OCR
Oxford Cambridge and RSA

Cambridge **TECHNICALS LEVEL 3**

Cambridge TECHNICALS 2016

LABORATORY SKILLS

Feedback on the June 2018 exam paper (including selected exemplar candidate answers and commentary)

Unit 3 – Scientific analysis and reporting

Version 1

CONTENTS

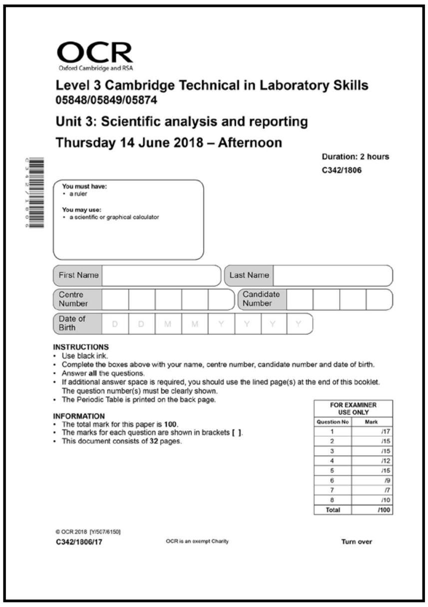
INTRODUCTION

This resource brings together the questions from the June 2018 examined unit (Unit 3), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

We have also included exemplar candidate answers with commentary for Questions 3(a)(i), 5(a)(i) and 7(a).

The marking guidance and the examiner's comments are taken from the Report to Centre for this question paper.

The Question Paper, Mark Scheme and the Report to Centre are available from:
https://interchange.ocr.org.uk/Modules/PastPapers/Pages/PastPapers.aspx?menuindex=97&menuid=250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Level 3 Cambridge Technical in Laboratory Skills
05848/05849/05874
Unit 3: Scientific analysis and reporting
Thursday 14 June 2018 – Afternoon
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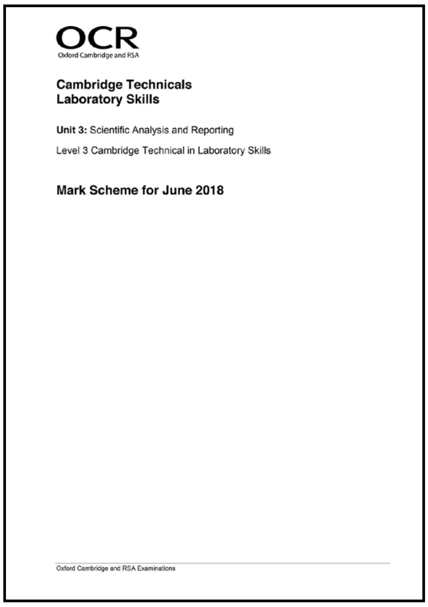
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Mark Scheme for June 2018
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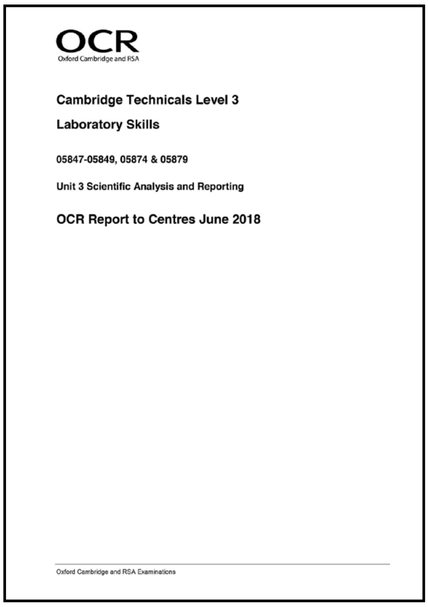
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Unit 3 Scientific Analysis and Reporting
OCR Report to Centres June 2018
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GENERAL EXAMINER COMMENTS ON THE PAPER

This is the first series for the Unit 3 paper. It was good to see that candidates responded well to the combination of open-response questions alongside objective formats. In general, calculations were carried out effectively and the analysis of data seen was relevant. The candidates had been prepared well for this paper and they appeared to be confident when responding to a wide range of scientific topics. The majority of candidates were able to respond to all questions in the time available, and relatively few failed to attempt to answer the questions. Additional pages were rarely used by candidates.

Resources which might help address the examiner comments:

From the link below, you'll find 'The OCR guide to examinations' (along with many other skills guides)
http://www.ocr.org.uk/i-want-to/skills-guides/

Command verbs definitions
http://www.ocr.org.uk/Images/273311-command-verbs-definitions.pdf

Question 1

Answer **all** the questions.

1 Near-Earth Objects (NEOs) are comets and asteroids that have orbits which bring them close to the Earth.

Fig. 1.1 shows an artist's impression of a comet orbiting the earth.

Comets are icy bodies releasing dust or gas.

Fig. 1.1

Table 1.1 shows the distance from Earth of some NEOs that passed by in early January 2017.

Date in January 2017	Distance from the Earth (Lunar Distance)
8th	47.1
8th	63.5
8th	1.5
9th	53.5
9th	39.4
9th	0.5
9th	11.0
10th	14.8
11th	15.1
13th	34.6
14th	29.2
14th	55.5
14th	6.7

Table 1.1

Questions 1(a), (b) and (c)

(a) Calculate the median for the distance from the Earth in **Table 1.1**.

29.2

median = ... **[1]**

(b) Calculate the mean distance from the Earth in **Table 1.1**.

Show your working.

FIRST CHECK THE ANSWER LINE
If answer = 28.65 OR 28.7 OR 28.6 award 2 marks

372.4 ÷ 13
28.65 OR 28.7

mean = ... **[2]**

(c) The formula below can be used to calculate the standard deviation for the data in **Table 1.1**.

standard deviation $s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$

N is the number of NEOs observed from the 8th to the 14th of January 2017.

x_i is the distance to the NEO

$\overline{x}$ is the mean NEO distance

Use the formula above to calculate the standard deviation for the data in **Table 1.1**.

Give your answer to **1** decimal place.

Show your working.

FIRST CHECK THE ANSWER LINE
If answer = 21.9 award 6 marks

calculates 13 $x_i - \bar{x}$ values
calculates 13 $(x_i - \bar{x})^2$ values
calculates sum of 13 $(x_i - \bar{x})^2$ values = 5742.9(33)
calculates (1/(N-1) of 5742.933 = 478.5777
calculates square root of 478.5777 = s = 21.87642
= 21.9 (adjusted to 1 d.p.)

standard deviation = ... **[6]**

Mark scheme guidance

Question 1(a):

ALLOW 28.646 = 2 marks.

DO NOT ALLOW 28.63.

Question 1(c):

ALLOW correct s value without any working shown = 2 marks.

ALLOW e.g. 21.88 OR 21.876 = 5 marks (not to 1 decimal place).

Examiner comments

Question 1(a) – The majority of candidates were able to determine the median of the data provided in Table 1.1. No pattern of alternative responses could be determined.

Question 1(b) – Again, most candidates successfully completed the calculation required to identify the mean value. No pattern of alternative responses could be determined, although it was noted that some candidates divided the total value by 12 rather than 13.

Question 1(c) – It was most encouraging to see that many candidates were not overtly challenged by the calculation of standard deviation. Many obtained the correct answer and presented it with one decimal place. Unfortunately, some were unable to utilise the equation provided but did, at least, obtain some marks for specific stages completed.

Questions 1(d) and (e)(i)

(d) The comet observed on January 10th 2017 had an estimated diameter of between 25 and 59 m.

Give **two** suggestions why the uncertainty of this estimate is so large.

1...

....

2...

....

Any two from:

- it may be very small/large/unsure of actual size
- a long way away
- moving very fast to measure
- limitations of technology/telescopes/equipment not powerful enough
- changing size/shape due to changing layer of ice.

[2]

Table 1.1 has been repeated below.

Date in January 2017	Distance from the Earth (Lunar Distance)
8th	47.1
8th	63.5
8th	1.5
9th	53.5
9th	39.4
9th	0.5
9th	11.0
10th	14.8
11th	15.1
13th	34.6
14th	29.2
14th	55.5
14th	6.7

Table 1.1

(e) One comet is a sphere with a diameter of 100 m.

(i) Calculate the surface area of the comet and give the units.

Use the formula: surface area = $4\pi r^2$.

$\pi = 3.14$

Show your working.

FIRST CHECK THE ANSWER LINE
If answer = 31400 m² award 2 marks

$4 \times 3.14 \times 50^2$
31400 m^2

surface area of comet = ...units ....

[2]

Mark scheme guidance

Question 1(d):

AWTTE

Question 1(e)(i):

MUST give correct units (m^2) for both marks.

ALLOW some variation in π value due to use of different scientific or graphical calculators (instead of given value = 3.14).

ALLOW range = 31,400 to 31,500

Examiner comments

Question 1(d) – Many candidates appreciated that the comet is too far away and moving fast. Others correctly noted that it is constantly changing in size due to melting ice or the dispersal of dust particles. Some candidates, however, struggled with this question and made incorrect references to misuse of the telescopes.

Question 1(e)(i) – Although many candidates successfully determined the comet surface area, they did not always use the correct units (m^2). A range of responses was accepted, based on the value of pi (π) provided by the type of graphical/scientific calculator used. However, π = 3.14 was clearly stated in the stem of the question.

Questions 1(e)(ii) and (f)

(ii) Calculate the volume of the comet and give the units.

Use the formula: volume = $\frac{4}{3}\pi r^3$.

π = 3.14

Show your working.

FIRST CHECK THE ANSWER LINE
If answer = 523333.33 m3 OR 524317 m3 award 2 marks

$(4 \div 3) \times 3.14 \times 50^3$
523333.33 m^3

volume of comet = ...units ....
[2]

(f) The average orbital speed of a comet can be calculated using the following formula:

$$v = 2 \times \pi \times \frac{r}{T}$$

v = orbital speed

r = orbital radius

T = time period

Rearrange the equation to show how you could calculate the orbital radius of the comet.

Show your working.

FIRST CHECK THE ANSWER LINE
If answer = r = vT/2 π OR r = v × T/(2 × π) award 2 marks

$v \times T = 2 \times \pi \times r$
$v \times T/(2 \times \pi) = r$
OR
$r = v \times T/(2 \times \pi)$

orbital radius, r = ...
[2]

Mark scheme guidance

Question 1(e)(ii):

ALLOW some variation in π value due to use of different scientific or graphical calculators (instead of given value = 3.14).

ALLOW range = 523,333.33 to 524,320

Examiner comments

Question 1(e)(ii) – Again, many candidates successfully calculated the volume (using the formula provided) but failed to show the correct units (m^3). A range of responses was accepted, based on the value of pi (π) provided by the type of graphical/scientific calculator used. However, π = 3.14 was clearly stated in the stem of the question.

Question 1(f) – A number of candidates were able to rearrange the equation to achieve the orbital radius. Some candidates struggled to balance the equation.

Question 2

2 Joe is investigating the speed of a ball rolling down a track.

Fig. 2.1 shows the apparatus used by Joe to show the relationship between

- the width of a channel ***(e)*** in a downwards sloping track and
- the acceleration of a ball ***(a)*** rolling down the channel in the track.

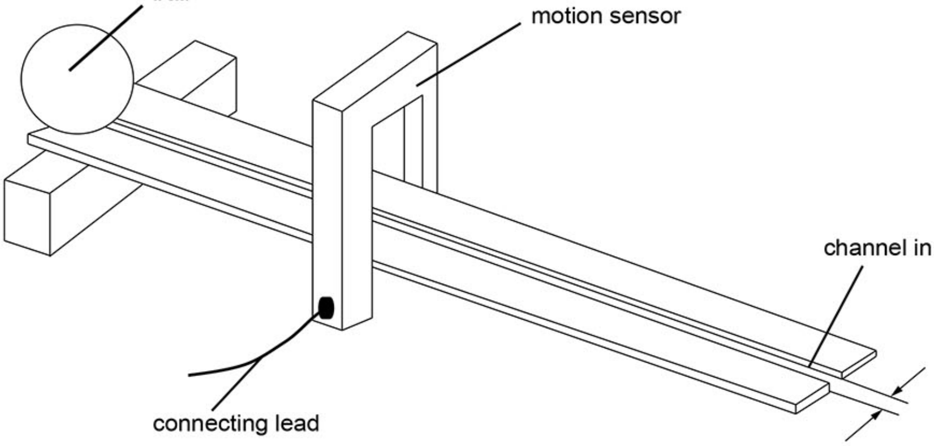


Fig. 2.1

Joe releases the ball at the top of the track. It passes through a motion sensor as it rolls down the track. The motion sensor measures the acceleration ***(a)*** of the ball.

Joe changes the width of the channel ***(e)*** in the track, and repeats the experiment.

The results of his investigation are shown in **Table 2.1**.

width of channel *(e)* (cm)	0.2	0.6	1.0	1.4	1.6	1.8	2.0
acceleration of the ball *(a)* (cm/s²)	350	343	326	293	225	222	148

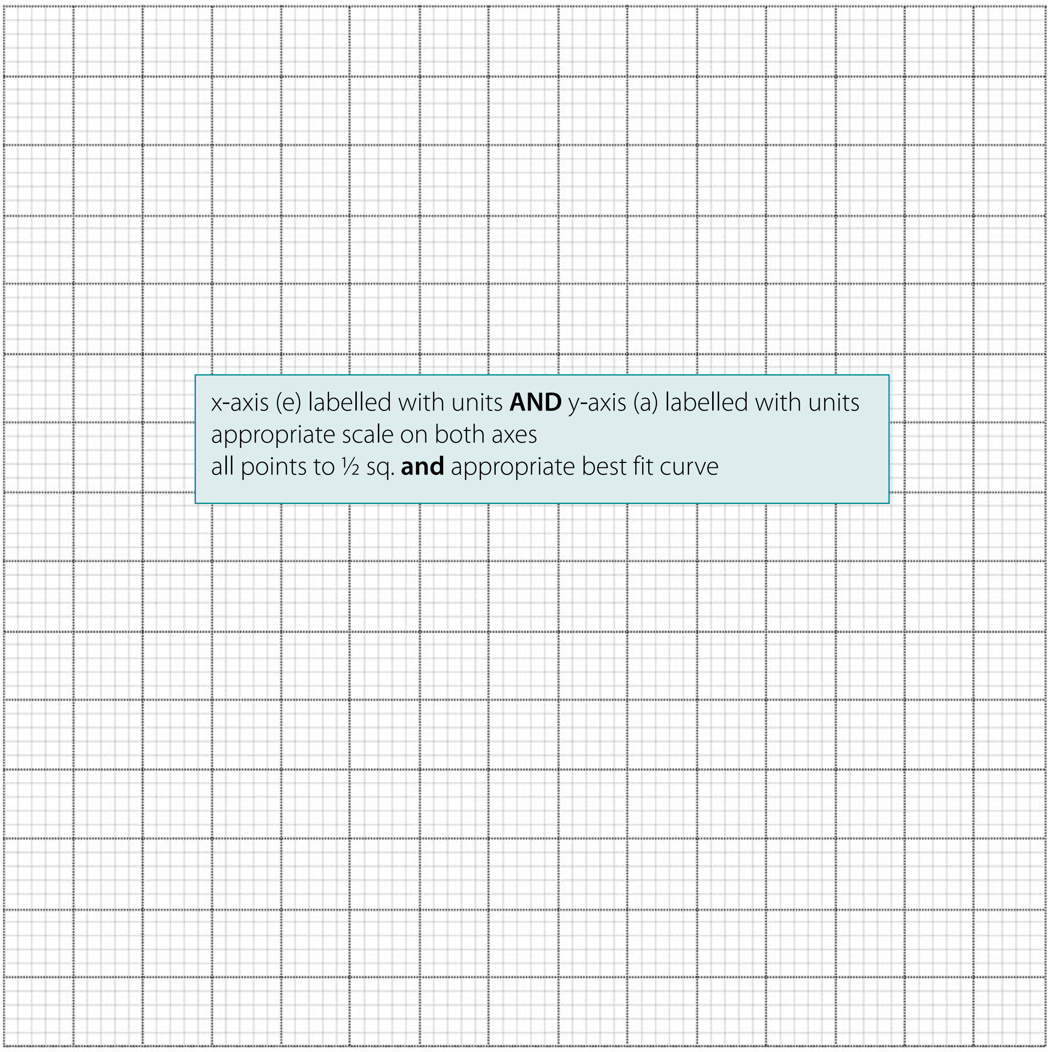
Table 2.1

The diameter of the ball = 2.2 cm

The angle of the sloping track = 30°

Questions 2(a)(i), (ii) and (iii)

(a) (i) Plot a graph of the acceleration ***(a)*** of the ball against the width of the channel ***(e)*** and draw a curve of best fit.



x-axis (e) labelled with units **AND** y-axis (a) labelled with units
appropriate scale on both axes
all points to ½ sq. **and** appropriate best fit curve

[3]

(ii) Draw a **circle** around the outlier in your graph.

[1]

FIRST CHECK THE ANSWER LINE
If answer = 255 ± 0.5 (cm s^{-1}) award 1 mark
point circled at (1.6, 225)

(iii) Use the curve of best fit to predict the true value of acceleration at this point.

225 ± 0.5 (cm s^{-1})

true value of acceleration = ……………………...... cm/s^2
[1]

Mark scheme guidance

Questions 2(a)(i):

DO NOT ALLOW extrapolation to y-axis (from 0.2 to 0.00) – not appropriate best fit curve.

Questions 2(a)(ii)

ALLOW any outlier as ecf in relation to actual curve drawn.

Questions 2(a)(iii)

ALLOW ecf in relation to actual curve drawn.

Examiner comments

Questions 2(a)(i) to (iii) – The majority of candidates successfully constructed the graph, showing appropriate units, title and range for both axes. They were also able to plot the values correctly. The outlier was identified correctly, in many cases, but there was some confusion when candidates were required to determine the expected value for this point in relation to the curve drawn.

Questions 2(a)(iv), (b) and (c)

(iv) Extrapolate the graph to find the value of the intercept with the x-axis when y = 0.

Suggest a reason for this value.

Intercept = 2.2

Reason: Reduced friction/ball falls off.

[2]

(b) Draw a straight line that passes through your curve at ***(e)*** = 0.8 and ***(e)*** = 1.2

Calculate the gradient of this line and give the units.

Show your working.

FIRST CHECK THE ANSWER LINE
If answer = -65.6 cm/s^2 OR cm s^{-2} award 4 marks
Drawn two vertical lines **OR** a triangle **OR** shown two appropriate values on y-axis.
$\Delta y \div \Delta x$ **OR** vertical distance ÷ horizontal distance
- 65.6
cm/s^2 OR cm s^{-2}

gradient = ... units ....

[4]

(c) Describe the trend shown by the graph in part **(a)(i)**.

The wider the channel in the track.
The lower the acceleration.

[2]

Mark scheme guidance

Questions 2(a)(iv):

ALLOW ecf in relation to actual curve drawn.

ALLOW as channel width increases the acceleration decreases.

Questions 2(b)

ALLOW $\Delta y \div 0.4$ OR $y = mx + c$

ALLOW ecf in relation to actual curve drawn.

Questions 2(c)

ALLOW visa versa.

OWTTE

IGNORE references to values.

Examiner comments

Question 2(a)(iv) – It appeared that many candidates were unable to use the guidance provided for this question. They were not able to determine the intercept value on the x-axis and were, therefore, unable to provide the appropriate explanation.

Question 2(b) – Many candidates completed the lines on the graph or created a suitable triangle to show the gradient. However, most did not appreciate that the gradient is based on vertical distance divided by the horizontal distance at the points given. This was a challenging question.

Question 2(c) – For this question, candidates frequently expressed the trend correctly as the wider the channel in the track, the lower the acceleration of the ball. Some candidates referred only to a negative correlation. This type of response was allocated one mark only.

Question 2(d)

(d) Joe changes the angle of the track.

He decreases the angle to 15° and repeats the experiment.

Joe only records two measurements, as shown in **Table 2.2**.

width of channel *(e)* (cm)	0.2	0.6	1.0	1.4	1.6	1.8	2.0
acceleration of the ball *(a)* (cm/s^2)	181	178					

Table 2.2

The diameter of the ball = 2.2 cm (unchanged from original experiment).

The angle of the sloping track = 15° (decreased from the original angle of 30°).

Suggest how the measurements in **Table 2.1** and **Table 2.2** and the data shown in the graph drawn in **(a)(i)** may be used to determine the values of ***(a)*** for values of ***(e)*** = 1.0 to ***(e)*** = 2.0.

Any two from:
- calculate the ratio/fraction/percentage (of Table 2.1 and Table 2.2 values)
- interpolate/read values from same shape graph line (drawn or extrapolated using 15° slope data)
- multiply Table 1 values by the ratio/fraction/percentage (to complete Table 2).

[2]

Mark scheme guidance

ALLOW e.g. the values in Table 2.2 are (approx.) 51.6% **OR** half of the values in Table 2.1 = 2 marks.

ALLOW correct approx. values written in Table 2.2 (grey boxes).

Examiner comments

A few candidates understood that the values between 1.0 and 2.0cm would, in general, be half those given earlier in the question. There were some correct references to the next stage in the process. Unfortunately, some candidates were unable to solve the problem in this question.

Question 3

3 The Wrasses are a family of marine fish called *Labridae*.

Many of these fish are brightly coloured and have a clear pattern (**Fig. 3.1**).

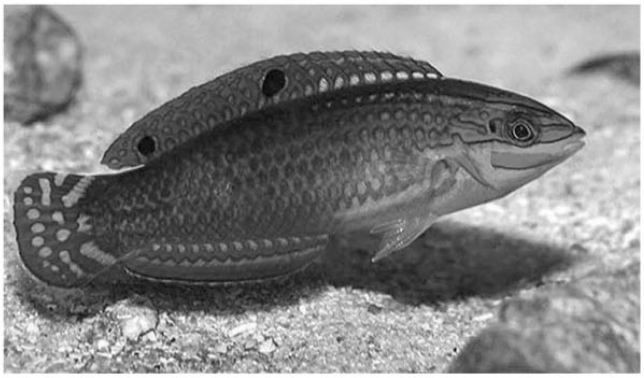


Fig. 3.1

Eastern Atlantic Wrasse are generally found at depths of 1 m to 50 m.

Male Wrasse build nests in different shapes from a variety of nesting materials.

The males may form a distinct pairing with a single female during breeding or they may live in a harem with several females.

Table 3.1 shows some of the distinguishing features of different types of Eastern Atlantic Wrasse.

Type of Wrasse	Depth range (m)	Pairing behaviour	Nest shape or nesting material	Common length (cm)
Symphodus baillonie	1 – 50	distinct	dish-shaped	18
Symphodus cinereus	1 – 20	harem	algae fragments	8
Symphodus mediterraneus	1 – 50	distinct	dish-shaped	12
Symphodus melops	1 – 30	distinct	large seaweed	20
Symphodus ocellatus	1 – 30	distinct	algae fragments	8.5
Symphodus roissali	1 – 30	harem	large seaweed	12
Symphodus rostratus	1 – 50	harem	algae fragments	9
Symphodus tinca	1 – 50	harem	large seaweed	25

Table 3.1

Question 3(a)

(a) (i) Explain the naming system used to identify Eastern Atlantic Wrasse.

Binomial nomenclature/classification/two-naming system
(*Symphodus* is the) **genus**
(e.g. *baillonie* is the) **species**

[3]

(ii) Use the data in **Table 3.1** to complete the blank spaces of the key shown in **Fig. 3.2**.

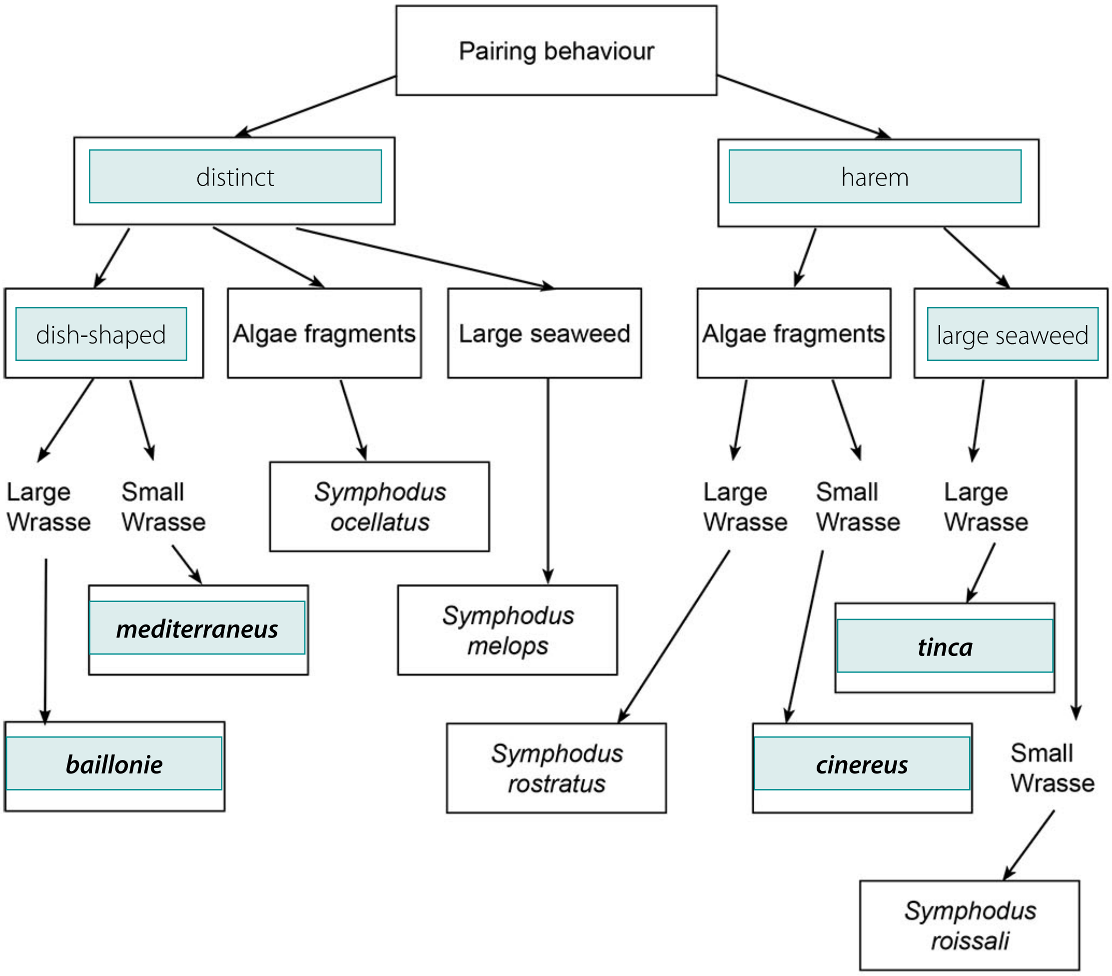


Fig. 3.2

[6]

Mark scheme guidance

Question 3(a)(i):

OWTTE

IGNORE repetition of generic and specific names (as in the stem).

Question 3(a)(i):

One mark for each of the first two correct **rows**.

One mark for each of remaining correct **specific names**.

Examiner comments

Question 3(a)(i) – Although a number of candidates could not recall the term binomial nomenclature, they did appreciate that generic and specific names were involved.

Question 3(a)(ii) – This appeared to be one of the most accessible questions for candidates. They were able to work through the key and to complete all of the stages involved. No pattern of alternative responses was determined.

Exemplar Candidate Work

Question 3(a)(i) – Low level answer

(a) (i) Explain the naming system used to identify Eastern Atlantic Wrasse.

A key is used to desnguish he name of he eastern atlantic wrasse as it looks at where he came from and he type of ~~fish~~ fish it is. **[3]**

Commentary

This response did not provide an explanation of the naming system used to identify Eastern Atlantic Wrasse. It was a low level answer and did not include any of the marking points. The response would function at a much higher level should it include a clear reference to the name of the system, 'binomial nomenclature', and/or the inclusion of the terms genus and species (or generic and specific names).

Question 3(a)(i) – Medium level answer

(a) (i) Explain the naming system used to identify Eastern Atlantic Wrasse.

They are grouped and ~~na~~ the name is determined by the speicies of the animal **[3]**

Commentary

This response represented a medium level answer since it included at least one of the marking points. In this case, it referred to the term 'species'. The response would have the potential to progress onto a higher level if it had also included a reference to the term 'genus'. Overall, the response failed to fully explain the naming system because it also did not include the name of the system (binomial nomenclature).

Questions 3(b) and (c)

(b) Explain **two** limitations of the key in **Fig. 3.2** when using it to distinguish between different types of Eastern Atlantic Wrasse.

Limitation 1 ....

Limitation 2 ....

[4]

Common length
(Wrasse have a) range of lengths as they grow/different ages sampled

Nest shape/nesting material
nests composed of algae fragments or large seaweed may also be dish shaped/some nests have both features

Depth range
vary greatly due to disturbance/feeding/water temperature/time of year/breeding season

Pairing behaviour
varies due to sampling period/time of year/disturbance

(c) *Labrus bergylta* is another type of Wrasse found in the Eastern Atlantic.

Use your understanding of the classification system to suggest the level of similarity between *L.bergylta* and *S.baillonie*.

[2]

Any two from:
- both belong to, the same family/Labridae
- they must (therefore) share some similarities
- (however) *S.baillonie* will have many more similarities with other species of, the same genus (*Symphodus*) **OR** vice versa.

Mark scheme guidance

Question 3(b):

ALLOW any other realistic suggestion eg. missing features such as genome/biochemistry.

Question 3(c):

IGNORE references to data shown in the key.

DO NOT ALLOW both are Wrasse.

IGNORE unqualified references to genus/species.

Examiner comments

Question 3(b) – This question was much more challenging. Some candidates referred correctly to features such as common length, depth range and nest shape/material but struggled to explain the variance for such features. For example, it was anticipated that common length would relate to the growth patterns of fish, the diet and age.

Question 3(c) – Some candidates were able to explain that the fish may differ since they are from different genera and species. This was acceptable but it was anticipated that their shared membership of the family Labridae was a source of some similarity.

Question 4(a)

4 Radar guns are used by the police to measure the speed of vehicles.

Ross carries out a controlled investigation on four radar guns (**W**, **X**, **Y** and **Z**).

He points each radar gun at a car moving away at a constant speed.

He repeats each test four times.

The results of his investigation are shown in **Table 4.1**.

Radar gun	**Speed (km/h)**			
	Test 1	**Test 2**	**Test 3**	**Test 4**
W	63.2	67.1	65.9	59.6
X	60.2	54.2	63.4	61.7
Y	59.7	59.9	60.3	60.1
Z	56.5	55.8	57.1	56.3

Table 4.1

(a) The true constant speed of the car is indicated by a satellite navigation (SatNav) device mounted on the car dashboard. This indicates 60.0 km/h.

(i) Comment on the accuracy and precision of radar gun **Y**.

Y is the **most** precise and accurate

......**[1]**

(ii) What is the range of the results for radar gun **Y**?

59.7 – 60.3
OR
0.6

range = ...
[1]

(iii) Calculate the interval of the results for radar gun **Y** as a percentage.

Any two from:
- Interval = ± 0.3
- 0.3 as a % of expected value (60.0)
- (0.3 ÷ 60) × 100 = 0.5%

interval = ... %
[2]

Mark scheme guidance

Question 4(a)(i):

ALLOW best/high level/good = most OWTTE.

Question 4(a)(iii):

ALLOW reference to three intervals = 0.2, 0.4 and 0.2 (expressed as a calculation OR shown in Table 4.1).

Examiner comments

Question 4(a)(i) – Most candidates correctly observed that the radar gun Y was very accurate and precise. No pattern of alternative responses was seen.

Question 4(a)(ii) – The calculation of the range did not present a difficulty for most candidates. This was expressed as either 59.7 – 60.3 or as 6.0.

Question 4(a)(iii) – The calculation of the interval presented a problem for most candidates. They were credited for references to the individual intervals of 0.2, 0.4 and 0.2 but the concept of the interval as +/- 0.3 was not appreciated.

Questions 4(b) and (c)(i)

(b) The speedometer on the dashboard of the car indicates that it is travelling at 64 km/h, as shown in **Fig. 4.1**.

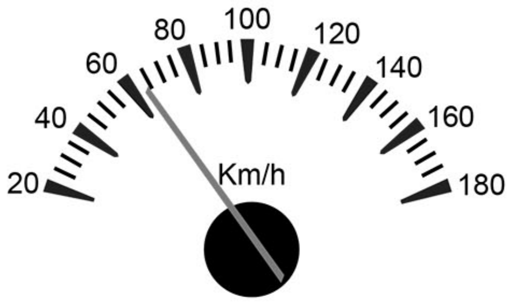


Fig. 4.1

The speedometer is not precise.

This leads to errors when monitoring the speed of the car.

(i) Which type of error is involved?

Put a **ring** around the correct answer.

Driving **Instrument** **Mathematical** **Random** **[1]**

(ii) Using **Fig. 4.1**, give a reason for your choice in **(b)(i)**.

(speedometer) only shows some of the divisions between whole numbers/ does not show detailed values/speeds **[1]**

(iii) Define the terms **repeatable** and **reproducible**.

Repeatable: **same result** is obtained using **same** method/equipment

Reproducible: **same result** is obtained using a **different** method/equipment **[2]**

(c) Ross suggests calculating the speed of the car by using a stopwatch to time it as it moves between two marked lines 10 metres apart.

(i) Describe **one** source of measurement error in the method proposed by Ross.

Any one from:
- reaction time
- when starting and stopping the stopwatch.

[1]

Mark scheme guidance

Question 4(b)(ii):

ALLOW correct reference to improvement e.g. show intervals of 10 units.

DO NOT ALLOW error with equipment/not accurate.

Question 4(b)(iii):

ALLOW repeatable uses the same method and reproducible uses a different method (no mention of results) = 1 mark **max**.

Question 4(c)(i):

IGNORE distance/instrument error.

OWTTE

Examiner comments

Question 4(b)(i) – The majority of candidates successfully identified the instrument as the type of error. No clear pattern of alternatives was observed.

Question 4(b)(ii) – Most candidates failed to see that the limited use of divisions on the speedometer was the key feature for the error.

Question 4(b)(iii) – A number of candidates referred correctly to both the method/equipment and results in the two definitions but others struggled to articulate a clear response.

Question 4(c)(i) – Many candidates realised that the measurement error was that of reaction time.

Questions 4(c)(ii) and (iii)

(ii) State and explain how Ross could reduce the error in his proposed method to calculate the speed of the car.

- increase the distance
- reaction time becomes smaller compared to the total time/less significant/has less impact

.....[2]

(iii) Ross uses a stopwatch with a high sensitivity.

Suggest what is meant by the term **sensitivity** when it is used to describe the reading on the stopwatch.

- the lowest count/smallest value measured/have more decimal points/higher resolution

.[1]

Mark scheme guidance

Question 4(c)(ii):

ALLOW any realistic suggestion to increase value >10m.

OWTTE

Question 4(c)(iii):

ALLOW it measures to 1/100th of a second.

DO NOT ALLOW more accurate.

Examiner comments

Question 4(c)(ii) – It was anticipated that candidates would continue to focus on the use of a stopwatch and refer to increasing the distance tested. However, many considered other options, such as automated/digital equipment. This was not creditworthy.

Question 4(c)(iii) – It was encouraging to see that many candidates realised that sensitivity related to the use of the stopwatch with the lowest values/higher resolution. No clear pattern of alternative responses was noted.

Questions 5(a)(i) and (ii)

5 Three student technicians are designing electric circuits.

One of the students, Nina, needs a resistor of resistance 9.0 Ω in one branch of her circuit.

She has a 1.0 m length of resistance wire labelled **X**.

Nina tests wire **X** and concludes that it has a resistance of 9.0 Ω.

The two other students, Rob and Ali, carry out tests on wires **Y** and **Z**.

The students record their measurements in **Table 5.1**.

Wire	Length of wire (m)	Potential difference (V)	Current (A)	Resistance (Ω)	Resistance of 1.0 m length of wire (Ω)
X	1.0				9.00
Y	0.5	4.5	0.81	....	....
Z	0.25	3.7	1.34	....	....

Table 5.1

(a) (i) Complete **Table 5.1** for wires **Y** and **Z**.

Use the equation: resistance = potential difference ÷ current

Give your answers to **2** decimal places.

Y = 4.5 ÷ 0.81 = **5.56**(Ω)
AND
Z = 3.7 ÷ 1.34 = **2.76**(Ω)
1.0m of Y = **11.12**(Ω)
1.0m of Z = **11.04**(Ω)
Use of 2 decimal places throughout.

[4]

(ii) Ali concludes:

'We all tested wires made of the same material'.

Explain whether Ali's conclusion is correct or incorrect.

Use the data in **Table 5.1** and your calculations in **(a)(i)** to justify your answer.

Ali is not correct.

EITHER
Conclusion:
Rob and Ali are (probably) testing the same material of wire/Z and Y are same.
Justification:
results are very similar/within experimental error.
OR
Conclusion:
Nina's wire is different material/X is not same as Y and Z.
Justification:
9.0 is much less than resistance of Y and Z/outside range of experimental error.

[3]

Mark scheme guidance

Question 5(a)(i):

First column correct = 1 mark.

ALLOW ecf from first column = 3 max.

Question 5(a)(ii):

IGNORE reference to wire diameter/Nina's wire might be thinner/thicker (the conclusion must refer to the material being tested).

Examiner comments

Question 5(a)(i) – The calculation of resistance was straightforward and most candidates were able to do this. It was unfortunate that some did not present their answers to 2 decimal places. Many were also successfully multiplied each resistance value by either 2 or 4 to complete the table.

Question 5(a)(ii) – Some candidates considered that Ali was correct. This led to some difficulty when presenting an appropriate explanation for their choice. No clear pattern of alternative responses was observed.

Exemplar Candidate Work

Question 5(a)(i) – Medium level answer

5 Three student technicians are designing electric circuits.

One of the students, Nina, needs a resistor of resistance 9.0 Ω in one branch of her circuit.

She has a 1.0 m length of resistance wire labelled **X**.

Nina tests wire **X** and concludes that it has a resistance of 9.0 Ω.

The two other students, Rob and Ali, carry out tests on wires **Y** and **Z**.

The students record their measurements in **Table 5.1**.

Wire	Length of wire (m)	Potential difference (V)	Current (A)	Resistance (Ω)	Resistance of 1.0 m length of wire (Ω)
X	1.0				9.00
Y	0.5	4.5	0.81	5.55	2.78
Z	0.25	3.7	1.34	2.76	0.69

Table 5.1

(a) (i) Complete **Table 5.1** for wires **Y** and **Z**.

Use the equation: resistance = potential difference ÷ current

Give your answers to **2** decimal places.

[4]

Commentary

This response functioned at a medium level because it presented one of the expected values with reference to the calculation using the equation: resistance = potential difference ÷ current. Furthermore, it failed to extend the calculations required to determine the resistance of 1.0m length of wire.

The resistance values were not fully correct since the value for Y was given as 5.55 whereas the expected value was 5.56. The resistance value for Z was, however, correct. A mark was, therefore, allocated only for the second value.

The response would progress onto a higher level if the candidate had related the lengths of wires Y and Z (0.5 and 0.25m, respectively) to the corresponding resistance values for 1.0m length of wire. In other words, the resistance value for Y should have been multiplied by 2 and the value for Z multiplied by 4.

Exemplar Candidate Work

Question 5(a)(i) – High level answer

5 Three student technicians are designing electric circuits.

One of the students, Nina, needs a resistor of resistance 9.0 Ω in one branch of her circuit.

She has a 1.0 m length of resistance wire labelled **X**.

Nina tests wire **X** and concludes that it has a resistance of 9.0 Ω.

The two other students, Rob and Ali, carry out tests on wires **Y** and **Z**.

The students record their measurements in **Table 5.1**.

Wire	Length of wire (m)	Potential difference (V)	Current (A)	Resistance (Ω)	Resistance of 1.0 m length of wire (Ω)
X	1.0				9.00
Y	0.5	4.5	0.81	5.56	11.11
Z	0.25	3.7	1.34	2.77	11.09

Table 5.1

(a) (i) Complete **Table 5.1** for wires **Y** and **Z**.

Use the equation: resistance = potential difference ÷ current

Give your answers to **2** decimal places.

Y = 4.5 ÷ 0.81 = 5.56   5.56 × 2 = 11.11

Z = 3.7 ÷ 1.34 = 2.77   2.77 × 4 = 11.09

[4]

Commentary

This response was at a high level because it correctly presented one of the resistance values (for wire Y) and proceeded to move onto the successful calculation of the corresponding resistance values for wires Y and Z at 1.0m length.

The resistance value for wire Z was incorrect since it was calculated at 2.77, whereas, the expected value was 2.76. However, this miscalculation was used correctly for the corresponding calculation since the error was carried forward.

The correct calculation of resistance for wire Z (as 2.76) would be an improvement to the overall response.

Questions 5(a)(iii) and (b)

(iii) Rob and Ali discuss their test results.

They conclude that Nina is wrong and the resistance of wire **X** is not 9.00 Ω.

Explain what further evidence Rob and Ali need to make their conclusion more secure.

- (to see) Nina's measurements (of voltage and current)
- to calculate her resistance/to check if her calculation is correct/repeat testing wire X

[2]

(b) **Fig 5.2** shows another equation for calculating resistance.

$$R = \frac{\rho l}{A}$$

Fig. 5.2

R = resistance (Ω)

l = length of wire (m)

ρ = resistivity (Ω.m)

A = cross-sectional area of the wire

Rob uses the equation to show Nina that her conclusion about wire **X** is incorrect.

Nina says:

'You have made assumptions about things you have not measured.'

Suggest **two** assumptions made by Rob.

1.
- **resistivity** is the same
- **cross-sectional areas**/diameter is the same

2.

[2]

Mark scheme guidance

Question 5(a)(iii):

OWTTE

Question 5(b):

ALLOW they have the same thickness.

Examiner comments

Question 5(a)(iii) – Some candidates realised that Nina's values were required but did not understand that the values should then be tested following a repeat of the experiment. Varied responses were seen with some candidates achieving full marks.

Question 5(b) – Most candidates successfully noted that Rob had made assumptions about resistivity and cross-sectional areas. No pattern of alternative responses was seen.

Questions 5(c) and (d)

(c) Nina uses a balance to measure the mass of each piece of wire.

Her results are shown in **Table 5.2**.

Wire	Mass (g)
X	1.03
Y	0.21
Z	0.42

Table 5.2

Discuss whether the evidence in **Table 5.2** supports or conflicts with the evidence in **Table 5.1**.

Any two from:

- supporting evidence for wire X is different to Y and Z
- supporting evidence - wires Y and Z are different
- conflicting evidence - mass of wire Z is 2x mass of wire Y (should be half mass)
- idea that if X, Y and Z are the same then their masses should be consistent with their lengths or X, Y, Z are not same as their masses are not consistent with their lengths.

[2]

(d) Describe how Nina, Ali and Rob should use primary and secondary sources of information to confirm whether wires **X**, **Y** and **Z** are made from the same material.

- use their own calculations/results **OR** repeat the tests (primary source)
- compare with other information in a text book/website **OR** other set of results (secondary source)

[2]

Examiner comments

Question 5(c) – This question proved to be a challenging question. Candidates found it difficult to articulate a discussion based on the results for the three wires. The key error was the lack of reference to the named wires, X, Y and Z

Question 5(d) – Most candidates realised that secondary sources included the internet or books but some, correctly, also referred to other sets of results. The primary source was often identified as the current set of results.

Questions 6(a) and (b)(i)

6 James is a public analyst. He is analysing the concentration of sodium hypochlorite in a series of samples of household bleach.

He uses **redox titrations** to find the concentration of hypochlorite in the bleach.

(a) The steps in the titration of a bleach sample are shown in **Table 6.1**.

The steps are **not** in the **correct** order.

A	add starch indicator
B	iodine is formed
C	titrate the brown mixture against sodium thiosulfate solution
D	dilute the sample of bleach
E	the colour fades to yellow
F	add an excess of acidified potassium iodide solution

Table 6.1

Put the steps in the correct order. One has been done for you.

Complete the table below.

D	F	B	C	E	A

[4]

(b) **(i)** James prepares a sodium thiosulfate solution (0.2 mol dm^{-3}) and dilutes a sample of bleach for titration.

Suggest **two** reasons why the bleach samples are diluted.

1 ....

Any two from:
- to make the concentration lower
- so that an appropriate titre (of thiosulfate) is obtained/the volume of thiosulfate required (for the titration) would be too large
- the iodine produced in the reaction is not very soluble.

2 ....

[2]

Mark scheme guidance

Question 6(a):

F immediately before B = 1 mark

B immediately before C = 1 mark

C immediately before E = 1 mark

E immediately before A = 1 mark

Question 6(b)(i):

ALLOW to improve the effectiveness of the reaction/titration.

Examiner comments

Question 6(a) – It appeared that most candidates were not familiar with the protocol for titration. A wide variety of responses were seen for the order of steps and many seemed to obtain one or two marks due to chance.

Question 6(b)(i) – Some candidates realised that the dilution of the bleach reduced the concentration. Others correctly referred to the improved effectiveness of the titration. A number of candidates linked the dilution to the hazard of the bleach. This was not acceptable in the context of this question.

Question 6(b)(ii)

(ii) The concentration of the sodium thiosulfate solution prepared by James is approximate. It must be standardised before use.

The sodium thiosulfate solution is standardised with potassium iodate solution using a titration.

Information from the titration recorded is shown in **Table 6.2**.

Concentration of the potassium iodate solution	0.033 mol dm^{-3}
Volume of potassium iodate in conical flask	25.0 cm^3
Average volume of sodium thiosulfate used	24.25 cm^3

Table 6.2

Calculate the concentration of the sodium thiosulfate solution.

Use the equation:

$$\text{concentration sodium thiosulfate} = \frac{\text{concentration potassium iodate} \times \text{volume of potassium iodate} \times 6}{\text{volume of sodium thiosulfate}}$$

Give your answer to **2** significant figures.

FIRST CHECK THE ANSWER LINE
If answer = 0.20 (mol dm^{-3}) award 3 marks

$$\text{concentration of sodium thiosulfate} = \frac{0.033 \times 25.0 \times 6}{24.25}$$

= 0.204
= 0.20 (mol dm^{-3}) (2 sig. figs)

concentration = ……................……mol dm^{-3}
[3]

Mark scheme guidance

ALLOW 0.204 final answer = 2 max.

Examiner comments

It was encouraging to see that so many candidates used the equation provided to determine the concentration. However, some failed to obtain full marks because they did not present their answer to 2 significant figures.

Questions 7(a) and (b)

7 Mia is a technician working in a plant science laboratory.

She is producing a set of temporary microscope slides of plant roots.

Fig. 7.1 shows a section of a plant root when viewed using a light microscope.

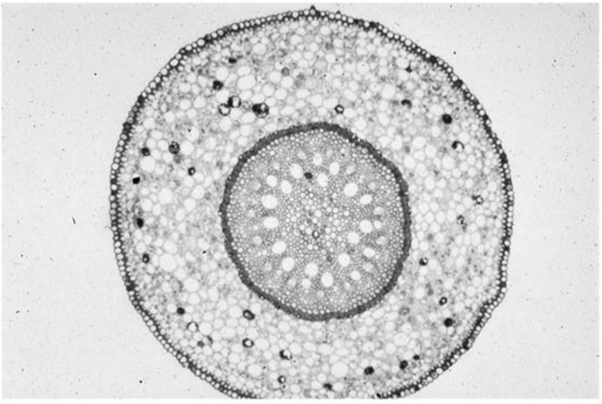


Fig. 7.1

(a) The production of a temporary microscope slide involves a number of steps.

The following steps are **not** in the correct order.

Step	Order
Add a drop of water to the plant root section.	3
Cut the plant root to obtain a thin section.	1
Place the section of plant root onto a dry microscope slide.	2
Put the microscope slide on the stage of a light microscope.	5
Place a coverslip above the root section.	4

Write the correct number (1 to 4) in each of the boxes to show the correct order.

One has been completed for you.

[4]

(b) Mia has been asked to produce permanent slides of plant root sections.

Identify **two** additional steps, other than staining, to be completed when making a permanent slide.

1.

2.

Any two from:
- mounting (in wax)
- fixation
- dehydration/use of alcohol series.

[2]

Mark scheme guidance

Question 7(a):

One mark for each correct order number in table.

Question 7(b):

IGNORE stain/dye (instruction in stem of question).

Examiner comments

Question 7(a) – Responses to this question seemed to reflect prior experience of creating temporary microscope slides. It was evident that some candidates had completed this task in the laboratory and were able to identify the correct order of steps. However, some candidates struggled to complete this question correctly.

Question 7(b) – Again, the responses reflected the experience of some candidates in the laboratory. Some candidates correctly referred to mounting, fixing and dehydration of specimens. Other students incorrectly described the location of specimens in sterile environments. This was not appropriate for this scenario.

Exemplar Candidate Work

Question 7(a) – Low level answer

7 Mia is a technician working in a plant science laboratory.

She is producing a set of temporary microscope slides of plant roots.

Fig. 7.1 shows a section of a plant root when viewed using a light microscope.

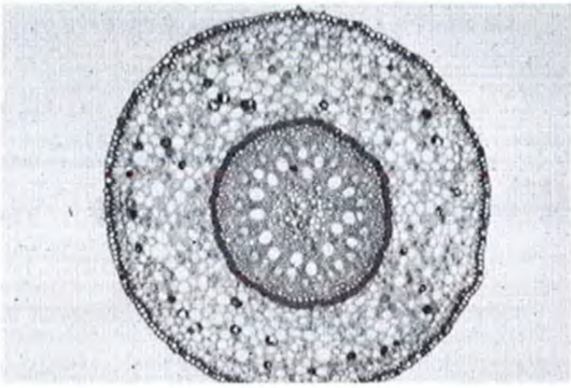


Fig. 7.1

(a) The production of a temporary microscope slide involves a number of steps.

The following steps are **not** in the correct order.

Step	**Order**
Add a drop of water to the plant root section.	~~3~~ 2
Cut the plant root to obtain a thin section.	1
Place the section of plant root onto a dry microscope slide.	4
Put the microscope slide on the stage of a light microscope.	5
Place a coverslip above the root section.	3

Write the correct number (1 to 4) in each of the boxes to show the correct order.

One has been completed for you.

[4]

Commentary

The candidate presented a low level answer since only the first step in the order was correct. The candidate correctly identified that the first step in the production of a temporary slide mount was to cut the plant root to obtain a thin section. Unfortunately, the following steps were listed incorrectly.

Improvements required to enable this response to function at a higher level include the presentation of the following steps in the correct order. In other words, the next step would be to place the section of plant root onto a dry microscope slide, to then add a drop of water to the root section and to place a coverslip above the root section. The final step, placing the microscope slide, was provided within the table.

Question 7(c)

(c) Stains can be added to plant tissues when making temporary or permanent slides.

Give **one** reason for staining plant tissues.

Any one from:
- distinguish different tissues/cell types/organelles
- identify specific materials/molecules
- clarify/enhance the arrangement of tissues.

......

..**[1]**

Mark scheme guidance

ALLOW to see/view the tissues/cells more clearly.

Examiner comments

Most candidates realised that staining enhances the overall quality of the image in terms of organelles, cells and/or tissues.

Question 8(a)

8 A scientific study in Ontario in Canada analysed the effects of living close to major roads on three neurological conditions: dementia, Parkinson's disease and multiple sclerosis.

The study was carried out between 2001 and 2012. During that time, the number of people who developed the three conditions was recorded.

Details of two groups of people studied in Ontario are shown in **Table 8.1**.

Group studied	Age range	Number of people	Neurological condition(s) analysed
1	55 – 85	2 165 268	dementia and Parkinson's disease
2	20 – 50	4 372 720	multiple sclerosis

Table 8.1

The two groups were based on people who:

- were free from the three conditions in 2001
- were born in Canada
- had lived in Ontario for 5 years or longer.

The numbers of people who developed the conditions between 2001 and 2012 are shown in **Table 8.2**.

Condition	Number developing the condition	Percentage developing the condition (as a % of the group studied)
dementia	243 611	11.3
Parkinson's disease	31 577	
multiple sclerosis	9 247	

Table 8.2

(a) Complete **Table 8.2** by calculating numbers of people who developed the condition as a percentage of the people studied in each group (as indicated in **Table 8.1**).

Parkinson's disease = 1.5 (%)
multiple sclerosis = 0.2 (%)

[2]

Mark scheme guidance

ALLOW 1.46 OR 1.458.

ALLOW 0.21 OR 0.211.

Examiner comments

Many candidates successfully determined the percentage developing the condition (as a % of the group studied) in Table 8.1. No clear pattern of alternative responses was noted.

Question 8(b)

(b) What conclusion can be made from the data in **Table 8.1**?

Tick (✓) **one** box.

People who are 50 to 55 years old do not develop multiple sclerosis. ☐

The development of specific neurological conditions does not appear to be age dependent. ☐

Young people less than 20 years old do not develop neurological conditions. ☐

More females are found in the 50 to 55 year old age group. ☐

[1]

Any one of the statements ticked.

Mark scheme guidance

ALLOW one tick for any statement since the data are inconclusive with regards to the conclusions listed. No one conclusion can be drawn with confidence.

Examiner comments

This question was a multiple choice type question where candidates had to identify the conclusion that could be reasonably concluded from Table 8.1. Candidates found this question challenging.

Questions 8(c) and (d)(i)

(c) The distance people in the study lived from the major roads in Ontario was calculated from their postcodes.

The association between distance from major roads and developing the three conditions was assessed.

The data from the study are shown in **Table 8.3**.

Distance from major road (m)	Hazard ratio (probability of developing the condition relative to people living over 300 m away from the roads (where the hazard ratio = 1.00))		
	Dementia	Parkinson's disease	Multiple sclerosis
< 50	1.07	1.01	1.02
50 – 100	1.04	1.01	0.93
101 – 200	1.02	0.99	1.01
201 – 300	1.00	0.99	1.01

Table 8.3

The data in **Table 8.3** were adjusted to take into account a series of factors, including diabetes, brain disease and household income.

Suggest why the data were adjusted in this way.

Any one from:
- (neurological conditions) may be **affected** by any of these factors (or others)
- (such factors) cannot be **controlled** and may affect the results of the study.

....[1]

(d) The researchers carrying out this study are invited to present their findings at a scientific conference.

(i) Suggest **two** conclusions that can be made from the study.

1..

Any two from:
- Correct ref. to % incidence in Table 8.2
- Correlation between distances and HR for dementia only
- HR increases with closeness to major roads
- (Unexpected) low HR for multiple sclerosis at 50-100 m distance
- HRs for Parkinson's disease/multiple sclerosis unaffected by distances between 101-300m.

2..

[2]

Mark scheme guidance

Question 8(c):

OWTTE

ALLOW correctly named example – lower income people may need to live in cheaper houses nearby major roads.

Question 8(d)(i):

ALLOW other realistic suggestions.

HR = hazard ratio.

Examiner comments

Question 8(c) – Most candidates appreciated that factors such as diabetes and household income may influence the incidence of the neurological diseases listed in Table 8.3. This did not present a difficulty for the majority of candidates.

Question 8(d)(i) – Many realistic conclusions were possible for the data in Table 8.3. As a result, most candidates obtained full marks for this question. However, some candidates struggled and drew conclusions that were not supported by the data. Others referred to 'diseases' without qualification and this prevented them from achieving the marking points.

Questions 8(d)(ii) and (iii)

(ii) Suggest **two** limitations of the study.

1. ....

2. .... **[2]**

Any two from:
- Factors (other than those listed) may affect the correlation between dementia and HR
- Not possible to cover all variables
- Conditions have multiple risk factors e.g. genetics
- Differences between major roads e.g. traffic density
- Differences in weather conditions may affect exposure to pollutants
- Impact of undiagnosed neurological conditions
- Age ranges do not encompass all cases
- Participants may be taking medication.

(iii) Suggest **two** recommendations for future research.

1. ....

2. .... **[2]**

Any two from:
- Replicate studies elsewhere
- Research effects of specific pollutants
- Compare with data from rural areas
- Include data for age/gender/background.

Mark scheme guidance

Question 8(d)(ii)

ALLOW any realistic suggestion.

Question 8(d)(iii):

ALLOW any realistic suggestion.

Examiner comments

Question 8(d)(ii) – A number of limitations was possible for this investigation. Any realistic limitation was creditworthy but some candidates struggled with this question and referred to the way in which the data were presented in the table. It was interesting to see that a number of candidates appreciated that people with a lower income may be forced to live nearer to major roads due to cheaper house prices.

Question 8(d)(iii) – The recommendations the candidates suggested were often correctly linked to the identified limitations. This approach was followed successfully by a number of candidates. No clear pattern of alternative responses was observed.

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