CAMBRIDGE TECHNICALS

Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

APPLIED SCIENCE

05847–05849, 05879, 05874

Unit 3 Summer 2024 series

Version 1

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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 answers 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 OCR.

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, however, be a context candidates are unfamiliar with.

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 question and care in answering the question 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:
• understood and applied the conventions to be followed when constructing line graphs and pie charts • showed working when carrying out calculations and were confident in the use of standard form and significant figures, and in the derivation of units • were able to successfully use knowledge gained from first-hand experience of practical activities to answer (Questions 3, 4, and 6) • were confident in the analysis of information and data presented in unfamiliar contexts (Questions 1, 2, and 7).	• did not draw appropriate lines of best fit and were inaccurate when drawing intercepts on graphs • did not set out calculations carefully and logically, and did not consistently carry forward answers when attempting multi-part questions (Question 6(b)) • appeared to have little first-hand experience of practical activities to draw on, or were not able to successfully use knowledge gained from practical activities (Questions 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)

1 Jupiter has more than 90 moons.

Eleven of these moons were discovered in the 20th century. Their diameters are shown in the table below.

Moon	Year of discovery	Diameter (km)
S/1999 J1	1999	13
Metis	1979	40
Adrastea	1979	25
Thebe	1979	100
Leda	1974	15
Ananke	1951	30
Carme	1938	49
Lysithea	1938	35
Sinope	1914	35
Pasiphae	1908	50
Elara	1905	75

(a)
(i) Use the data in the table to determine the mode, median and range of these diameters.

- mode = ...
- median = ...
- range = ...

[3]

This question presented candidates with few problems; nearly all were able to correctly calculate the mode, median, and range of the data. This question assessed LO1.

Question 1 (a) (ii)

(ii) Use the data in the table to calculate the mean of the moon diameters.

Give your answer to the nearest whole number.

Mean = ……………..…………….................. km **[1]**

This question presented few problems to candidates. Nearly all candidates correctly calculated the mean and correctly rounded to the nearest whole number. Those candidates who did not answer this question correctly had invariably calculated the correct mean value, but either rounded it incorrectly or did not round it to a whole number. This question assessed LO1.

Question 1 (b) (i)

(b) The data in the table can be compared across two time periods.

Six of the moons in the table were discovered between 1905 and 1951 and five after 1951.

Compare the diameters of the moons discovered between 1905 and 1951 with the diameters of the moons discovered after 1951.

(i) Identify the name of the outlier in the data for moons discovered after 1951.

.... **[1]**

Nearly all candidates correctly identified Thebe as the outlier for moons discovered after 1951, although a handful of candidates stated the diameter rather than its name. This question assessed LO4.

Question 1 (b) (ii)

(ii) Describe the trend in the data between the two time periods if the outlier is ignored.

....

.... **[1]**

The majority of candidates either compared the relative diameters of the moons discovered in the two time periods or identified a trend of decrease in diameter across both time periods. A small number of candidates did not gain marks because they described fluctuations in diameter across both time periods without identifying the underlying trend or described the trend in only one of the time periods. This question assessed LO2.

Question 1 (b) (iii)

(iii) Suggest an explanation for the trend.

....

.... **[1]**

The majority of candidates identified improvements in technology over time as the reason for smaller moons having been discovered later. Where a specific technology was mentioned, it was invariably telescopes that featured – only one or two candidates referred to the use of space probes in space exploration. This question assessed LO5.

Question 1 (c)

(c) Elara was discovered in 1905.

Elara has a radius, R of 3.75×10^4 m and a mass, *M* of 8.7×10^{17} kg.

The gravitational field strength, *g* at the surface of Elara can be calculated using the equation:

$g = \frac{GM}{R^2}$, where $G = 6.67 \times 10^{-11}\ N\,m^2 kg^{-2}$

Calculate *g*.

Give your answer to **2** significant figures and state the units.

g = ... units .... **[4]**

Nearly all candidates were able to calculate the gravitational field strength (g), and only a handful of candidates did not round the calculated answer to two significant figures. The derivation of the units proved to be more challenging, with only one or two candidates correctly stating N kg^{-1}. This question assessed LO1.

Assessment for learning

Derivation of units has proved challenging for candidates throughout the lifetime of the specification. It is a skill that centres could address when candidates are practising calculations in which units are manipulated/derived.

Question 1 (d) (i)

(d) An image of Thebe taken by a spacecraft is shown below.

According to internet sources, the diameter of Thebe is 100 ± 4 km.

(i) Suggest how this value would be determined from the image.

....

.... **[2]**

Very few candidates identified the significance or use of the scale bar, nor that the irregular shape of the moon required measurements being taken of at least three diameters leading to the calculation of a range. Many candidates made vague references to magnification in an attempt to answer the question. This question assessed LO1.

Question 1 (d) (ii)

(ii) Explain why there is uncertainty in the quoted value.

.... **[1]**

A significant number of candidates correctly identified that the image was not clear or blurred leading to an inability to measure the diameter accurately, or that Thebe had an uneven shape. This question assessed LO4.

Misconception

A common misconception was that uncertainty arose from the diameter having been measured differently by a number of different individuals.

Question 2 (a)

2 Moths belong to a large order of insects called *Lepidoptera*. This order is divided into two groups: butterflies (*Rhopalocera*) and moths (*Heterocera*).

(a) *Lepidoptera*, *Rhopalocera* and *Heterocera* are terms used to classify living things.

Give **two** reasons why scientists use a classification system for living things.

1 ....

2 ....

[2]

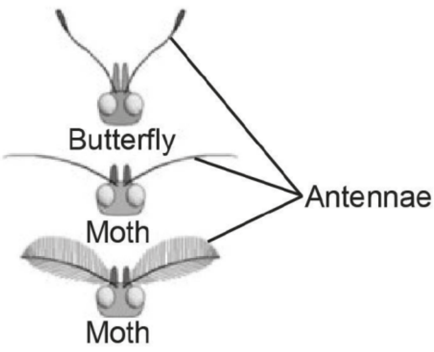
A significant number of candidates suggested identification as a reason for classifying organisms – this is the reason for using classification keys. However, the majority of candidates were able to gain at least 1 mark for suggesting categorising/ordering living organisms (with the more successful responses including reference to phylogenetics) and/or the use of a universally-recognised accepted naming convention. This question assessed LO3.

Question 2 (b) (i)

(b) A biology student is investigating insects classified as *Lepidoptera*.

The student finds a diagram on the internet which shows how to tell moths and butterflies apart by the shape of their antennae.

The diagram is shown below.



(i) Describe **two** features of the butterfly antennae that are different from the moth antennae.

1 ....

2 ....

[2]

A significant number of candidates suggested that butterflies had smooth antennae compared to the 'feathery'/e.q. antennae of moths, overlooking the fact that of the two moths illustrated one had 'feathery' antennae, while one had smooth antennae. However, nearly all candidates scored at least 1 mark, and those that gained 2 marks did so for identifying the differences in shape of butterfly and moth antennae. This question assessed LO3.

Question 2 (b) (ii)

(ii) Suggest **two** additions to the diagram that would improve the quality of the information.

1 ....

....

2 ....

....
[2]

A number of candidates did not appreciate that the question was asking for additions to the existing diagram, rather than additional diagrams from different angles or enlarged diagrams. Some suggested diagrams of alternative parts of the insects' bodies, not appreciating that the diagram was specifically relating to the ability to identify moths and butterflies by the shape of their antennae. The majority of candidates did manage to score at least 1 mark for suggesting scale and/or labelling and/or use of colour. This question assessed LO3.

Question 2 (c) (i)

(c) The student investigates the possibility of designing a key to assist with identifying moths.

The table below shows descriptions of the larvae (caterpillars) of three different moths.

Arctia caja (garden tiger moth)	The larvae are extremely furry, the hairs being long. They are mostly black with reddish or ginger hairs at the sides. The tips of the long black hairs are white. As they grow larger, they moult several times until reaching full size at around 4 cm long.
Arctia villica (cream-spot tiger moth)	The young larvae are very furry and are black in the early stages. The larvae will eat dandelion, nettle and many other wild and garden plants.
Callimorpha jacobaeae (cinnabar moth)	The larvae are black-and-orange banded and are found feeding on the flowers of ragwort during July and August.

(i) The garden tiger moth is also known as *Arctia caja*.

Explain the nomenclature used for *Arctia caja*.

....

.... **[2]**

Nearly all candidates correctly referred to the nomenclature identifying the genus and species, with a majority also referring to binomial nomenclature. This question assessed LO3.

Question 2 (c) (ii)

(ii) The student needs more information to construct a key.

What **two** pieces of further information are needed for *Arctia caja* to compare with the other moths?

1 ....

2 ....
[2]

The majority of candidates appeared to have investigated the table to find the missing pieces of information for *Arctia caja*, and correctly identified its food and the time of year seen. This question assessed LO3.

Question 2 (c) (iii)

(iii) What **three** pieces of further information are needed for *Arctia villica* to compare with the other moths?

1 ....

2 ....

3 ....
[3]

The majority of candidates appeared to have investigated the table to find the missing pieces of information for *Arctia villica*, although a lack of specificity limited the number of marks candidates were given. Candidates frequently referred to 'change of appearance [sic]' with age (rather than 'change of colour'), or 'colour of hairs' (rather than 'colour of hairs at tip'), or 'appearance of hairs' (rather than 'colour of hairs at tip' or 'length of hairs'. Length/size and time of year seen were the most common suggestions, with references to moulting (MP3) being very rarely seen. This question assessed LO3.

Question 2 (d)

(d) A recent study concluded that the total number of moths in Britain decreased by 33% over the 50-year period up to 2017.

Explain why moths can be used as indicator species.

....

.... **[2]**

This question proved challenging for nearly all candidates – very few candidates correctly stated that an indicator species shows a change in population in response to a change in environment. The more successful candidates suggested that moths responded to changes in the environment, without explaining what the response was. Other candidates suggested that moths were common or easy to count as being reasons for their use as indicator species. This question assessed LO3.

Question 3 (a) (i)

3 Amylase is an enzyme responsible for breaking down starch.

The rate at which starch is broken down can be monitored in a laboratory by testing with iodine solution. If starch is present, iodine changes from orange-brown to blue-black.

A group of students is investigating how the activity of the enzyme amylase changes with temperature. They use the method outlined below.

1. Set up a water bath at 25 °C.
2. Add 10 cm^3 of starch solution to a test tube, and 10 cm^3 of amylase solution to another test tube.
3. Place both test tubes in the water bath for 5 minutes.
4. During this period, put one drop of iodine into each dimple on a spotting tile.
5. Pour the amylase into the test tube containing the starch and start a timer.
6. Immediately remove a sample of the starch-amylase mixture and add to a drop of iodine on the spotting tile.
7. Remove a sample of the starch-amylase mixture every 2 minutes and add to another drop of iodine on the tile.
8. Continue for 14 minutes.
9. Repeat the experiment at different temperatures in the water bath, set at 30 °C, 35 °C, 40 °C and 45 °C.

Fig. 3.1 shows the results of the investigation.

Fig. 3.1

	Temperature (°C)				
Time (mins)	25	30	35	40	45
0	●	●	●	●	●
2	●	●	●	●	●
4	●	●	●	●	●
6	●	●	○	●	●
8	●	●	○	○	●
10	●	○	○	○	●
12	●	○	○	○	○
14	○	○	○	○	○

Key:

Colour of iodine solution

● = blue-black

○ = orange-brown

(a)
(i) Describe the trends in the results shown in **Fig. 3.1**.

....

....

....

.... **[3]**

This question asked candidates to describe the pattern of results for the breakdown of starch shown in Fig. 3.1. Only a handful candidates described the pattern of results in terms of the time taken to break down starch as temperature increases, and of those only a minority referred to the breakdown of starch. Nearly all candidates attempted to explain the results in terms of reaction kinetics, and so – without referring to breakdown of starch – scored no marks. A few did refer to breakdown of starch in their answer and gained MP3. This question assessed LO5.

OCR support

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 3 (a) (ii)

(ii) Explain **three** trends in the results shown in **Fig. 3.1**.

1 ....

....

2 ....

....

3 ....

....
[3]

This question proved challenging for nearly all candidates. Having described the pattern of results shown in Fig.3.1. in 3(a)(i), this question required candidates to explain that pattern in terms of enzyme kinetics. Unfortunately, as the majority of candidates had provided an explanation of the results as their answer to 3(a)(i), they struggled to find an answer for this question.

Moreover, the handful candidates who had described the pattern of results in 3(a)(i) also failed to provide an explanation for the pattern of results observed – a small minority of candidates did gain MP1 for stating that starch was present for the shortest time or that the enzyme worked quickest at 35ºC, but the majority of responses were framed in the context of the enzyme working faster closer to its optimum temperature. This question assessed LO5.

Question 3 (b) (i)

(b) The students use their results to determine the optimum temperature for the activity of amylase.

(i) Explain why the results only give an approximate estimate of the optimum temperature.

....

....

....

.... **[2]**

Many candidates showed an understanding that the results only suggested a range for the optimum temperature, but a significant number used 'approximate/approximation' and/or 'estimate' in their answers, both of which were in the stem of the question and so MP1 could not be awarded. Very few candidates referred to the correct range of 31-39°C. This question assessed LO5.

Question 3 (b) (ii)

(ii) Suggest **three** modifications the students could make to the method to obtain a more accurate value for the optimum temperature.

1 ....

....

2 ....

....

3 ....

....

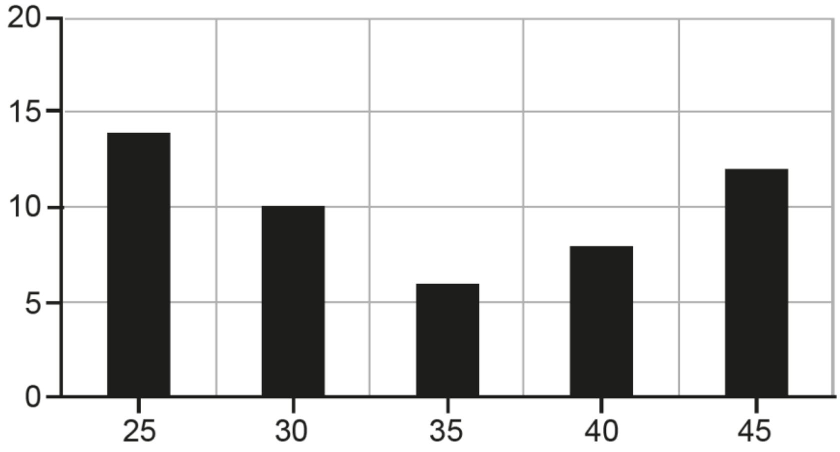
[3]

This question proved challenging to the majority of candidates; few suggested that samples could be taken more frequently or at smaller temperature intervals, and only a few candidates then made reference to the relevant temperature range of 30-40°C.

A wide variety of possible improvements were suggested, including use of pH buffers, use of digital thermometers, use of known concentrations of iodine, use of more concentrated starch solutions, and performing the experiment in a temperature-controlled environment. This question assessed LO5.

Question 3 (c) (i)

(c) The students plot a graph of their results as shown below.



(i) What information should the students include to complete their graph?

.... **[1]**

The majority of candidates identified that that the axes required labelling, with some candidates referring to variables and units. The most common error was to suggest that the graph required a title, while a few candidates suggested that error/range bars should be included – these responses were not considered creditworthy as titles and error/range bars are not mandatory features of a graph. This question assessed LO2.

Question 3 (c) (ii)

(ii) The students' teacher says that a scatter graph would be more appropriate than a bar graph.

Explain why a scatter graph is more appropriate.

....

.... **[1]**

A small minority of candidates identified that bar graphs should be used for discontinuous data and/or that the continuous nature of the data presented would be better represented by a scatter graph. The majority of responses suggested that scatter graphs better show trends/patterns/variations in the data, show anomalous results, or that times at other temperatures could be interpolated. This question assessed LO2.

Question 3 (c) (iii)

(iii) The students decide to repeat the investigation three times at each temperature before constructing a scatter graph.

What **three** pieces of extra information should the students include to complete their scatter graph?

1 ....

2 ....

3 ....

[3]

This question proved challenging for the majority of candidates, who referred to the need to label axes, and/or provide units, and/or provide a title. Very few candidates scored maximum marks – references to constructing a line of best fit and providing an indication of outliers/anomalies were the most commonly seem mark points, with references to drawing error/range bars comparatively rare. This question assessed LO5.

Question 4 (a)

4 Scientists are investigating the chemical reaction between sodium thiosulfate and a dilute acid.

A precipitate is produced which makes the reaction mixture turn cloudy.

(a) The scientists first investigate how the rate of reaction changes as the initial concentration of sodium thiosulfate is changed.

They use the following method.

Step 1: place a card with a cross on it under a conical flask.

Step 2: put 10 cm^3 sodium thiosulfate solution and 40 cm^3 water into the conical flask.

Step 3: add 5 cm^3 of dilute acid.

Step 4: swirl the flask and measure the time taken for the cross to become invisible when viewed from above.

Step 5: repeat the procedure using different volumes of sodium thiosulfate and water in **Step 2**.

The scientists' results are shown in the table.

Volume of sodium thiosulfate (cm^3)	**Volume of water (cm^3)**	**% concentration of sodium thiosulfate**	**Time taken for the cross to disappear (s)**	$\frac{1}{\text{time}}$ **(s^{-1})**
10	40		164	
20	30		85	
30	20		56	
40	10		42	

Complete the table by doing the following calculations:

- Calculate the % concentration of the sodium thiosulfate solution in the flask at the start of each experiment and record the values in the results table.

  Use the equation: $\% \text{ concentration} = \frac{\text{volume of thiosulfate}}{\text{volume of thiosulfate plus volume of water}} \times 100$

- Calculate the value of $\frac{1}{\text{time}}$ for each experiment and record each value in the table.

  Record your answers to **2** significant figures.

  The value of $\frac{1}{\text{time}}$ can be taken as a measure of the rate of reaction.

[3]

Most candidates performed well on this question, gaining 3 marks. Some candidates did not calculate 1/time correctly to two significant figures – often the number of significant figures was correct, but the rounding was incorrect.

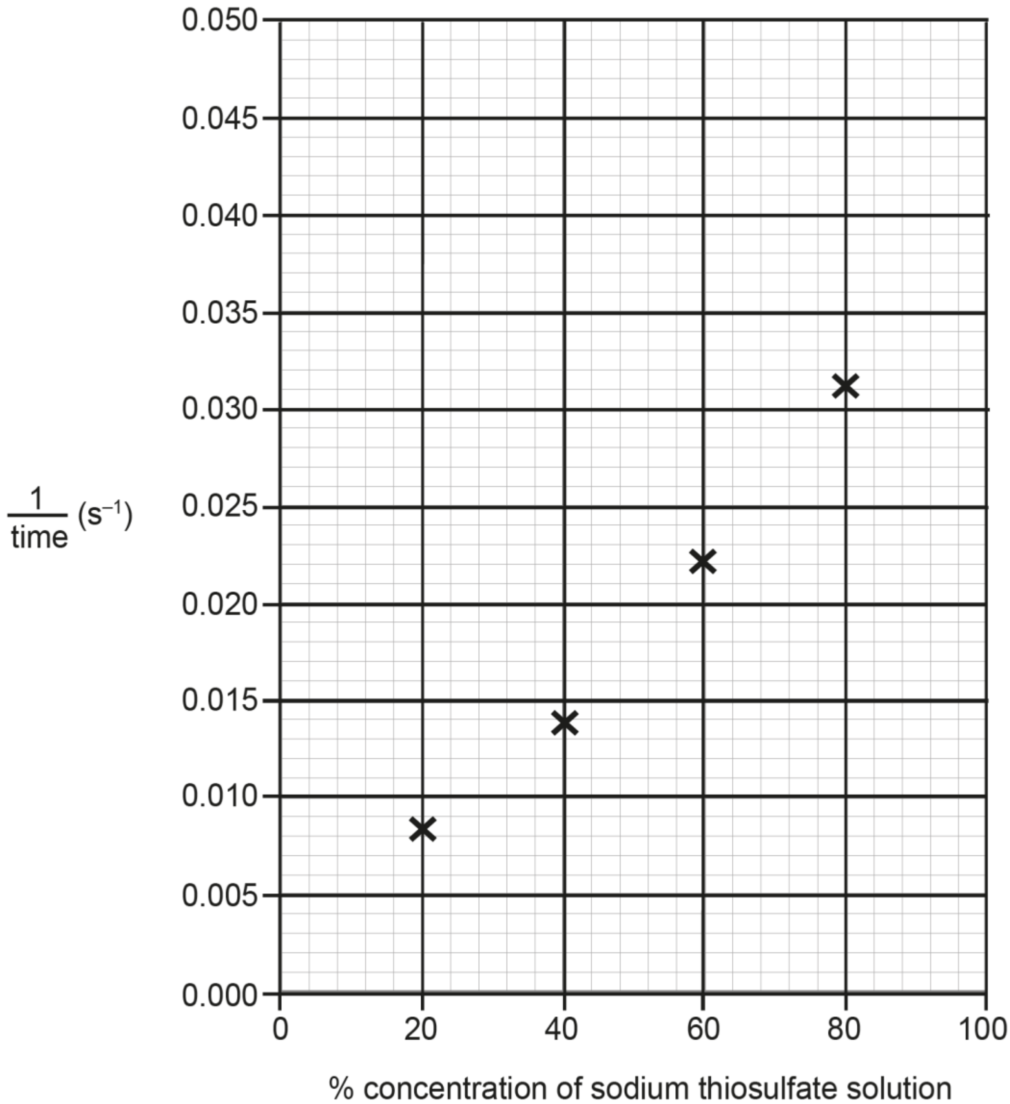
A small number of candidates appeared not to understand that leading zeros are never significant, and consequently rounded their calculated 1/time values to one significant figure. This question assessed LO1.

Questions 4 (b) (i) and (ii)

(b) The scientists then investigate whether changing the initial concentration of acid affects the rate of reaction.

They follow the same method as in part **(a)** but use a different concentration of acid in **Step 3**.

The graph shows their results.



(i) Draw the line of best fit.

[2]

(ii) Use the graph to estimate the time taken for the cross to disappear when the concentration of sodium thiosulfate is 70%.

Show your working on the graph.

Time = ……………..……………................. s **[3]**

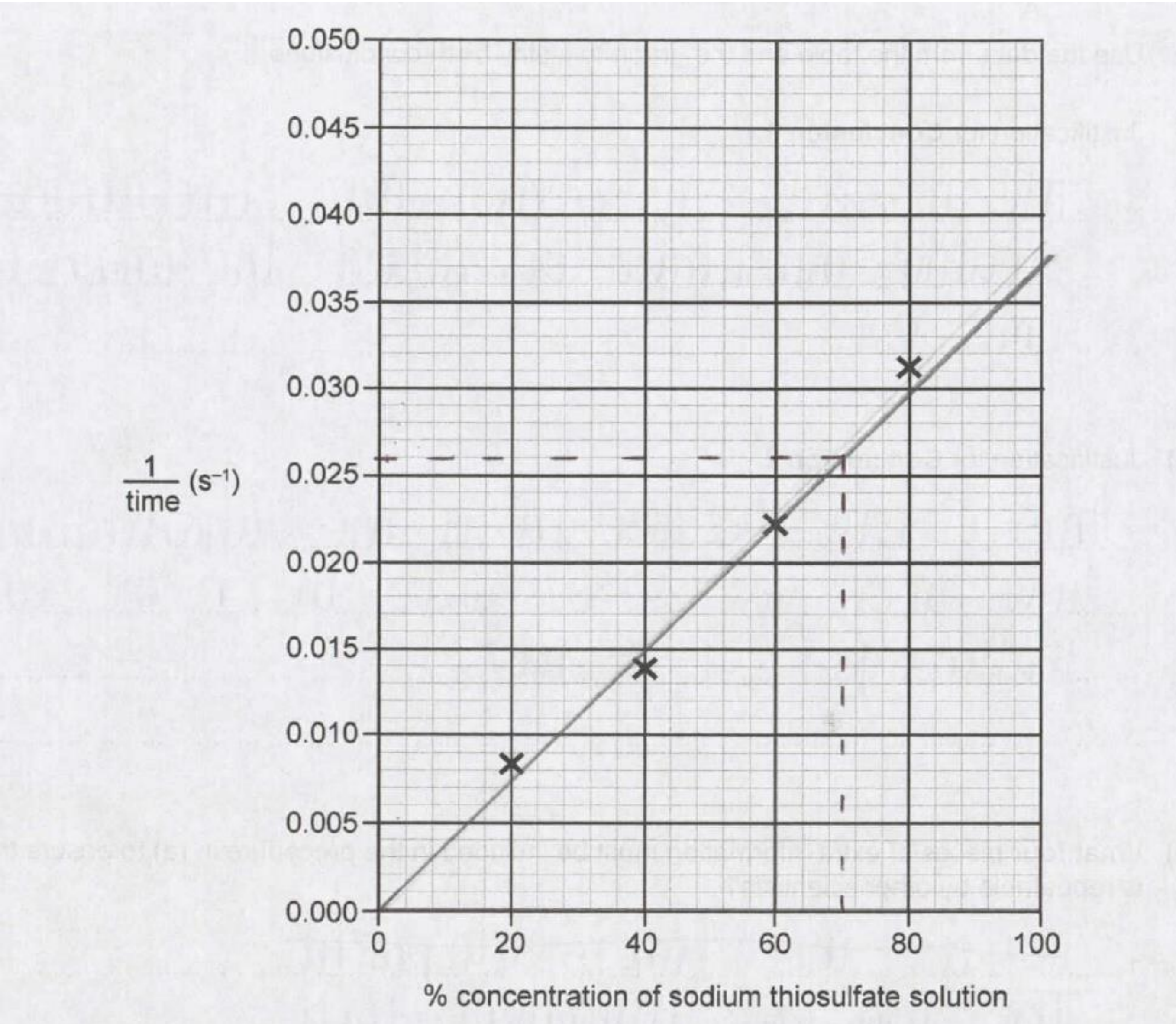
4(b)(i) This part of the question was addressed well by nearly all candidates, who drew a straight line through the origin with a roughly even distribution of points above and below the line. Lines were invariably thin and continuous, without overlapping/broken sections or feathering – the quality of lines drawn on graphs by candidates has improved significantly over the lifetime of the qualification. A small number of candidates drew straight lines which did not pass through the origin or attempted to link all the points using various curved lines, which may or may not have passed through the origin.

4(b)(ii) Nearly all candidates gained MP1 and MP2 – only a small number candidates converted the value of 1/time read-off from the graph to give a time value for MP3.

MP2 was credited for the correct read-off for the candidates drawn line-of-best fit (a correctly-drawn line of best fit would have given a 1/time value of 0.27). A small number of candidates drew vertical lines from sodium thiosulfate concentrations other than 70%, or lines from 70% that were not quite vertical – in these cases MP1 was not credited, but an error-carried-forward was allowed for MP2 for a correct read-off of 1/time for the intercept on the line-of-best-fit.

This question assessed LO1.

Exemplar 1



(ii) Use the graph to estimate the time taken for the cross to disappear when the concentration of sodium thiosulfate is 70%.

Show your working on the graph.

$\frac{\text{change in } y}{\text{change in } x} = \frac{70-0}{0.026-0} = 2692.3$

Time = ...0.026........ s **[3]**

4(b)(i) The candidate has drawn a suitable line-of-best for MP1 and MP2 – it is a straight line starting at the origin, with a roughly even distribution of points above and below the line (the line should have been drawn between the points at 60% and 80% sodium thiosulfate, but candidates are allowed a degree of error in drawing lines-of-best fit). The line drawn is also sharp, unbroken, and unfeathered.

4(b)(ii) A vertical line has been drawn from 70% sodium thiosulfate for MP1, and the intercept for 1/time on the drawn line-of-best fit correctly read-off as 0.26 for MP2.

t has not been calculated, so MP3 was not awarded.

The calculation of dy/dx was ignored.

Question 4 (c) (i)

(c) The scientists make **two** conclusions from their investigations in **(a)** and **(b)**:

Conclusion 1: the rate of reaction is directly proportional to the concentration of sodium thiosulfate.

Conclusion 2: the acid used in **(b)** is more concentrated than the acid used in **(a)**.

Use the data from the table and the graph to justify **both** conclusions.

(i) Justification for **Conclusion 1**.

....

....

.... **[2]**

This question proved challenging for nearly all candidates. The majority of candidates quoted two sets of data from the table to support conclusion 1 (gaining MP1), but were unable to use the graph to supply supporting evidence (MP2) – many candidates simply did not refer to the graph in their answers. This question assessed LO5.

Question 4 (c) (ii)

(ii) Justification for **Conclusion 2**.

....

....

....

.... **[3]**

This question proved less challenging for candidates than Question 4(c)(i). A significant number of candidates were able to state values of 1/t at the same concentrations of sodium thiosulfate, gaining MP1 and MP2. However, a significant minority did not compare the two values to support conclusion 2. Also, where the two 1/time values were compared, many candidates seemed to be under the impression that the smaller the 1/time value the faster the rate of reaction, and so ended up contradicting Conclusion 2 by stating that the acid used in (a) was more concentrated than the acid used in (b). As a result, only a minority of candidates gained MP3. This question assessed LO5.

Question 4 (d)

(d) What **four** pieces of extra information must be included in the procedure in **(a)** to ensure that it is repeatable by other scientists?

1 ....

....

2 ....

....

3 ....

....

4 ....

....

[4]

A variety of suggestions was offered by candidates, including: type of equipment used; where the test was done; test conditions; date of experiment; names of investigators and composition of reagents. Many candidates did not score any marks on this question. However most gained at least 1 mark, but responses scoring more than 2 marks were rare – all the mark points were seen, with name of acid being slightly the most common. This question assessed LO4.

Question 5 (a)

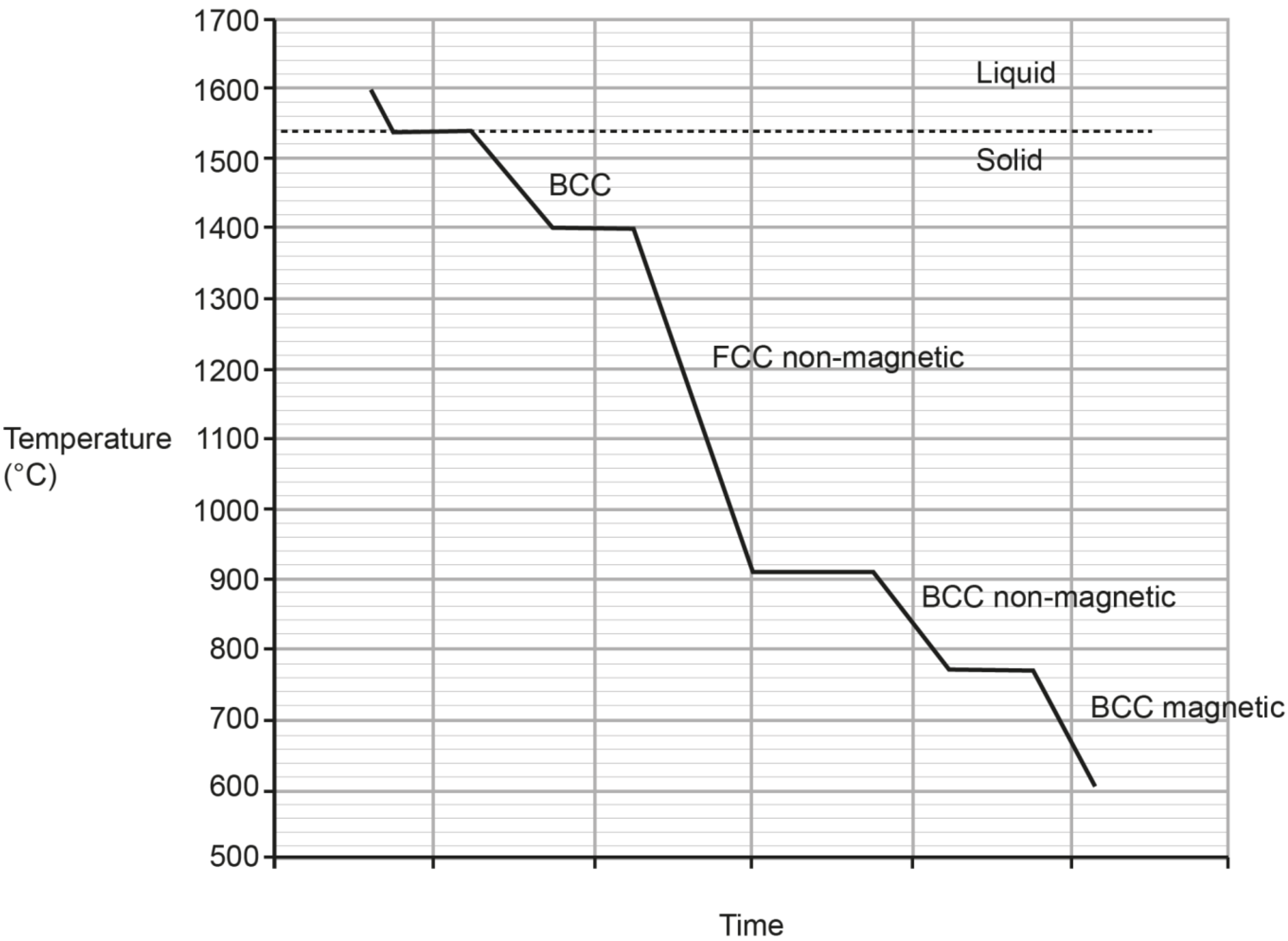
5 Iron is an important metal in the construction industry.

(a) Liquid iron is poured into a mould.

As the iron cools the arrangements of its atoms change. One arrangement is known as body-centred cubic (BCC) and the other is known as face-centred cubic (FCC).

The magnetic property of the iron also changes as it cools.

The graph shows how the structure of pure iron changes as it cools.



Use the graph to describe how the structure of iron changes as molten iron cools down.

....

....

....

....

....

.... **[6]**

The overwhelming majority of candidates scored Level 1, 2 marks, for providing a simple description of the cooling of iron as illustrated by the graph. A few candidates were inaccurate when reading temperatures from the graph and were limited to Level 1, 1 mark. Only a few candidates added detail to their descriptions by linking change in atomic arrangement or change in magnetic properties to a period of constant temperature during the cooling process, or by identifying that magnetic proprieties do not depend on the atomic arrangement – such candidates achieved Level 2, but no candidate provided sufficient detail to access Level 3. This question assessed LO2 and LO5.

Exemplar 2

Firstly, the molten iron changes from a liquid back to a solid at a temperature of 1540°c and ~~st~~ remains in that state for the rest of the cooling process. Next, as it cools ~~from~~ to a temperature of 1400°c it's atoms rearrange to form it's body-centered cubic form ~~until~~ which is constant until the temperature begins to rapidly decline from 1400°c to 910°c, during which time it has held the atomic arrangement of a non-magnetic face-centred cubic. This form is again constant, ~~be~~ for a longer period of time until it's atomic arrangement becomes ~~be~~ a non-magnetic body-centred cubic as the temperature steadily drops to 770°c. Last but not least, the ~~Molecule~~ atom arrangement of the iron becomes Magnetic as the temperature gradually declines to 600°c and below! **[6]**

This is a typical, but well written, Level 1 response worth 2 marks. The candidate has demonstrated a basic understanding of the data by providing a simple description of the cooling of iron as illustrated in the graph.

Question 5 (b) (i)

(b) Mild steel is an alloy of iron.

This alloy contains five elements in addition to iron.

The table shows the relative amounts of the five elements in proportion to each other.

Element	**Symbol**	**Proportion (%)**
Carbon	C	37%
Silicon	Si	25%
Manganese	Mn	21%
Phosphorus	P	16%
Sulfur	S	1%

Complete the pie chart below using the following steps:

(i) Convert the percentages of carbon and silicon in the table to degrees.

Carbon = ... °

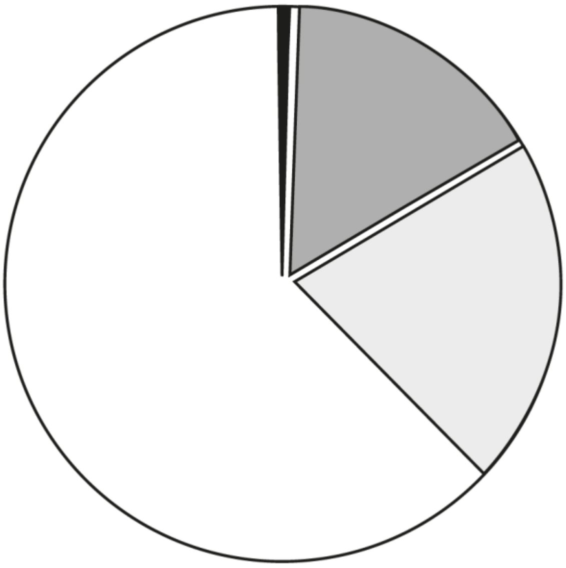
Silicon = ... °

[1]

The majority of candidates were able to correctly convert the percentages of carbon and silicon to degrees. Some candidates who calculated incorrect values nevertheless managed to segment with the correct proportions when completing the pie chart in question 5(b)(ii) – there was no error-carried-forward for pie charts constructed using incorrectly-calculated degrees. This question assessed LO1.

Question 5 (b) (ii)

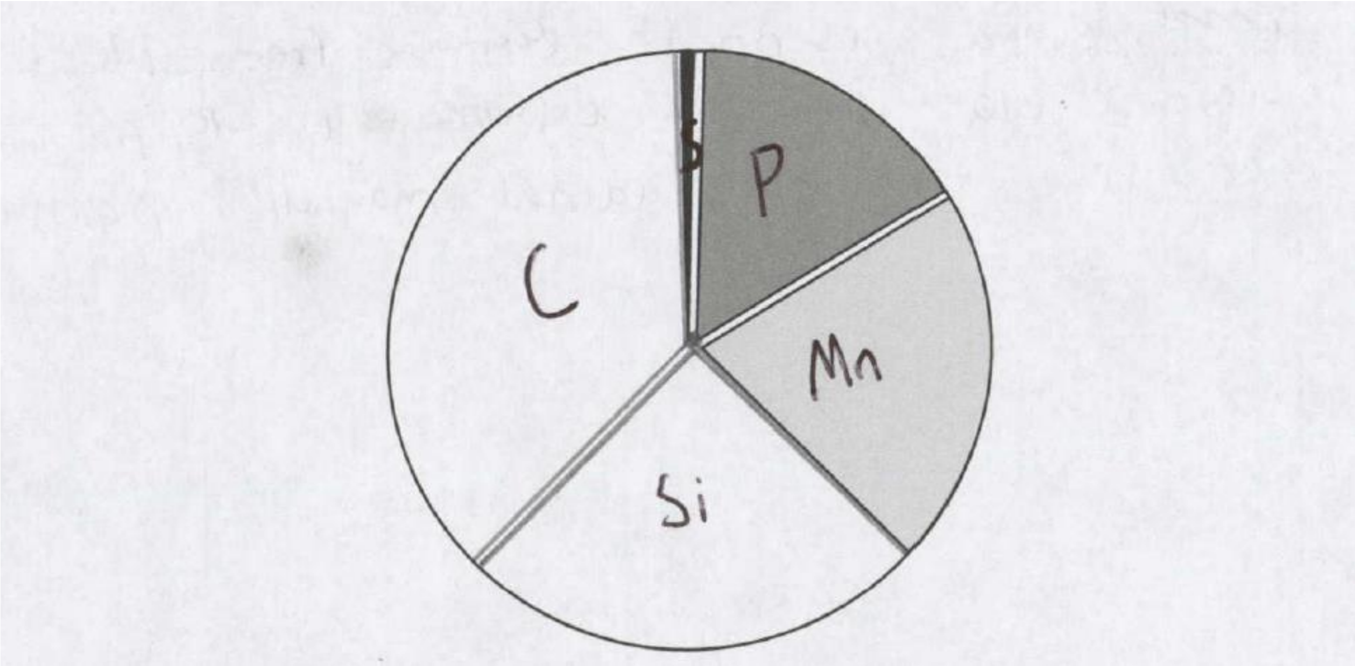
(ii) Draw the segments for carbon and silicon in the correct positions on the pie chart and label each segment of the pie chart with the correct symbol.



[2]

The majority of candidates correctly constructed a pie chart with a radius drawn at 90^{O} to the third segment, and with all segments correctly labelled. A small number of candidates, having correctly constructed the pie chart, did not label the segments or omitted to label the pre-drawn segments. Some candidates reversed the sequence of the final two segments by drawing a tangent at 90^{o} to the first segment. As long as the segments were correctly labelled these candidates were still able to gain MP2. This question assessed LO2.

Exemplar 3



Exemplar 3 is a response that gained both MP1 and MP2 – a radius has been drawn at 90° to the third segment (MP1) and all five segments have been labelled with the correct element (MP2).

Misconception

Many candidates remain uncertain about the ordering of segments within a pie chart. Ordering should go from the largest segment to the smallest segment, except when the segments have an inherent ordering – such as age ranges or months of the year – when either order may be used dependent on what information the pie chart is intended to convey.

Question 6 (a) (i)

6 Hydrogen peroxide (H_2O_2) is an active ingredient in some mouthwashes and in contact lens solutions.

A chemist determines the concentration of hydrogen peroxide in mouthwash by titration with acidified potassium manganate (VII), $KMnO_4$.

$$5H_2O_2(aq) + 2MnO_4^- + 6H^+ \longrightarrow 5O_2(g) + 2Mn^{2+} + 8H_2O$$

Purple Colourless

A 5.00 cm³ portion of mouthwash was transferred to a 100 cm³ volumetric flask and made up to the mark with water.

10.00 cm³ portions of the diluted mouthwash were acidified and titrated against 0.020 mol dm⁻³ $KMnO_4$.

(a) The titration is a **redox** reaction.

(i) Balance the half equation for the conversion of MnO_4^- ions to Mn^{2+} ions.

$MnO_4^-(aq)$ + …….$H^+(aq)$ + …….e^- $\longrightarrow$ $Mn^{2+}(aq)$ + …….$H_2O(l)$

[1]

This question proved challenging for nearly all candidates; only a few candidates were able to correctly balance the half equation. A large variety and combinations of numbers were provided, with little to suggest that many candidates were doing anything other than merely guessing. This question assessed LO6.

Question 6 (a) (ii)

(ii) Is $MnO_4^-(aq)$ oxidised or reduced?

Explain your answer in terms of electrons.

....

.... **[2]**

Nearly all candidates provided answers which included a statement about oxidation/reduction of MnO_4^- and an explanation in terms of loss or gain of electrons. Most understood that oxidation involves loss of electrons and that reduction involves gain of electrons although a small number incorrectly stated that MnO_4^- was being oxidised and consequently gained zero marks. A small but significant number of candidates, whose knowledge of oxidation/reduction was somewhat confused, were able to gain 1 mark for stating that MnO_4^- was oxidised and gained electrons or that it was reduced and lost electrons. This question assessed LO6.

Question 6 (a) (iii)

(iii) State the colour change at the end point of the titration.

From .... to ....

[1]

Nearly all candidates suggested that colour change at the end point of the titration would be from purple to colourless, copying the information in the stem of the question. Only the most successful candidates understood that MnO_4^- ions would only be in excess once the endpoint had been reached, and that the colour change would be from colourless to purple/pink. A handful of candidates offered various other colour changes. Knowledge of how to recognise the end point when using standard potassium manganite (VII) to determine the concentration of hydrogen peroxide is specified in the exemplification of LO 6.3 Unit 3 teaching content. This question assessed LO6.

Questions 6 (b) (i), (ii), (iii) and (iv)

(b) The mean titre was found to be 12.20 cm^3.

(i) Calculate the number of moles of $KMnO_4$ in 12.20 cm^3 of 0.020 mol dm^{-3} $KMnO_4$.

Use the following equation in your calculation.

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

Number of moles $KMnO_4$ = ... **[1]**

(ii) In this reaction 5 moles of H_2O_2 react with 2 moles of $KMnO_4$.

Use this information to calculate the number of moles of H_2O_2 in 10.00 cm^3 of the diluted mouthwash.

Number of moles H_2O_2 = ... **[1]**

(iii) Calculate the concentration in mol dm^{-3} of H_2O_2 in the diluted mouthwash.

Concentration of H_2O_2 in the diluted mouthwash = ... mol dm^{-3} **[1]**

(iv) Calculate the dilution factor and use this value to calculate the concentration of H_2O_2 in the original mouthwash.

Dilution factor =…………….…………….................

Concentration of H_2O_2 in original mouthwash = …………….…………….................. mol dm^{-3}

[2]

6(b)(i) The majority of candidates were able to substitute the given values in the equation provided to correctly calculate the number of moles of $KMnO_4$ present.

6(b)(ii) A smaller, but significant, number of candidates understood that with a stoichiometry of 5:2 there would be 2.5 times the number of moles of H_2O_2 present in 10.00 cm^3 of diluted mouthwash compared to $KMnO_4$.

6(b)(iii) This question proved more challenging for candidates, with a significant number not appreciating that the concentration of H_2O_2 in mol dm^{-3} would be a factor of 100 times that in 10 cm^3.

6(b)(iv) This question proved challenging to all except the most successful candidates. Many candidates seemed unaware of how to calculate the dilution factor - seemingly random numbers appearing from nowhere – or that this should be used to multiply the concentration of H_20_2 calculated in 6(b)(iii).

At each stage in this series of linked calculations an increasing number of candidates gave up, with a corresponding increase in the number of null responses – this series of questions had the highest omit rate for the paper.

Questions 6(b)(i)/(ii)/(iii)/(iv) assessed LO1.

Question 6 (c)

(c) Contact lens solutions contain ingredients such as hydrogen peroxide which sterilise contact lenses.

The label on a bottle of contact lens solution says it is a 3% solution of hydrogen peroxide. A 3% solution means there are 3 g of H_2O_2 in 100 cm^3 of solution.

Calculate the concentration of H_2O_2 in mol dm^{-3}.

Concentration of H_2O_2 in contact lens solution = ……………..……………................ mol dm^{-3} **[3]**

This question proved challenging to all except the most successful candidates. A significant number of candidates recognised the need to calculate the Mr for H_20_2, and did so correctly, gaining MP1. However, the subsequent calculation of the concentration of H_20_2 appeared to present problems at both stages. This question assessed LO1.

Question 6 (d) (i)

(d) Some contact lens solutions contain sodium chloride solution to sterilise contact lenses.

The chemist decides to do a titration to determine the concentration of Na*Cl* in a brand of saline contact lens solution.

The chemist titrates 10.0 cm^3 portions of the contact lens solution against 0.100 mol dm^{-3} silver nitrate ($AgNO_3$).

(i) What type of titration is this?

Put a (ring) around the correct answer.

Acid-base **Complexometric** **Precipitation** **Redox**

[1]

Candidates appeared unclear about the type of titration described in the question – all possible responses were selected with approximately equal preference. Knowledge of this precipitation titration is specified in the exemplification of LO 6.3 in the Unit 3 teaching content. Candidates should also have used all four titration techniques on consumer products when completing the mandatory NEA Unit 21 (Testing consumer products) – this is specified in the teaching content for LO3. This question assessed LO6.

Question 6 (d) (ii)

(ii) The indicator for this titration is potassium chromate.

Describe what you would observe at the end point.

....

....

.... **[1]**

Very few candidates were able to correctly state the end point when using standard silver nitrate with potassium chromate indicator to determine the concentration of chloride ions. A variety of colour changes were suggested, but only a few correctly suggested the appearance of a permanent red colour. Knowledge of how to recognise the end point for this titration is specified in the exemplification of LO 6.3 in the Unit 3 teaching content. This question assessed LO1.

Assessment for learning

Responses to Questions 6(a)(iii), 6(d)(i), and 6(d)(ii), 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 21 (Testing consumer products) is not strong. 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 6 (d) (iii)

(iii) The chemist obtained the following results.

	Trial	Accurate 1	Accurate 2	Accurate 3
Final burette reading (cm^3)	17.95	35.75	17.70	35.50
Initial burette reading (cm^3)	0.00	17.95	0.10	17.70
Titre (cm^3)	....	....	....	....

Complete the results table to show the titre obtained for each titration and use the concordant values to calculate the mean titre.

Mean titre = ... cm^3 **[2]**

Nearly all candidates were able to subtract the initial burette reading from the final burette reading to calculate the titre for each titration – a number of candidates stated one or more of the accurate titrations to only one decimal place. The concept of concordant titres remains a difficult one for a significant number of candidates; this was evident from the number of candidates who calculated the mean titre by averaging either all four titrations or the three accurate titrations, rather than from the two concordant titrations of 17.80 cm^3. This question assessed LO1 and LO6.

Question 6 (d) (iv)

(iv) The burette has an uncertainty of ± 0.05 cm^3 in each reading. Calculate the percentage error in the first **accurate** titre.

% error = ... % **[2]**

Calculation of percentage error proved challenging yet again for all but the most successful candidates, for whom the question proved straightforward. However, significant number of candidates appeared to have very little idea of how to calculate percentage error or of which figures to substitute in the calculation. This question assessed LO1.

Question 7 (a) (i)

Astonishing new Nasa image shows stars and planets as they form.

Item removed due to third party copyright restrictions

Fig. 7.2 shows part of a publication in *The Astronomical Journal* about discoveries made using the James Webb Space Telescope.

Fig. 7.2

Item removed due to third party copyright restrictions

(a) The two reports are designed for different audiences.

(i) Choose the intended audience (peers, public or scientific community) for the two reports and justify your answer.

Fig. 7.1

Intended audience ....

Justification ....

....

....

Fig. 7.2

Intended audience ....

Justification ....

....

....

[4]

Nearly all candidates selected their intended audiences from the options in the stem of the question – just a small number chose alternatives not listed, depriving themselves of MP1 and/or MP3. The majority of candidates correctly identified that Fig 7.1 was intended for the public and that Fig. 7.2 was intended for the scientific community/peers and provided correct justifications for their choices based on the information provided in the question and/or Figs. This question assessed LO7.

Question 7 (a) (ii)

(ii) Suggest **one** reason why it is important to publish scientific findings which are easily accessible to members of the public.

....

.... **[1]**

Nearly all candidates expressed, in one way or another, the idea of promoting wider understanding of science within the population or the development of that idea in terms of the benefits of having a better-informed population. This question assessed LO7.

Question 7 (b) (i)

(b) **Fig. 7.2** was published in a peer reviewed journal.

(i) State **one** advantage of peer reviewed publications.

....

.... **[1]**

A variety of responses were seen which addressed in various ways the idea of being able to have more confidence in the article/findings/research – only rarely was this linked to the process of independent validation. Examiners exercised professional judgement in terms of how each response was phrased, but were flexible in their assessment and reference to independent validation was not looked for. A common misconception was that peer review, in the context of publications, involves the reviewers repeating experiments/investigations and correcting findings where required – this misconception was also evident in responses to Question 7(b)(ii). This question assessed LO7.

Question 7 (b) (ii)

(ii) Describe the process of peer review.

....

....

....

.... **[3]**

In general, candidates had a poor understanding of the process of peer review in the context of published journals. Many candidates were under the impression that it involved passing experimental results – few responses referred to draft publications – to a colleague (rather than an independent expert) for checking.

A common misconception was that this review involved the reviewers repeating experiments/investigations and correcting findings where required. This misconception was also evident in responses to Question 7(b)(i). No response conveyed the understanding that peer review, in the context of publications, ends with the editor acting on an independent report to decide whether or not to publish. This question assessed LO7.

Question 7 (c) (i)

(c) Use **Fig. 7.2** to deduce:

(i) how many months it took to complete the peer review.

.... **[1]**

A range of responses was seen, of which the correct and allowable answers were in the minority. Candidates seemed to find determining the number of months it took to complete the review problematic. This question assessed LO7.

Question 7 (c) (ii)

(ii) the number of institutions that collaborated on this work.

.... **[1]**

Nearly all candidates correctly identified that six institutions collaborated on the work in question. This question assessed LO7.

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