

[1]

All candidates gained this mark.

Question 4 (a) (ii)

(ii) Calculate the average rate of flow, R, of the water as the water level increases from h_1 to h_2.

Give the units of R.

Use your values of Δh and Δt from **(a)(i)** in the equation:

$$R = \frac{\pi d^2 \Delta h}{4 \Delta t}$$

R = ... units .... **[3]**

Almost all candidates calculated R correctly but no candidates were able to determine the units of this equation.

Key point call out

Candidates need to be taught how to determine units from the dimensions of an equation.

Most candidates determined /s (per second) but it was most likely to be recorded as cm/s.

No candidate recognised that, in this example, on the top line, we have the units of d and h in cm. Hence: $cm^2 \times cm = cm^3$.

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Question 4 (a) (iii)

(iii) Felix plots two graphs as shown in **Fig. 4.2**.

The graphs show:

- the time taken against height of water in the measuring cylinder (marked with triangles ▲)
- the rate of flow of water, R, against height of water in the measuring cylinder (marked with crosses ×)

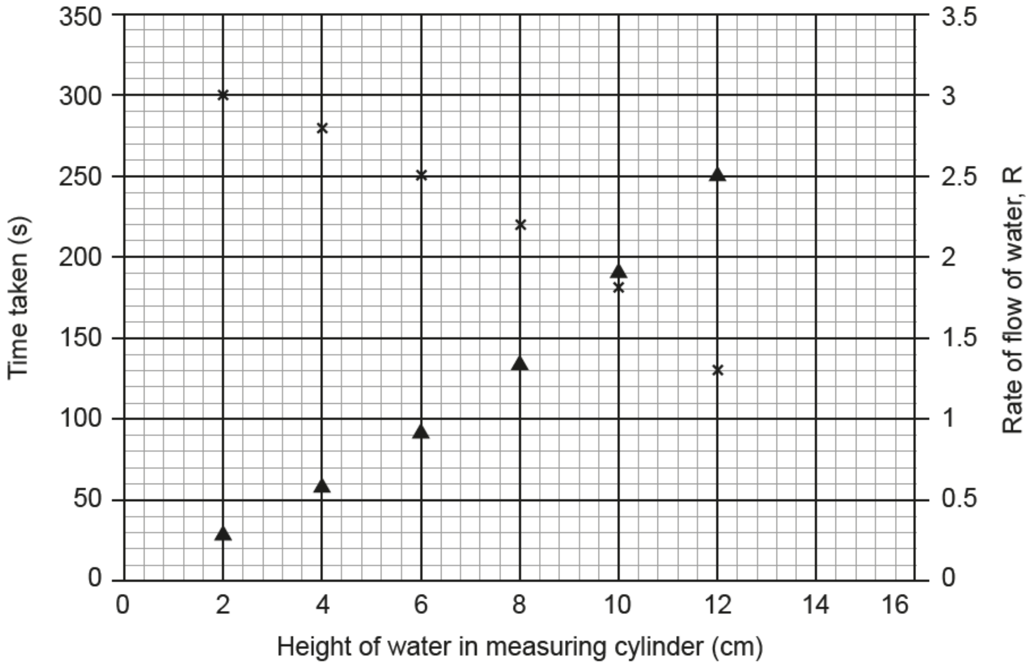

Fig. 4.2

On the grid in **Fig. 4.2**:

- draw the symbol ▲ to plot the value of t_2 used for the calculation in **(a)(i)**.
- draw the symbol **×** to plot your value of R calculated in **(a)(ii)**.

[2]

A common error was to plot t_2 at 320 instead of 330. Most candidates made at least one error in plotting these points.

Question 4 (a) (iv)

(iv) Use **Fig. 4.2** to estimate R when the height of the water in the measuring cylinder is 1.0 cm.

R = ... **[1]**

Only the most successful candidates were able to extend the trend in the × plots to the left, as a curve and extrapolate the value of R at h = 1, from the right hand axis.

Question 4 (b)

(b) Felix takes a photograph of the water in the measuring cylinder as it reaches the 14 cm mark on the ruler.

The photograph is shown in **Fig. 4.3**.

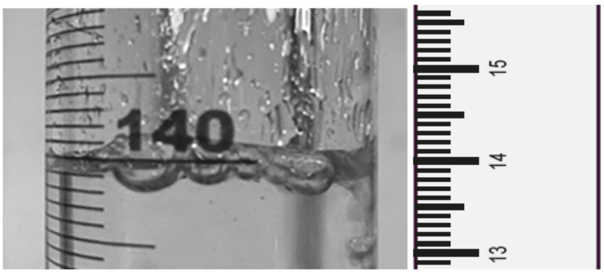

Fig. 4.3

Describe and explain the trend in R, and suggest why there are errors in Felix's time measurement at 14 cm.

Use information from **Fig. 4.2** and **Fig. 4.3** to support your answer.

....

....

....

....

....

.... **[6]**

Most candidates were able to comment on the difficulty in determining an accurate time measurement due to either the bubbles in the water or the need to read from the meniscus.

Many candidates also described a correct trend in the data.

Level 2 was most often given. Very few candidates made any attempt to explain the trend, therefore limiting marks given.

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Question 4 (c)

(c) Felix concludes that the rate of flow of water, R, depends on the depth of water in the steel can.

Which equation can be used to increase confidence in Felix's conclusion?

Tick (✓) **one** box.

Acceleration = change in speed ÷ time	☐
Density = mass ÷ volume	☐
Force = mass × acceleration	☐
Pressure = density × gravitational field strength × depth	☐

[1]

Many candidates correctly identified the fourth equation.

However none returned to part (b) to apply it as an explanation in the Level of Response question.

Here, density and gravitational field strength are constants, so when there is a high depth of water in the can, there is more pressure at the small hole, hence a greater flow rate.

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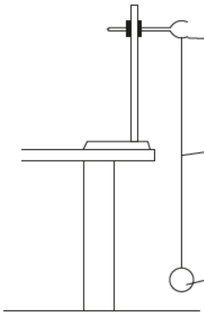
Question 5 (a)

5 Amos is investigating a simple pendulum. He sets up the apparatus shown in the diagram.



A pendulum string is tied to a clamp at one end and has a heavy weight known as a pendulum bob at the other.

- Amos moves the pendulum bob from the vertical position to 12 cm to the right.
- When he releases the pendulum bob, it swings to the left and then swings back. The size of the swing (amplitude) decreases slightly with each swing.
- Amos starts a stopwatch when the pendulum is 12 cm to the right of the vertical position.
- When the distance of the pendulum bob from the vertical position decreases to 10 cm, he records the time taken.
- He continues to record the time taken each time this distance decreases by 2 cm.
- He carries out two experiments using two different lengths of pendulum string.

The results of his investigation are shown in the table.

Decrease in distance of pendulum bob from vertical position (cm)	0	2.0	4.0	6.0	8.0	10.0
First experiment: length of pendulum string = 130 cm:						
Time (s)	0	60	200	230	330	480
Second experiment: length of pendulum string = 54 cm:						
Time (s)	0	30	70	120	170	220

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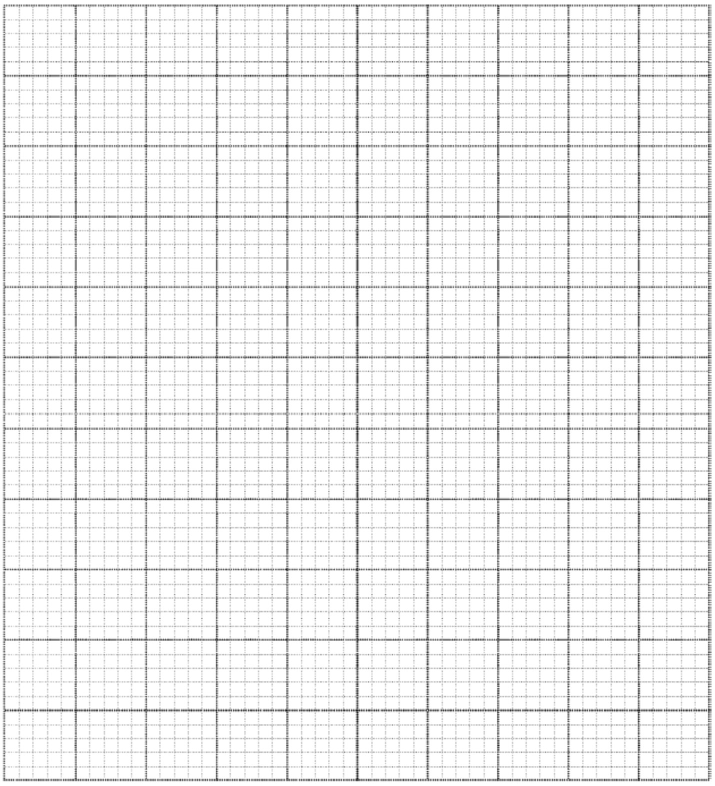
(a) Plot a graph of time (s) on the vertical axis against decrease in distance of pendulum bob from vertical postion (cm), for both sets of results from the table.

Draw curves of best fit for both sets of results **and** label the lines '130 cm pendulum' and '54 cm pendulum'.

Put a ring around the outlier on your graph.



[7]

Candidates are showing great improvement in their responses to graph plotting. Candidates who score well label both axes with units and use appropriate scales. A common error was to ignore the instruction to circle the outlier and these candidates lost another mark for drawing an S-shaped curve to accommodate the anomaly. Some candidates made a rubric error by drawing a straight line for the second set of results.

Key point call out

Candidates must be discouraged from using large blobs that are bigger than half of one small square.

Points must be plotted with precision using fine crosses made with sharp pencils.

Best fit lines must be drawn as indicated by the question – either straight or curved.

Best fit lines must be continuous and smooth.

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Question 5 (b) (i)

(b) Amos estimates that the percentage uncertainty in his time measurements is ±10%.

(i) Calculate the minimum and maximum possible times when the decrease in distance is 6.0 cm, using the 130 cm pendulum string.

Minimum time = ... s

Maximum time = ... s
[2]

Only the most able candidates calculated 207 and 253. Some candidates gained a mark for two equal values either side of 230, but most candidates did not score.

?	**Misconception**	It was clear from the responses that most candidates are unfamiliar with the convention '±'.

Question 5 (b) (ii)

(ii) Draw a range bar on the graph to indicate the values calculated in **(b)(i)**.
[1]

Many candidates made no response. Some candidates drew a range bar but not at the 230 s point.

Key point call out

Candidates must be taught how to calculate ranges and draw range bars on graphs to indicate the uncertainty in measurements.

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Question 5 (b) (iii)

(iii) Which **two** changes will cause the percentage **uncertainty** in the time measurements to **increase**?

Tick (✓) **two** boxes.

A larger decrease in the distance from the vertical position with each swing.	☐
A smaller decrease in the distance from the vertical position with each swing.	☐
The pendulum bob changing direction more quickly.	☐
The pendulum bob changing direction more slowly.	☐
An increase in the time for one swing of the pendulum bob.	☐

[2]

Most candidates gained at least one mark here indicating some practical experience in using stop-watches to time changes in movement.

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Question 6 (a)

6 Potamogeton is a type of aquatic plant, commonly known as pondweed.

Many species have leaves that float on the surface of the water and leaves that are underwater.

Some species are entirely submerged, and all of their leaves and stems are underwater.

The features of one species of Potamogeton are shown in **Fig. 6.1**.

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Fig. 6.1

The table shows some features of Potamogeton.

The table is used to identify individual species.

Species	**Underwater leaf width (mm)**	**Underwater leaf tip shape**	**Underwater leaf blade shape**	**Floating leaf tip shape**
P. biculpatus	0.1 – 0.4	acute	linear	lanceolate
P. spirillus	0.5 – 2	obtuse	linear	obtuse
P. robbinsii	3 – 8	acute	linear	n/a
P. crispus	3 – 8	rounded	linear	n/a
P. gramineus	3 – 27	acuminate	elliptic	acuminate
P. perfoliatus	7 – 40	acute	lanceolate	n/a
P. nodosus	10 – 35	acute	lanceolate	obtuse
P. amplifolius	15 – 58	acuminate	lanceolate	obtuse
P. pulcher	60 – 165	acute	lanceolate	acute

n/a = the species does not have any floating leaves, all leaves are submerged.

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(a) A partly completed classification key of the information in the table is shown in **Fig. 6.2**.

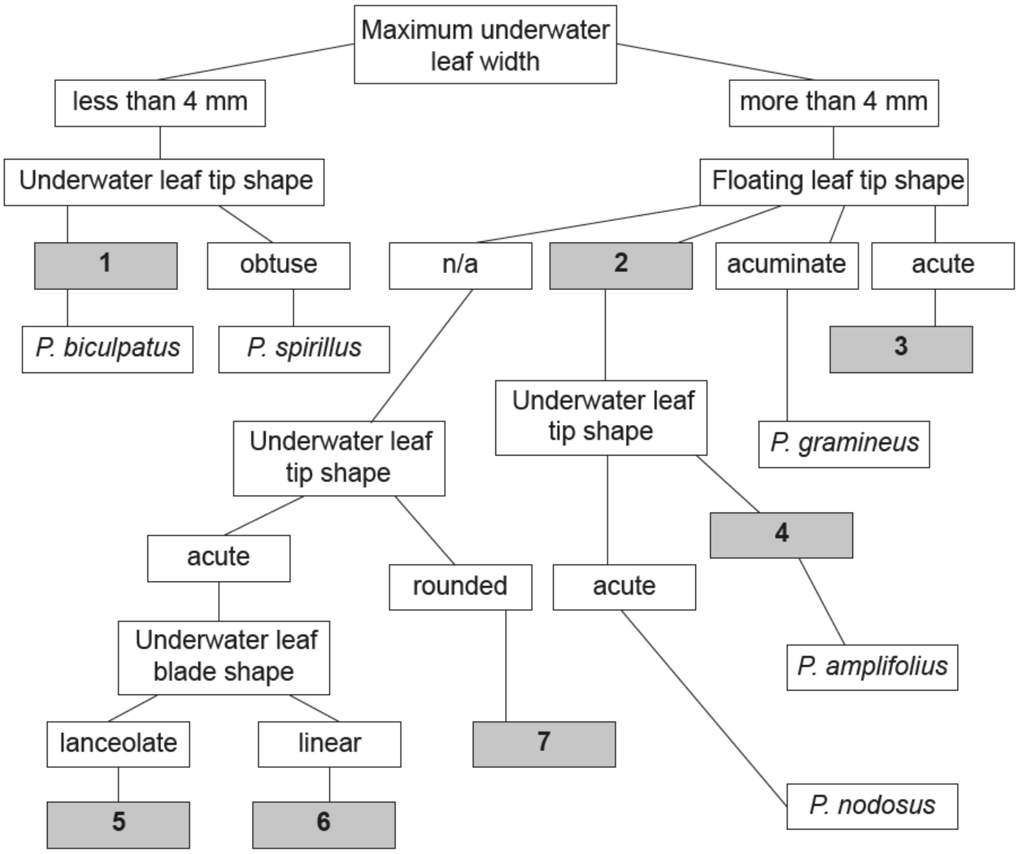

Fig. 6.2

Complete the classification key in **Fig. 6.2** by writing the correct word next to each number in the list.

Use the table.

1 ....

2 ....

3 ....

4 ....

5 ....

6 ....

7 ....

[7]

Very few candidates scored less than full marks. Applying keys to identify species is clearly a strength.

Key point call out

Candidate must also be able to construct keys based on identifiable differences also. This skill was not tested here.

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Question 6 (b) (i)

(b) **(i)** Explain why it is difficult to distinguish between *P. nodosus* and *P. amplifolius*.

....

....

....

.... **[2]**

Most candidates were able to describe both features of these two species that were identical.

Question 6 (b) (ii)

(ii) Suggest **one** feature, other than those described in **Table 6.1**, which can be used to identify different plants.

.... **[1]**

Most candidates gave a relevant feature, e.g. colour and how it is used to identify, e.g. '… of leaf'.

Question 6 (c)

(c) Complete the sentences about Potamogeton.

Use the words.

You can use each word once, more than once, or not at all.

binomial	**family**	**genus**	**monomial**
numerical	**phylum**	**polynomial**	

Potamogeton is the name of a plant ....

The naming system used to identify all plants, including for example *P. crispus*

is ....

[2]

A common error was 'family' instead of genus. Most candidates recognise the naming system as binomial.

Question 6 (d)

(d) Environmental scientists often study the presence of pondweeds in freshwater.

Pondweeds are indicator species.

Explain why the ability to distinguish between different species of pondweed is important for assessing the quality of the environment.

....

....

....

....

....

.... **[3]**

A few candidates scored a mark here for references to pollution and fewer still connected this to how it might affect populations.

Key point call out

Candidates must be taught that the presence or absence of indicator species are used to make judgements about the purity of water or the presence of contaminants.

Changes in the populations of indicator species are prompts for further investigations.

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Question 7 (a)

7 An acid-base titration is one technique that chemical laboratories can use to determine the concentration of a substance.

Other titration techniques can be used to determine the concentration of substances that are not acids or bases.

(a) Complete the table by identifying **two** alternative titration techniques.

Tick (✓) **two** boxes.

Complex formation	
Density	
Optometry	
Redox	
Spectroscopy	

[2]

Candidates generally gained a mark for recognising redox.

Question 7 (b) (i)

(b) Ivan is a technician working in a scientific analysis laboratory.

He determines the concentration of chloride ions (Cl^-) in seawater by titration against silver nitrate, using potassium chromate as the indicator.

- When silver nitrate is added from the burette to the sample of seawater, Ivan observes a white precipitate.
- When sufficient silver nitrate has been added to react with all the chloride ions in the seawater, additional silver nitrate reacts with the potassium chromate indicator forming a coloured precipitate. This is the end point of the titration.

(i) State the name of the precipitate formed at the end point.

.... **[1]**

The most successful candidates were able to suggest a precipitate based on the reactants but often they did not apply knowledge of reactivity and displacement to identify silver chromate as the insoluble product. A common error was silver chloride. However it is the additional silver nitrate + potassium chromate that forms the precipitate so this response indicates a rubric error.

Question 7 (b) (ii)

(ii) State the colour of the precipitate at the end point.

.... **[1]**

Few candidates recalled that silver chromate forms a white precipitate.

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	AfL	Section 6.4 of the syllabus indicates that candidates will be familiar with qualitative tests from Unit 2.

Question 7 (c)

(c) Potassium chromate is a carcinogen.

State **one** precaution that Ivan should take when working with potassium chromate.

.... **[1]**

Most candidates were able to suggest a suitable precaution.

Question 7 (d)

(d) Silver nitrate solutions can cause chemical burns.

State what action Ivan should immediately take if silver nitrate gets onto his skin.

.... **[1]**

Most candidates were able to state an appropriate action.

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Question 7 (e) (i)

(e) Ivan dissolves 2.125 g of silver nitrate solid, $AgNO_3$, in distilled water. He then transfers the solution to a 250 cm^3 volumetric flask and makes up to the 250 cm^3 mark with more distilled water.

(i) Calculate the molar mass of silver nitrate and use it to calculate the number of moles of silver nitrate present in the 250 cm^3 volumetric flask.

Use the equation: $\text{number of moles} = \dfrac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$

Molar mass of $AgNO_3$ = ... $g\ mol^{-1}$

Number of moles of $AgNO_3$ = ... moles

[2]

Only the most successful candidates were able to interrogate the Periodic Table to find the A_r values of Ag, N and O.

A few were able to combine these values to find the M_r value of 169.9.

A common error was to divide the calculated M_r value by 2.125.

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Question 7 (e) (ii)

(ii) Calculate the concentration, in mol dm^{-3}, of the silver nitrate solution.

Use the equation: concentration (mol dm^{-3}) = $\frac{\text{number of moles}}{\text{volume (dm}^3\text{)}}$

Concentration = ... mol dm^{-3} **[1]**

Only a few candidates understood what was expected. They used their value of moles from Question 7 (e) (i) and divided it by 250 cm^3 converted to a volume in dm^3

Question 7 (f) (i)

(f) The normal concentration of chloride ions (Cl^-) in tap water in a coastal village is 0.01 mol dm^{-3}.

After a severe storm there is concern that the village tap water might be contaminated with sea water.

Ivan has been asked to investigate whether the tap water is contaminated.

- He uses a pipette to measure out 20.0 cm^3 of the tap water and adds distilled water to make a final volume of 100.0 cm^3.
- He titrates 25.0 cm^3 of the diluted tap water against a 0.100 mol dm^{-3} standard solution of silver nitrate, using potassium chromate as the indicator.
- He finds that the average volume of 0.100 mol dm^{-3} silver nitrate needed to reach the end point is 15.5 cm^3.

(i) Calculate the number of moles of Ag^+ ions in 15.5 cm^3 of silver nitrate.

Use the equation: number of moles = $\frac{\text{volume (cm}^3\text{)} \times \text{concentration (mol dm}^{-3}\text{)}}{1000}$

Number of moles of Ag^+ ions = ... mol **[1]**

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Only the most successful candidates were able to select the correct data to substitute into this equation.

There are several volumes here. However the answer line indicates Ag^+ ions and so 15.5 must be selected.

A candidate who may be uncertain about what is meant by concentration should look back at Question 7 (e) (ii) where the unit is defined hence only 0.100 can be selected.

Question 7 (f) (ii)

(ii) The equation for the reaction between silver ions (Ag^+) and chloride ions (Cl^-) is

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

Deduce the number of moles of chloride (Cl^-) ions in the 25.0 cm^3 of diluted tap water.

Number of moles of Cl^- ions = ... mol **[1]**

Only the most successful candidates recognised that in this chemical reaction one silver ion reacts with one chloride ion giving a 1:1 ratio for the number of moles.

Key point call out

The command word here is 'deduce'. This means that no further calculation is needed.

Question 7 (f) (iii)

(iii) Calculate the concentration of chloride (Cl^-) ions in the **diluted** tap water.

Use the equation: $\text{concentration (mol dm}^{-3}\text{)} = \dfrac{\text{number of moles}}{\text{volume (dm}^3\text{)}}$

Concentration = ... mol dm^{-3} **[1]**

Only the most able candidates converted 25 cm^3 to 0.025 dm^3 for this calculation.

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Question 7 (f) (iv)

(iv) Calculate the concentration of chloride (Cl^-) ions in the **undiluted** tap water.

Concentration = ... $mol\,dm^{-3}$ **[1]**

Candidates needed to refer back to the stem of the question to find that 20 cm^3 of tap water was diluted in a 100 cm^3 mixture of tap water and distilled water, i.e. one-fifth.

Hence removal of the distilled water results in five times the concentration calculated in Question 7 (f) (iii).

Question 7 (f) (v)

(v) State if the tap water tested by Ivan was contaminated with sea water.

Explain your answer.

....

.... **[1]**

Candidates needed to refer back to the stem of the question to find the value for the normal concentration of chloride ions and compare this with their calculated value. No candidates did this.

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Question 7 (g)

(g) Ivan's job also involves finding the concentration of calcium ions in water samples taken from the local area.

Complete the sentences about the determination of calcium ions by titration.

Use the terms.

You can use each term once, more than once, or not at all.

potassium dichromate	**starch**	**EDTA**	**sodium thiosulfate**
eriochrome black T	**iodine**	**methyl orange**	

Ivan measures out 25.0 cm^3 of a sample of water and places it in a conical flask with a

few drops of .... as the indicator.

He fills up the burette with a standard solution of .... and adds

it to the solution in the flask until the indicator changes colour.

[2]

Many candidates identified the indicator and/or the solution correctly. Common errors were methyl orange for the indicator and sodium thiosulfate for the standard solution.

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Question 6, Fig. 6.1 (Image): An Illustrated Flora of the Northern United States, Canada and the British Possessions/Zannichelliaceae, Adapted from Wikisource: available under the Creative Commons Attribution-ShareAlike License www.en.wikisource.org

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