CAMBRIDGE TECHNICALS

OCR
Oxford Cambridge and RSA

Examiners' report

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

APPLIED SCIENCE

OCR Level 3 Cambridge Technical in Applied Science

Certificate: 05879

Extended Certificate: 05847

Foundation Diploma: 05848

Diploma: 05849

Extended Diploma: 05874

Unit 3 Summer 2025 series

Version 1

Contents

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. A selection of candidate responses is also provided. 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 Teach Cambridge.

Unit 3 series overview

Unit 3 (Scientific analysis and reporting) is a mandatory unit for the Level 3 Cambridge Technical Foundation Diploma, Diploma, and Extended Diploma in Applied Science. All learning outcomes within the specification are assessed in every series through a paper worth a maximum of 100 marks and of two hours duration.

This unit assesses:

- the ability to:
  - use mathematical techniques to analyse data
  - use graphical techniques to analyse data
  - use keys to classify organisms
  - critically analyse and evaluate the quality of data
  - draw justified conclusions from data
  - record, report on, and review scientific analyses.
- knowledge of the use of modified, extended, or combined laboratory techniques in analytical procedures – building on Unit 2 (Scientific techniques).

Questions are presented to candidates using a range of styles, including short answer, calculation, fill-the-blanks, matching pairs, true/false, and a longer 6 mark level-of-response question. Questions are presented in a scientific context, which may be one with which candidates are unfamiliar.

Centres must provide candidates with extensive opportunities for practising those skills detailed in the unit specification as well as exposure to the required experimental techniques and apparatus – this will allow candidates to answer questions in this paper with greater confidence.

Some of the questions in this paper required candidates to answer precisely, applying their knowledge tightly to the context given, and using stimulus material to work out the answer, using skills of observation, analysis, and evaluation. Careful reading of the questions and care in answering them precisely and in depth was important to gain maximum credit.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• showed working when carrying out calculations, were confident in the use of standard form and significant figures, and in the derivation of units • were able to use knowledge gained from first-hand experience of practical activities (**Q 3, 4, and 6**) • were confident in the analysis of information and data presented in unfamiliar contexts (**Q 1, 2, 3, 4, and 7**).	• did not set out calculations carefully and logically, and did not consistently carry forward answers when attempting multi-part questions (**Q 6 (a) (iii)**) • appeared to have little first-hand experience of practical activities on which to draw (**Q 3, 4, and 6**) • provided vague responses to questions, which were not framed within the context within which the question was set.

Question 1 (a) (i), (ii), (iii), (iv) and Question (b) (i)

1 The concentration of nitrogen dioxide (NO_2) in air is an important measure of air quality.

In the UK, the concentration of NO_2 is subject to Air Quality Standards Regulations (2010). NO_2 can cause inflammation of the airways and increase susceptibility to respiratory infections and to allergens.

The table shows how the mean annual concentration of NO_2 changed in London, UK between 2013 and 2019.

Year	NO_2 ($\mu g\,m^{-3}$)	NO_2 ($\mu g\,m^{-3}$) (to one decimal place)
2013	50.02	
2014	60.34	
2015	44.91	
2016	47.17	
2017	41.75	
2018	40.10	
2019	34.83	

(a)
(i) The NO_2 values in the table are recorded to the same number of significant figures.

How many significant figures are recorded?

.... **[1]**

(ii) Complete the empty column of the table by rounding each NO_2 value to one decimal place. **[1]**

(iii) Determine the mean concentration of NO_2. Use the values you calculated in **(a)(ii)**.

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

Mean = ... $\mu g\,m^{-3}$ **[2]**

(iv) Determine the median and the range of the values you calculated in **(a)(ii)**.

Median .... $\mu g\,m^{-3}$

Range .... $\mu g\,m^{-3}$
[2]

(b)
(i) Convert the 2018 value (recorded to one decimal place) of the NO_2 concentration to $g\,m^{-3}$.

Give your answer in standard form.

.... $g\,m^{-3}$ **[2]**

Questions 1 (a), 1 (a) (ii), 1 (a) (iii), 1 (a) (iv), and 1 (b) (i) were, in general, answered well by the vast majority of candidates. The most common errors were:

Q1 (a) (i), confusing the number of significant figures with the number of decimal places or the number of figures listed in the table;

Q1 (a) (ii), rounding 50.02 to 50;

Q1 (a) (iii), using the values provided in the table rather than the values calculated in 1 (a) (ii) to determine the mean NO_2 concentration, and/or quoting the calculated mean to three decimal places rather than three significant figures and/or made simple rounding errors when quoting their final answer;

Q1 (b) (i), seemingly random errors in the power of ten when converting to standard form, very few candidates showed any working for this calculation.

These questions addressed LO1.

Question 1 (b) (ii)

(ii) State the names of the SI units of mass and length.

Mass ....

Length ....

[2]

Despite being instructed to 'state the names of the SI units' a significant number of candidates chose to provide symbols, some of which were for an incorrect unit and/or not in the conventional SI format. G/g//KG/Kg were frequently offered for mass and variously KM/Km/km/M/Cm/cm for length. Many candidates were unsure of the SI unit and offered (in word or symbol) grams (for mass) and/or kilometres/centimetres (for length). A handful of candidates appeared not to be clear about the distinction between mass and weight and offered either Newton(s) or N for mass. This question addressed LO1.

Question 1 (c)

(c) A molecule of NO_2 contains one atom of nitrogen and two atoms of oxygen.

The relative atomic masses of nitrogen and oxygen are: N = 14 and O = 16.

- Calculate the molar mass of NO_2.

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

- Calculate the percentage by mass of oxygen in NO_2.
  Give your answer to **three** significant figures.

% by mass of O = ...%

[2]

Calculation of molar mass presented few problems for the vast majority of candidates.

Calculation of percentage content by mass for the second part proved more challenging. As with Question 1 (a) (iii), some candidates were confused by the distinction between 'significant figures' and 'decimal places', and/or made simple rounding errors when quoting their final answer.

This question addressed LO1.

Question 1 (d) (i)

(d) Nitrogen dioxide, NO_2, is a polluting gas that is produced by car engines during the combustion of fossil fuels. It is monitored by specialised sensing devices placed at various roadside and other urban and rural locations (monitoring stations).

(i) Suggest **two** explanations for the trend in NO_2 concentration and suggest further evidence that would support your explanations.

reason 1 ....

supporting evidence ....

....

reason 2 ....

supporting evidence ....

....
[4]

This question proved challenging for the majority of candidates. Rather than look at the trend in the table, consider reasons for that trend, and then suggest evidence that might back-up their suggestion(s), the majority of candidates described the trend and then suggested a reason for the trend. In this way no credit could be given, as the reason was stated as supporting evidence. This question addressed LO4.

Question 1 (d) (ii)

(ii) The information relating to all types of air pollution has improved since 2015.

Suggest **three** reasons why the quality of data relating to air pollution has improved since 2015.

1 ....

....

2 ....

....

3 ....

....
[3]

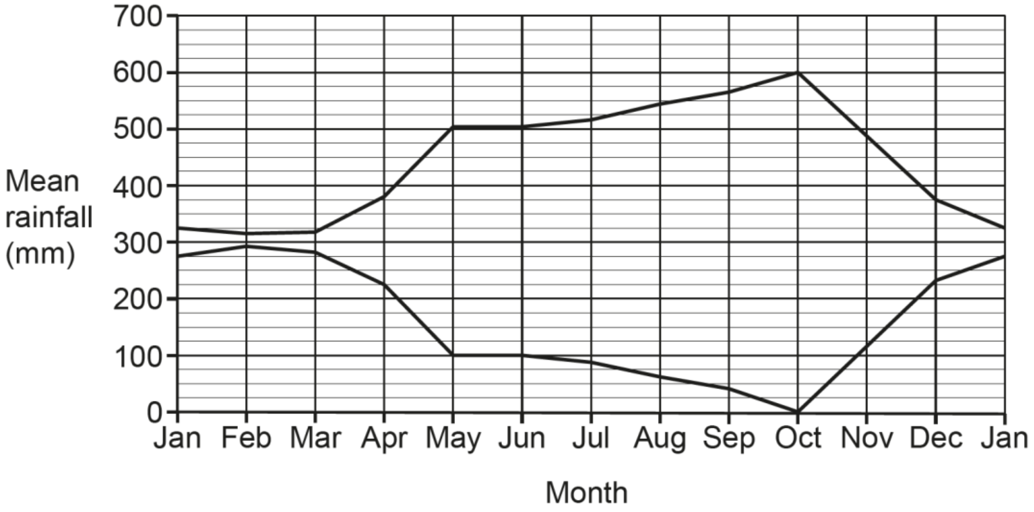
This question proved challenging for nearly all candidates. The majority of responses referred vaguely to 'improvements' in technology of monitoring. Very few responses developed the suggestions offered to explain why they would improve the quality of data. This question addressed LO4.

Question 2 (a)

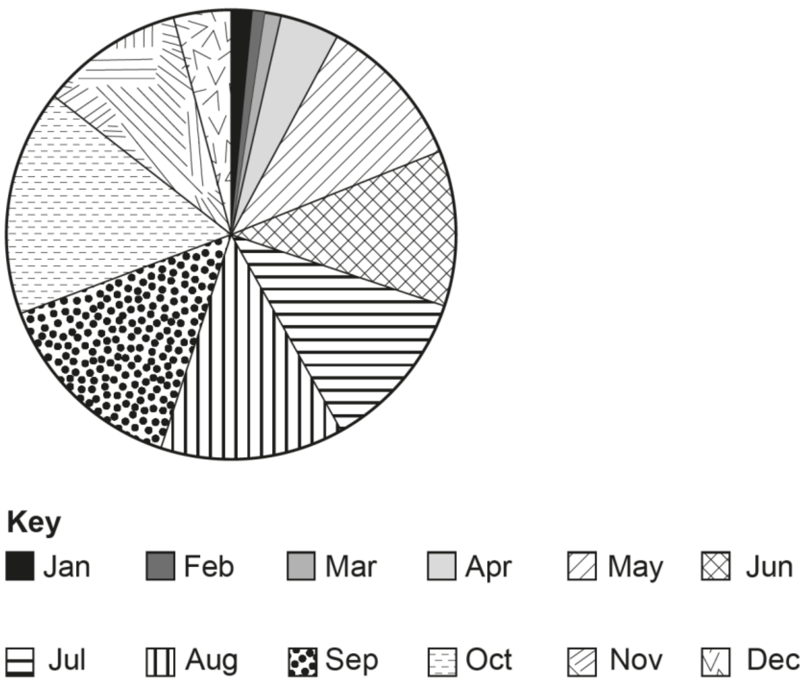
2 An environmental scientist is investigating rainfall data over a one-year period for a tropical island.

The scientist uses two different graphical methods to present the rainfall data, as shown below.

Method 1



Method 2



(a) Identify the two graphical methods shown.

Explain the advantages and limitations of each method for representing the rainfall data. **[6]**

The majority of candidates were able to correctly identify both methods of graphical representation, although a small number of candidates did not identify which method was which; candidates who did not correctly identify at least one method were unable to score any marks and were limited to Level 0. Many responses lacked a logical and clear structure and switched between methods and/or interspersed discussion of advantages and limitations. A number of responses were contradictory within themselves, using the same point as both an advantage and a limitation. Some responses lacked balance, concentrating on one or other of the methods, and then mentioning the other almost as an afterthought – such responses generally limited themselves to Level 2 by failing to consider both advantages and limitations of both methods. When addressing the advantages and disadvantages of each method, some candidates responded in a very technical manner, while other candidates responded in a more "anecdotal" manner based on personal perspective. This question addressed LO2.

Exemplar 1

Method one is a line graph, whereas method two is a pie chart both methods show the rainfall that happens in each month an how much it is. Method one has two seperate lines which one shows the month and the second one shows much rainfall occurs in those months. Furthermore it also shows how much it increases and decreases each month. Method two on the other hand is a pie chart that shows the amount of rainfall that happens each month as well. There is different patterns to identify the ~~amount~~ different months. However, method one looks more confusing than method two this is because method two you can look at the shape of the pie chart and compare easily which one is more bigger than the other.

The candidate has identified both methods and has provided an advantage for one method. This is a Level 1 answer, worth 2 marks.

Exemplar 2

method 1 ~~which~~ is a scatter graph. one advantage of it is that it is very precise but it can be very confusing to people. method 2 is a pie chart and it is very easy to understand and is very accurate and precise but it is difficult to draw and is also more confusing than other graphical methods.

The candidate has identified one method and has provided an advantage and a limitation for that method – this is the idea that by comparing the sizes of segments in the pie chart, one can easily compare rainfall month-to-month. This is a Level 2 answer worth 4 marks.

Exemplar 3

Method 1 used a kite diagram to represent the rainfall data. An advantage of this is that it visibly shows how much rainfall there is every month making it easier to interpret. Also, its faster to analyse the data when it is in a kite diagram format. Futher-more, the data is quantitative telling the exact number of rainfall in mm. However, it can be a little hard to compare the months. Method 2 presents the data as a pie chart. An advantage of this is that it clearly demonstrates how much rainfall each month has by the width of its sections. Another advantage is that pie charts are widely understood so other researchers would be familiar. However, it doesn't exactly say the number of rainfall in numbers which can make the data subjective and unreliable. Another limitation is the key might take longer to dicipher. ~~t~~ Pie charts are used for qualitative data.

The candidate has identified both methods and has provided at least one advantage and one limitation for each method – the candidate has identified that the kite diagram allows quantification of rainfall in each month, and that the pie chart is clearer/more easily understood (either of which would be acceptable). This is a Level 3 answer, worth 6 marks.

Question 2 (b)

(b) State **two** other graphical methods that the environmental scientist could use to present the rainfall data.

1 ....

2 ....
[2]

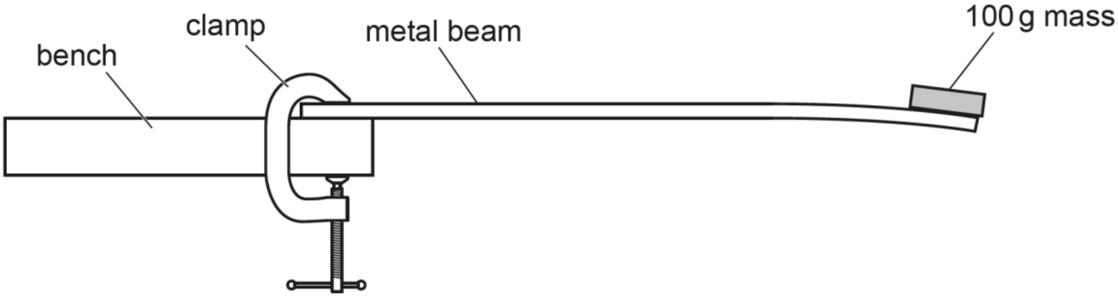
The majority of candidates correctly suggested bar chart and line graph. A number of candidates suggested histogram and/or scatter diagram instead of bar chart and line graph respectively, revealing a degree of confusion among candidates over the distinction between, and correct use of, bar charts versus histograms and line graphs versus scatter diagrams. This question addressed LO2.

Question 3 (a)

3 An engineer is designing a buggy for a small child.

The wheels of the buggy must be able to move up and down so that the buggy can travel smoothly when pushed over uneven ground.

The engineer makes a model to see how a 100 g mass moves up and down at the end of a metal beam.



(a) The engineer uses a piece of adhesive material to attach a 100 g mass to the end of the metal beam.

Explain why there is a systematic error in the actual mass at the end of the beam and suggest what the engineer should do to correct this error.

....

....

....

....

.... **[2]**

This question proved challenging for the majority of candidates, with only a minority recognising that the adhesive would have added extra mass – the majority were under the misapprehension that the metal beam was responsible for the systematic error in mass. Very few candidates offered a suggestion as to how the error could be corrected, possibly because the majority of candidates had suggested that the end of the metal beam had added mass and could not see how this could be corrected for. Among those candidates who had correctly identified the adhesive as being the cause of the systematic error it was still a minority that suggested the 100g mass should be weighed with adhesive applied before it was attached to the beam, only a couple-or-so candidates suggested using an adhesive material of very small mass. This question addressed LO4.

Question 3 (b) (i)

(b) The engineer uses a 30 cm ruler with millimetre divisions.

The ruler is used to measure the length *L* of the beam from the edge of the bench to the centre of the 100 g mass.

(i) What is the precision of this ruler?

.... **[1]**

A range of responses was seen, ranging from 0.1 mm to 30 cm, with only a small number of candidates correctly stating 1mm. A small number of candidates prefixed their answers with '+/-'. This question addressed LO4.

Question 3 (b) (ii)

(ii) Explain why there is an uncertainty of at least 2 mm in the measurement of *L* when using this ruler.

....

....

....

.... **[2]**

Only one or two candidates referred back to Question 3 (b) (i) for the required precision and understood that uncertainty in the measurement would be present at both ends of the ruler when *L* was measured. Otherwise, a range of suggestions was seen; the most common being that the metal beam was bent, or that the precision being +/-1mm resulted in a total uncertainty of 2mm.

Question 3 (b) (iii)

(iii) The engineer holds the ruler next to the beam. The engineer looks to the left and notes the scale reading at the bench and then looks to the right and notes the scale reading at the centre of the mass.

The engineer estimates that the total uncertainty in length L is 5 mm.

Suggest **three** sources of error in the method used to measure L that causes the additional uncertainty.

1 ....

2 ....

3 .... **[3]**

Many candidates simply listed three of the types of error from instrument error, measurement error, systematic error, and random error, with 'human error'/'operator error' being listed occasionally. A large number of responses referred vaguely to 'holding the ruler', without qualification. Only one or two candidates achieved 3 marks, a significant number gained just one mark. The most common suggestions were parallax error and movement of the hand holding the ruler; less commonly seen were references to the beam not being straight and difficulty in judging the centre of the mass. This question addressed LO4.

Question 3 (b) (iv)

(iv) The engineer determines that L = 17.5 cm and the uncertainty is 5 mm.

Calculate the percentage uncertainty.

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

Percentage uncertainty .... % **[2]**

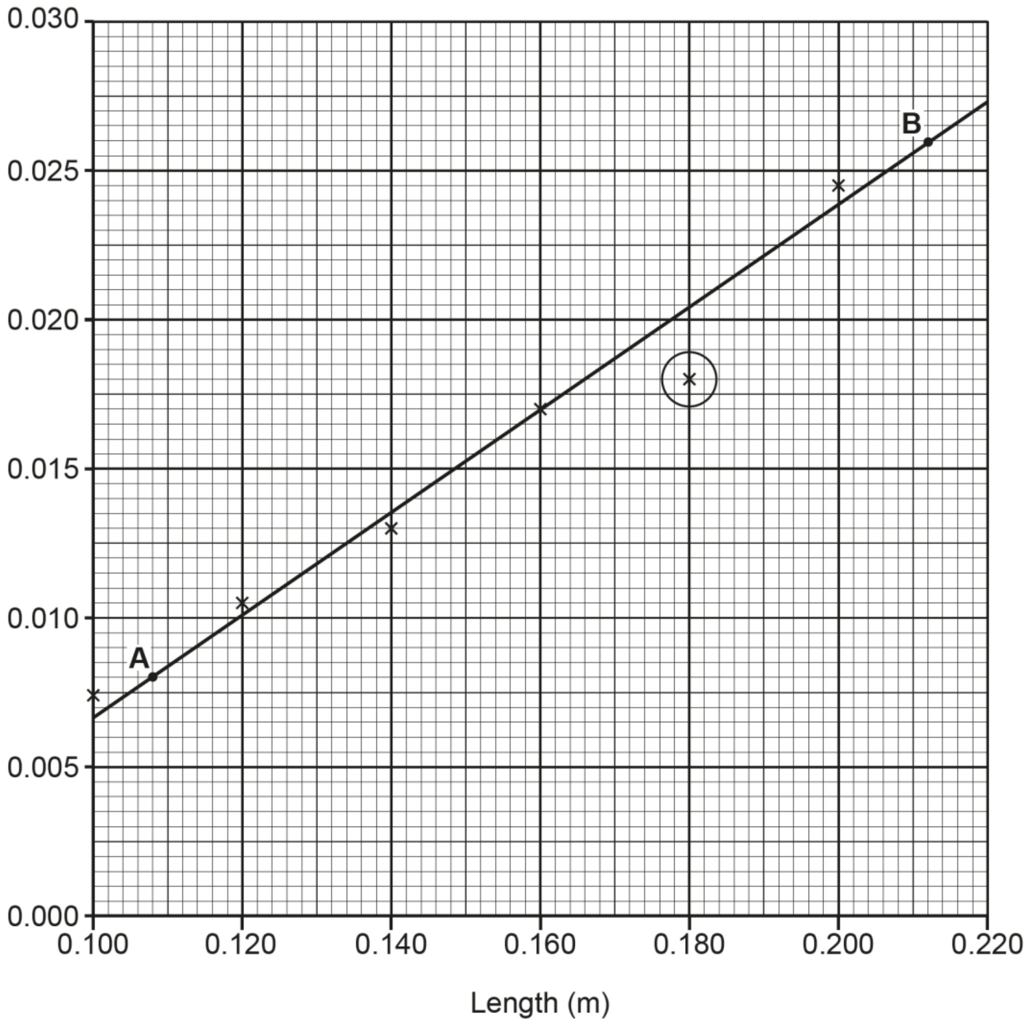
Calculation of percentage uncertainty always seems to prove challenging for candidates. As with Questions 1 (a) (iii) and 1 (c) some candidates seemed uncertain about the distinction between 'significant figures' and 'decimal places'; a number of candidates made simple rounding errors when quoting their final answer. This question addressed LO1 and LO4.

Question 3 (c) (i)

(c) The engineer takes measurements to find the time *t* in seconds for one up-and-down movement of the mass using different lengths *L* between 10 cm and 20 cm.

The results, marked as crosses, are shown in the graph.

....



(i) Label the *y*-axis on the dotted line beside the graph.

.... **[1]**

This question presented few problems to candidates; all but one or two candidates providing 'time' as s/sec/seconds – a disappointingly large number of candidates offered 'sec' as the symbol rather than the accepted SI abbreviation of 's'. The very small number of candidates who did not score either omitted the unit or stated 't'. This question addressed LO2.

Question 3 (c) (ii)

(ii) What type of graph is shown?

.... **[1]**

All but one or two candidates correctly suggested line graph or scatter graph/diagram. As with Question 2 (b) it is clear that candidates are unclear about the distinction between and correct use of line graphs versus scatter diagrams. This question addressed LO2.

Question 3 (c) (iii)

(iii) Explain why the engineer has drawn a circle around the point at L = 18 cm.

.... **[1]**

All but one or two candidates correctly identified the point at L = 18cm as being an outlier/anomaly. This question addressed LO2.

Question 3) (c) (iv)

(iv) Explain why the line of best fit is **NOT** correct.

.... **[1]**

Only a minority of candidates identified the imbalance of points above and below the line as being the issue with the 'line-of-best-fit'; it was only the stronger candidates who suggested that this imbalance might have reflected the inclusion of the point at L = 18cm when considering where to draw the line. Incorrect answers were roughly evenly split between those candidates who suggested 'the line continued beyond the point at L = 0.2m' and those who suggested 'the x-axis did not extend to 0' (overlooking the fact that an axle of length 0m would not exist). This question addressed LO2.

Question 3 (c) (v)

(v) The engineer marks point **A** on the graph at x = 0.108 and y = 0.008.

Determine the x and y value of point **B** on the graph.

x = ...

y = ... **[2]**

This question presented few problems to candidates, with nearly all gaining both marks for correct determination of both x and y values. A handful of candidates correctly read the values from the graph but then transposed the values incorrectly when recording their answers. This question addressed LO2.

Question 3 (c) (vi)

(vi) Using the x and y values of points **A** and **B** determine the gradient of the engineer's line.

Show your working and determine the SI unit of this line.

Gradient ....

SI unit .... **[2]**

This question proved challenging for nearly all candidates. A large number struggled to determine the gradient, and very few candidates were able to derive the unit correctly (a significant number of candidates offered ms^{-1}, although suggestions including various units of length and mass were seen). Nearly all candidates attempted to determine the gradient by constructing a triangle against the line-of-best-fit where use of the equation $y = mx + c$ may have been easier. Unfortunately, evidence from the graph showed that many candidates constructed very small triangles and/or used very blunt pencils for their construction, both of which led to inaccuracies when trying to read off measurements. Although candidates were instructed in the stem of the question to show their working, there were a significant number of candidates that produced answers without doing so. This question addressed LO1 and LO2.

Derivation of units

Derivation of units continues to be challenging for candidates. It is a skill that centres could address when candidates are practising calculations in which units are manipulated/derived.

Question 3 (c) (vii)

(vii) The engineer calculates the percentage uncertainty in *t*.

At $L = 0.16\,\text{m}$, this gives an uncertainty in *t* of ± 0.002.

Draw a range bar on the graph to show this uncertainty. **[1]**

This question proved to be very challenging for candidates across the attainment range, and the number of 'null responses' far exceeded the number of attempts. Very few candidates constructed an error bar of the correct length, the majority being two small squares either side of the line-of-best fit. A small number of candidates drew error bars that were of unequal length either side of the line-of-best-fit; almost invariably they were the correct length on one side but not on the other, suggesting a lack of attention to detail in their construction. A handful of candidates constructed error bars at points other than 0.16m. This question addressed LO2.

Question 3 (d)

(d) Another engineer repeats the experiment.

Suggest **two** pieces of information about the metal beam that this engineer should be given to ensure that the experiment is repeatable.

1 ....

....

2 ....

....

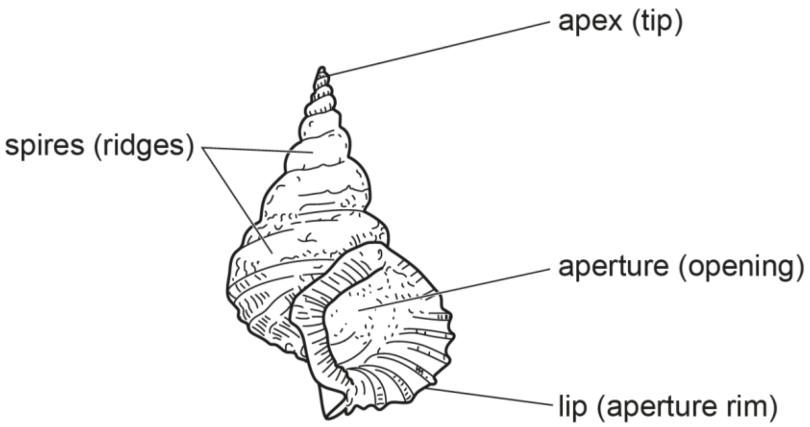
[2]

Many did not score any marks on this question. The most common mistake was to offer two different measurements for points 1 and 2, one of which was invariably 'length', which meant that no marks could be given – candidates had not understood that the length of the beam was the independent variable in the investigation and that the stem of Question 3 (b) had told them that engineer had measured the length, *L*, of the beam from the edge of the bench to the centre of the 100g mass, and that these lengths had been recorded in the graph provided in the stem of Question 3 (c). Some candidates did offer 'thickness' and 'width' as two separate suggestions for which one mark was given in combination. A surprisingly small number of candidates suggested 'type of metal' (references to 'make beam of same metal' were not credited as the question was asking for information that should be provided to the other engineer) and invariably offered it together with just one measurement. Very few candidates suggested thickness and width (or size/dimensions) together as one point.

Question 4 (a) (i)

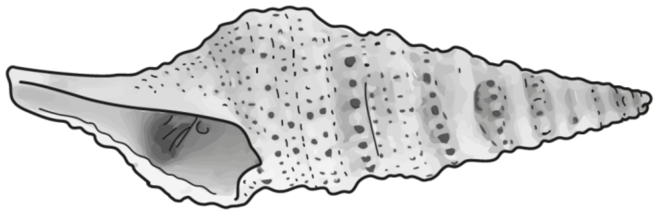
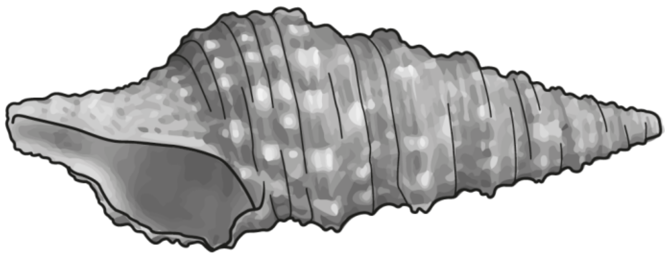
4 The shells of different types of sea snail share a number of external features.

The external features are shown in the diagram.



An ecologist collects data to identify different types of sea snails.

The shells of four of the sea snails are shown in the table.

	*Lophiotoma acuta*. Location Japan.
	*Lophiotoma capricornica*. Location Australia.
	*Lophiotoma ruthveniana*. Location Mauritius.
	*Lophiotoma pseudoannulata*. Location Antarctica.

(a)
(i) Use information shown in the diagram and table to:

- suggest **two** measurements that can be recorded to classify the different sea snails,
- suggest **two** ratios that can be calculated using these and other measurements.

Measurements

1 ....

2 ....

Ratios

1 ....

2 ....
[4]

This question proved challenging for nearly all candidates; many candidates did not score any marks, and only one or two secured more than one mark, with only one or two scoring two or above.

Many candidates were vague when suggesting measurements, offering, for example, features such as 'lip' or 'aperture' without specifying what measurement (thickness/diameter/circumference/etc) would be taken, or measurements which would be difficult to determine, such as 'width of tip' (hard to measure accurately) or length of tip (how far, exactly, down the shell does this start?). Most of the candidates suggested colour/patterning (not a measurement) or weight/mass of shell (not using information from the diagram/table).

Many candidates suggested measurements that were not ratios. Unfortunately, where candidates did suggest ratios they repeated errors made when suggesting their measurements and suggested ratios that were vague in terms of the measurements to be taken, or which would have been difficult to determine from the required measurements.

This question addressed LO3.

Question 4 (a) (ii)

(ii) Suggest **one** advantage and **one** disadvantage of using external features only for the classification of organisms such as the sea snail.

Advantage

....

Disadvantage

.... **[2]**

The majority of candidates identified that using external features for classification is easy/quick to do.

Only a minority of candidates identified that growth and/or damage might change the external appearance of sea snails. The majority of candidates suggested that 'similarity of features' would be a disadvantage, overlooking the fact that classification systems are based on differences and that any system where similarity of features was an issue would be completely unworkable.

This question addressed LO3.

Question 4 (a) (iii)

(iii) Each type of shell is named according to binomial nomenclature.

Use the sea snail, *Lophiotoma pseudoannulata*, to explain what is meant by the term binomial nomenclature.

....

....

.... **[3]**

This question was well answered; the vast majority of candidates identified *Lophiotoma* as the generic name and *pseudoannulata* as the specific name – these were the only 2 marking points that tended to be offered, a few candidates referenced that the system used Latin and one or two candidates specifically mentioned the use of two names (as opposed to it being implicit in their answer). This question addressed LO3.

Question 4 (a) (iv)

(iv) Sea snails are animals.

They are classified as members of Kingdom Animalia.

Give the names of **two** other types of Kingdom.

.... and ....

[2]

The majority of candidates were able to suggest two of the other five or six Kingdoms (depending on whether the five or six Kingdom classification system was used). The most common error was to suggest 'Archea' as a Kingdom (within the six-Kingdom classification system) when it is, in fact, a 'domain' corresponding to the Kingdom Archaebacteria. Protista was suggested more frequently than the equivalent Kingdom name Protoctista. This question addressed LO3.

Question 4 (a) (v)

(v) Kingdom Animalia is divided into further sub-groups or taxa.

Which type of sub-group within Kingdom Animalia contains the largest number of organisms?

Put a tick (✓) in the correct box.

class	
family	
order	
phylum	

[1]

The majority of candidates selected 'phylum'; incorrect responses were split roughly equally between the other three options. This question addressed LO3.

Question 4 (b) (i)

(b) The table shows some of the criteria used to evaluate the quality of data collected for this and other types of scientific investigations.

	Criteria for evaluation
A	Accuracy: the closeness of the measured value to the true value
B	Availability: how easily the data can be accessed and obtained for analysis
C	Consistency: the degree of agreement across different sources if multiple sources of data are used
D	Relevance: how well the data address the research objectives
E	Source credibility: the reliability and reputation of the organisation or individual that collected and published the data
F	Timeliness: how current and up-to-date the data are
G	Validity: the suitability of the method used to answer the question being asked

(i) State the letters (**A** to **G**) of **two** criteria used to judge the quality of primary data.

.... and ....

[2]

A variety of responses was seen, but only a minority of candidates achieved both marks, although most secured one mark. Options A and G were offered most frequently, either individually or in combination. Option D was the most frequently offered incorrect option. This question addressed LO4 and LO5.

Question 4 (b) (ii)

(ii) State the letters (**A** to **G**) of **two** criteria used to judge the quality of secondary data.

.... and ....

[2]

A variety of responses was seen, but only a minority of candidates secured both marks. Most candidates gained one mark. Option E was offered most frequently, with option F being the most frequently offered incorrect option. This question addressed LO4 and LO5.

Question 5 (a) (i)

5

(a) The relative atomic mass (A_r) of an element is the weighted average of the masses of its isotopes compared to 1/12th of the mass of one atom of Carbon-12.

The mass number of an atom is the number of protons plus neutrons in the nucleus of an atom.

Table 5.1 shows the relative atomic masses of all the elements that begin with the letter A.

Table 5.1

Element	Relative atomic mass
Actinium	227.029
Aluminium	26.982
Americium	243.061
Antimony	121.760
Argon	39.948
Arsenic	74.922
Astatine	209.987

In 1917, relative atomic mass was known as atomic weight.

Atomic weights were calculated by comparing the mass of an element's atoms with a reference element. In one system, atomic weight was determined by comparing the mass of an atom with the mass of one hydrogen atom. In another system, atomic weight was determined by comparing the mass of an atom with 1/16th of the mass of an oxygen atom.

The calculated atomic weights were slightly different depending on which reference element was used.
Table 5.2 shows the atomic weights (calculated in 1917) of all the elements that begin with the letter A.

Table 5.2

	Atomic weight (calculated in 1917)	
Element	**Compared to hydrogen**	**Compared to oxygen**
Aluminium	26.8	27.1
Antimony	119.2	120.1
Argon	39.6	39.9
Arsenic	74.37	74.96

(i) Explain why there are more elements listed in **Table 5.1** compared with **Table 5.2**.

....

....

.... **[2]**

The overwhelming majority of candidates identified that elements had been discovered since 1917, but only one or two candidates referred specifically to those elements. This question addressed LO5.

Question 5 (a) (ii)

(ii) Hydrogen has one proton and oxygen has eight protons.

Suggest how the number of protons in the reference elements (hydrogen and oxygen) affect the calculated value of the atomic weight of aluminium shown in **Table 5.2**.

....

.... **[1]**

This question proved challenging for candidates across the attainment range. Very few responses referred to atomic weight, as opposed to atomic mass, and most answers were framed in the context of the number of protons influencing the atomic mass of an element, missing the idea of how the number of protons in a reference element affected the atomic weight of one element (in this case aluminium). This question addressed LO5.

Question 5 (a) (iii)

(iii) Explain whether your suggestion in **(a)(ii)** is supported by the data for argon in both of the tables.

....

.... **[1]**

This question proved to be quite challenging – there were a large number of 'null responses' where candidates did not provide any response. This question addressed LO5.

Question 5 (b) (i)

(b) **Table 5.2** shows some more data relating to the element antimony.

Table 5.2

Symbol	Atomic number	Relative atomic mass (A_r)	Mass numbers of the stable isotopes	
Sb	51	121.76	121	123

(i) Explain why the mass numbers are whole numbers, but the relative atomic mass is not a whole number.

....

....

.... **[2]**

This question proved to be either quite straightforward for the majority of candidates, who recognised that mass numbers are the sum of two numbers which must be whole numbers while relative atomic masses are an average of different isotopic masses and as such might well not be whole numbers. A minority of candidates struggled to provide explanations, which often referred to numbers of isotopes or the relative numbers of protons versus neutrons in the atom. This question addressed LO5.

Question 5 (b) (ii)

(ii) What can you conclude about the relative abundance of the two isotopes of antimony? Give a reason for your answer.

....

....

.... **[2]**

This question proved challenging for the majority of candidates, but the minority of candidates who did gain marks on this question almost without exception secured both marks. There were a significant number of 'null responses' for this question. This question addressed LO5.

Question 5 (c) (i)

(c) Aluminium is the most abundant metal in the Earth's crust.

The main source of aluminium is Bauxite which is a rock containing aluminium oxide, Al_2O_3.

Aluminium is extracted by electrolysis of molten aluminium oxide.

The overall equation is for this process is shown below.

$2Al_2O_3 \rightarrow 4Al + 3O_2$

(i) Calculate the expected mass of aluminium which would be produced from 1500 g Al_2O_3 if the yield was 100%.

The molar mass of Al_2O_3 is 102 g mol^{-1} and the relative atomic mass of Al is 27.

Give your answer to the nearest whole number.

Expected mass .... **[2]**

Very few candidates showed any working for this question, so it was challenging for examiners to identify where the 50% of candidates who provided an incorrect expected mass had made mistakes. Nearly all candidates did correctly round their calculated value to the nearest whole number. This question addressed LO1.

Question 5 (ii)

(ii) A chemical engineer finds that 1500 g of Al_2O_3 produces 720 g of aluminium.

Calculate the percentage yield of aluminium using the equation:

$$\text{percentage yield} = \frac{\text{amount of product obtained} \times 100}{\text{expected amount of product}}$$

% yield = ... **[1]**

This question presented few problems to candidates, nearly of whom were able to take their calculated value from Question 5 (c) (i) and substitute into the equation provided to calculate a percentage yield. A number of candidates ended up with percentage yields greater – sometimes much greater – than 100%, but this did not encourage them to go back and check their calculation(s) for the expected mass of aluminium in Question 5 (c) (i). This question addressed LO1.

Question 6 (a) (i)

6

(a) A food scientist carries out an investigation to determine the concentration of vitamin C in oranges. The method involves a redox titration using iodine.

The scientist uses the following method.

1. Take 100 g of an orange and cut it into small pieces.

2. Add about 50 cm^3 water and blend in a food processor.

3. Strain the mixture to remove the pulp and make the extracted solution up to 100 cm^3 in a volumetric flask.

4. Pipette 20.0 cm^3 of the orange juice into a conical flask, add a suitable indicator and titrate against 0.005 $mol\,dm^{-3}$ iodine solution.

5. Repeat step 4 until concordant titres are obtained.

(i) State the name of the indicator and describe how the end point is detected.

Indicator ....

Observation at the end point

....

[2]

A variety of indicators was suggested, including iodine, methyl orange, phenolphthalein, and universal indicator – only a minority of candidates suggested starch. Many candidates stated 'colour change' for the observation at the end point. Otherwise, a variety of colour changes was suggested, many of which were not correct for the chosen indicator – only a minority of candidates suggested the appearance of a blue-black colour, a significant number of whom had selected indicators other than starch. Very few candidates achieved both marks. This question addressed LO6.

Question 6 (a) (ii)

(ii) Explain what is meant by concordant titres.

.... **[1]**

Many candidates were unclear about the definition of concordance, and among those who were able to define it in terms of close agreement there were differing opinions on how close titres needed to be – suggested values ranged for 0.01mm^3 to 1cm^3, an unfortunately high number of candidates quoted a figure without quoting units. Some candidates stated that concordant titres needed to be consecutive titres.

Burettes are graduated every 0.1cm^3, but by determining whether the meniscus is within the upper or lower half of the division it is possible to read to an accuracy of 0.05 cm$^{3.}$

This question addressed LO6.

Question 6 (a) (iii)

(iii) The scientist obtains a mean titre of $12.05\,cm^3$ $0.005\ mol\,dm^{-3}$ iodine.

Determine the mass, in mg, of vitamin C in 100 g of orange using the following steps.

You will need to use the following equations in your calculations:

$$\text{Number of moles} = \frac{\text{concentration in mol dm}^{-3} \times \text{volume in cm}^3}{1000}$$

$$\text{Mass in g} = \text{number of moles} \times \text{molar mass (g mol}^{-1}\text{)}$$

- Use the mean titre to calculate the number of moles of iodine required to reach the end point.

- Vitamin C is ascorbic acid. During the titration one mole of ascorbic acid reacts with one mole of iodine.
  Deduce the number of moles of ascorbic acid in $20.0\,cm^3$ of orange juice.

- The molar mass of ascorbic acid is $176\,g\,mol^{-1}$.
  Calculate the mass, in mg, of ascorbic acid in 100 g of orange.
  Give your answer to **two** significant figures.

Mass of vitamin C in 100 g of orange .... mg **[5]**

Only one or two candidates gained full marks on this question. Nearly all candidates were able to calculate the number of moles of iodine required to reach the end point, but few candidates then clearly stated that this was the same as the number of moles of ascorbic acid in $20.0cm^3$ of orange juice. Many candidates then did not adjust for $100cm^3$ of orange juice, or in so doing carried out an incorrect manipulation (such as dividing by a factor of five or dividing/multiplying by a factor of 20). Many candidates then did not realise that their calculated mass of ascorbic acid in 100g orange was in grams and so did not convert to their answer to mg. A good number of candidates who did recognise the need to convert their answer from grams to milligrams applied an incorrect conversion and divided rather than multiplied by a factor of 1000. The majority of candidates did, however, round their final answer correctly to 2sf. The majority of candidates who did attempt to continue through the calculation to determine the mass of vitamin C in 100g of orange were able to gain 2 or 3 marks for correct calculations/manipulations through error carried forward (ecf). This question addressed LO1 and LO6.

Question 6 (b) (i)

(b) Spinach leaves are a good source of iron.

The food scientist is tasked with finding out how the iron content in spinach is affected by the cooking time.

The food scientist oxidises the spinach leaves to ensure that all the iron is in the form of iron(III).

The scientist then determines the iron(III) content by colorimetry using potassium thiocyanate to produce a coloured iron(III)-thiocyanate complex.

(i) Describe what the scientist would observe when potassium thiocyanate is added to a solution containing iron(III) ions.

....

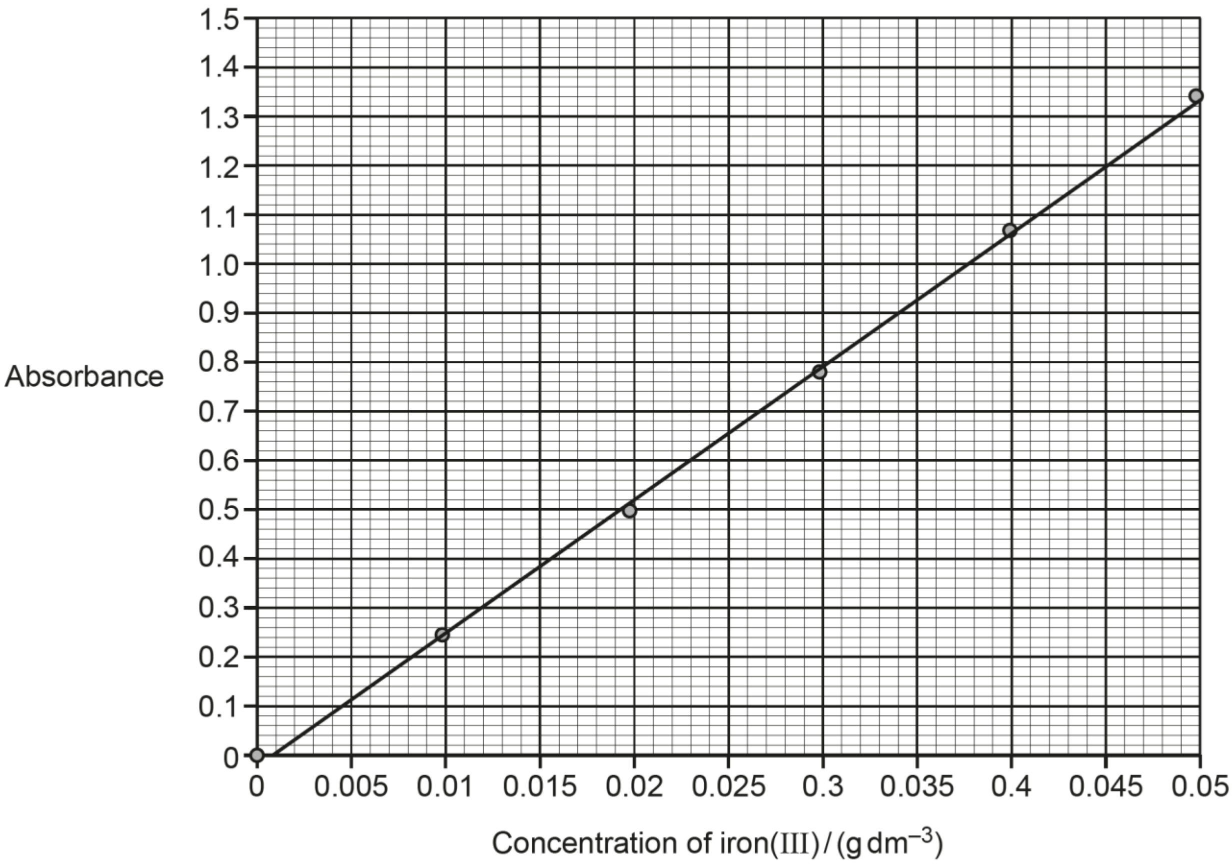
.... **[1]**

A large proportion of candidates offered 'colour change' as their answer again here. Otherwise, a variety of colour changes was suggested, of which a majority favoured the appearance of some form of red coloration – dark red, intense red, bright-red, orange-red, brick-red, blood-red, brown(y)-red were all seen. This question addressed LO6.

Question 6 (b) (ii)

(ii) The food scientist uses a colorimeter to measure the absorbance of known concentrations of iron(III) solutions which have been treated with potassium thiocyanate.

A graph of absorbance reading against concentration of iron(III) is shown below.



A weighed sample of uncooked spinach leaves is oxidised and treated with potassium thiocyanate. The absorbance reading for the sample is found to be 1.2.

Use the graph to determine the concentration of iron in uncooked spinach.

Concentration of iron in uncooked spinach .... g dm^{-3} **[1]**

This question was answered correctly by most candidates. The errors on the x-axis at 0.03 and 0.04 g dm^{-3}, which were incorrectly stated as 0.3 and 0.4 g dm^{-3}, respectively, did not seem to have adversely affected any candidates – nevertheless, an alternative response of 0.45 (g dm^{-3}) was added to the mark scheme in case any candidates had been confused by the incorrect value of 0.4 on the x-axis. This question addressed LO2 and LO6.

Question 6 (b) (iii)

(iii) The scientist boils the oxidised spinach leaves for different lengths of time using the same mass of spinach as the raw sample. After treating each sample with the same volume of potassium thiocyanate, the scientist measures the absorbance.

The results are shown below.

Boiling time / mins	0	2	4	6	8	10
Absorbance reading	1.2	0.65	0.38	0.24	0.15	0.14

- Describe what these results tell us about the effect of boiling on the iron content of spinach leaves.

  ....

  .... **[2]**

- Calculate the percentage of iron remaining in the spinach leaves after cooking for 6 minutes.

% iron remaining .... **[1]**

The majority of candidates did not achieve any marks for part one because they referred to the change in absorbance with time, rather the change in iron content. All but one or two candidates, who described a rapid fall in the first four minutes followed by a levelling-off, referred simply to a fall in either iron content or absorbance over time. There were a significant number of 'null responses' for part two, although it involved a straightforward calculation – those candidates who did attempt the calculation generally gained the one mark available. This question addressed LO1 and LO5.

Question 6 (c)

(c) The food scientist uses a range of redox titrations to determine the amounts of metal ions in food supplements.

Draw a line to link the metal ion with the reagent used in the titration.

	EDTA
Calcium ions	
	Potassium manganate(VII)
	Silver nitrate
Iron(II) ions	
	Sodium thiosulfate

[2]

A variety of responses was seen, but the majority of candidates correctly linked calcium ions with EDTA and iron(II) ions with potassium manganate(VII). There were fewer incorrect responses for iron(II) ions than for calcium ions – a small, but significant, number of candidates linked calcium ions with silver nitrate. This question addressed LO6.

Quantitative titration techniques

Responses to Questions 6 (a) (i), 6 (b) (i), and 6 (c) suggested that candidates exposure to and knowledge of the titration techniques specified in the teaching content for Unit 2 (Analytical techniques), Unit 3 (Scientific analysis and reporting), and the mandatory NEA Unit 10 (Testing consumer products) could be enhanced. Centres should make sure the whole of the specification content is taught and that candidates have, wherever possible, the opportunity to gain first-hand experience or required practical techniques. Where such exposure is not possible, candidates should have the opportunity to observe demonstrations or video recordings of the techniques being carried out.

Question 7 (a) (i)

7 Battery electric vehicles (BEVs) are becoming increasingly popular in the UK as people become more environmentally aware.

(a) The table below shows the number of BEVs on the UK's roads since 2015.

Item removed due to third party copyright restrictions.
Data about electric car usage © www.rac.co.uk, RAC.

(i) Data can be displayed in different ways.

Suggest how data in the table could be presented to the wider public.

Give a reason for your answer.

....

....

.... **[2]**

Nearly all candidates suggested some form of graphical or visual presentation would be easy to process or understand. A small number of candidates misunderstood what the question was asking and suggested a medium such as magazines, social media, or podcasts through which the information could be broadcast – such responses were limited to one mark. This question addressed LO7.

Question 7 (a) (ii)

(ii) Many stakeholders are interested in this information. These include members of the public, car manufacturers, garage mechanics, and politicians.

Explain why this information is useful to each stakeholder.

- Members of the public

....

....

- Car manufacturers

....

....

- Garage mechanics

....

....

- Politicians

....

....

[4]

Nearly all candidates achieved 1 or 2 marks here, with a handful securing 3 marks, and just one or two achieving all 4 marks. A lot of answers were very vague, particularly so for 'members of the public' and 'politicians', where responses such as 'know what car to buy' and 'know what laws to make' were common – the mark for 'politicians' was given infrequently. In contrast, answers for 'car manufacturers' and 'mechanic' tended to be much more specific, such as 'know how many BEVs to make'/'know what will sell' or 'know whether it is worth training on BEVs'/'know what stock of spares to keep', although a common answer for 'mechanic' was 'so they can train on BEVs'. This question addressed LO7.

Question 7 (b) (i)

(b) On a long journey, drivers will need to recharge the electric vehicle battery.

- The average time for a rapid charger to charge this type of battery is about 45 minutes.
- Some charging devices can charge more than one car at the same time, others can only charge one at a time.
- Different models of car require different connectors.

One of the main concerns for drivers of BEVs is the number and type of public rapid charging devices available. Many BEV drivers use a charging device App which tells them the location, type of connector and availability of charging points.

The following information was obtained from the most popular EV charging device App and published by the Department for Transport.

The data shows the number of electric vehicles per rapid charging device since 2017.

Year	2017	2018	2019	2020	2021	2022
Number of BEVs per public rapid charging devices	41	43	35	37	56	81

(i) Data validity is a measure of the accuracy and reliability of data.

Explain whether you think data in the table are valid.

....

....

.... **[1]**

Only one or two candidates gained the mark for this question, by identifying that the data comes from an EV App and not the installers of the equipment so its accuracy may be open to doubt. Some candidates referred to the fact that the data had been published by Department of Transport as assuring its validity, but they did not consider whether or not the Department of Transport would have checked the accuracy of the data itself. The majority of candidates answered in terms of an increase in the number of BEVs being correct (overlooking the data being about the number of BEVs per public rapid charging device) and, therefore, that the data must be accurate. This question addressed LO7.

Question 7 (b) (ii)

(ii) Identify the main trends shown by the data and explain what impact this data has on BEV drivers.

....

....

....

.... **[2]**

Nearly all candidates overlooked that the trend shown by the data is of an increase in the number of BEVs per public rapid charging device and instead stated that the trend showed an increase in the number of BEVs or of both BEVs and public rapid charging devices. They then did not go on to explain the impact on drivers, in terms of greater difficulty in finding an unoccupied public rapid charging device.

OCR support – command verbs

Available on Teach Cambridge, there is a useful generic resource 'Teacher guide: Command verbs and definitions' which gives definitions for command verbs used for all Cambridge Technicals qualifications.

Question 7 (b) (iii)

(iii) Suggest **one** additional piece of information about chargers which drivers would find useful.

....

.... **[1]**

Many candidates provided a list of extra pieces of information that might be required, but frequently suggested information – type of connector, location, availability - which they had been told in the stem of Question 7 (b) was provided by the App. Nevertheless, the majority of candidates managed to gain the mark for this question. This question addressed LO7.

Copyright information

Question 7 (a) (i): Data about electric car usage © www.rac.co.uk, RAC. Link to material - www.rac.co.uk/drive/electric-cars/choosing/road-to-electric/.

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