Cambridge Assessment International Education

# Cambridge International AS & A Level

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|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CENTRE NUMBER | | | | | | CANDIDATE NUMBER | | | | |

*9015892676*

**BIOLOGY** **9700/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2023**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

**INFORMATION**

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.


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**1** Catalase is an enzyme that is found in many plant cells and animal cells. Catalase breaks down hydrogen peroxide, which is a waste product from cell metabolism.

Fig. 1.1 shows the breakdown of hydrogen peroxide by catalase.




**Fig. 1.1**

A student decided to investigate how catalase activity varies along the length of a carrot root.

Fig. 1.2 shows a photograph of some carrots.

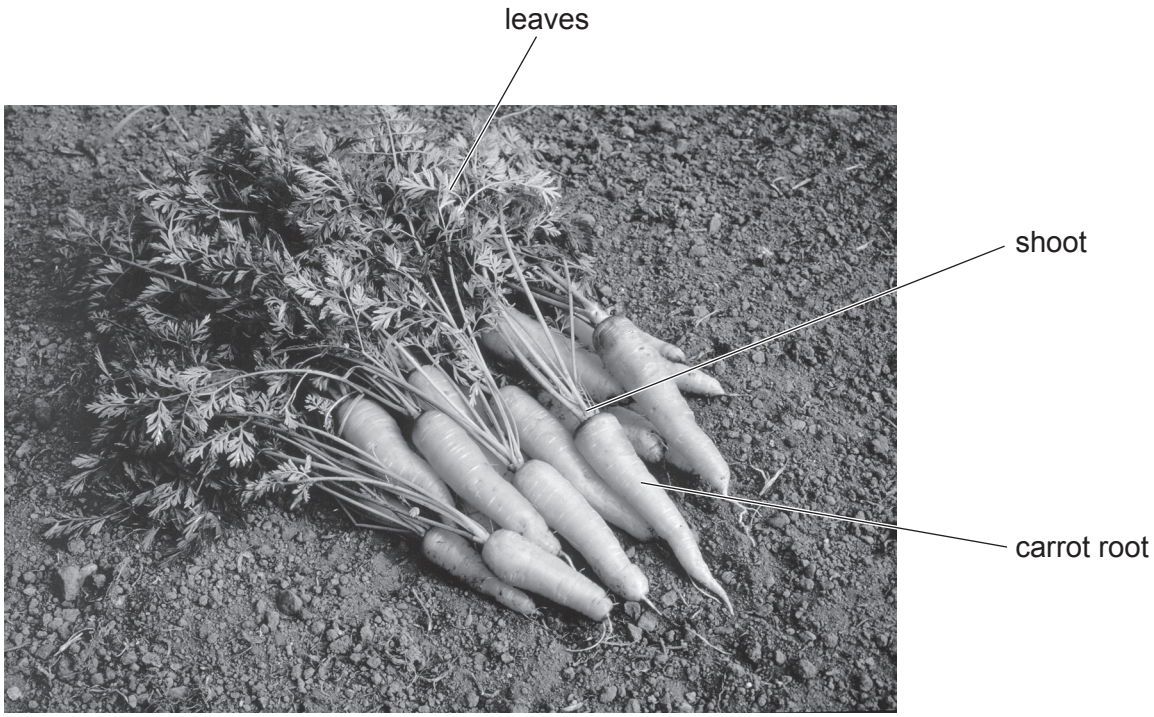



**Fig. 1.2**

The student extracted catalase from different parts of the carrot root tissue.

- Carrot root tissue was mixed with a small volume of pH7 buffer and some fine sand.
- The mixture was ground with a pestle and mortar.
- The mixture was placed into a centrifuge tube and spun in a variable speed centrifuge for a few minutes.
- This caused the mixture to be separated into a solid pellet at the bottom of the centrifuge tube and a liquid carrot extract at the top, as shown in Fig. 1.3.
- The liquid carrot extract was poured into a clean test-tube. This liquid contained catalase.

Fig. 1.3 shows a centrifuge and centrifuge tube with its contents, after spinning in the centrifuge for a few minutes.

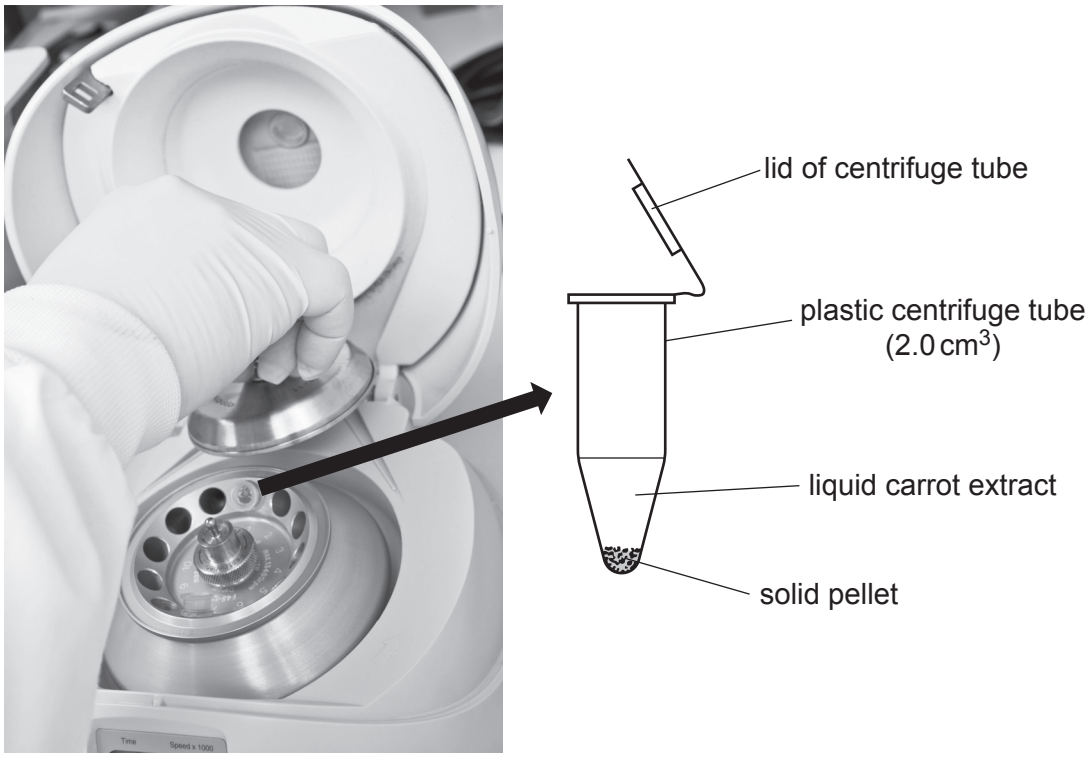



**Fig. 1.3**

**(a)** State **one** variable that should be standardised in the procedure to obtain the liquid carrot extract, **other than** the carrot tissue, fine sand and apparatus used.

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..... [1]

The student carried out these steps to investigate the activity of catalase in the different samples of carrot root tissue.

- A disc of filter paper of 5 mm diameter was dipped into the liquid carrot extract using forceps.
- The filter paper disc was placed at the bottom of a beaker of 1% hydrogen peroxide solution using forceps.
- The time taken for the filter paper disc to rise to the surface of the hydrogen peroxide solution was measured.

Fig. 1.4 shows the apparatus used to measure the time taken for the filter paper disc to rise.

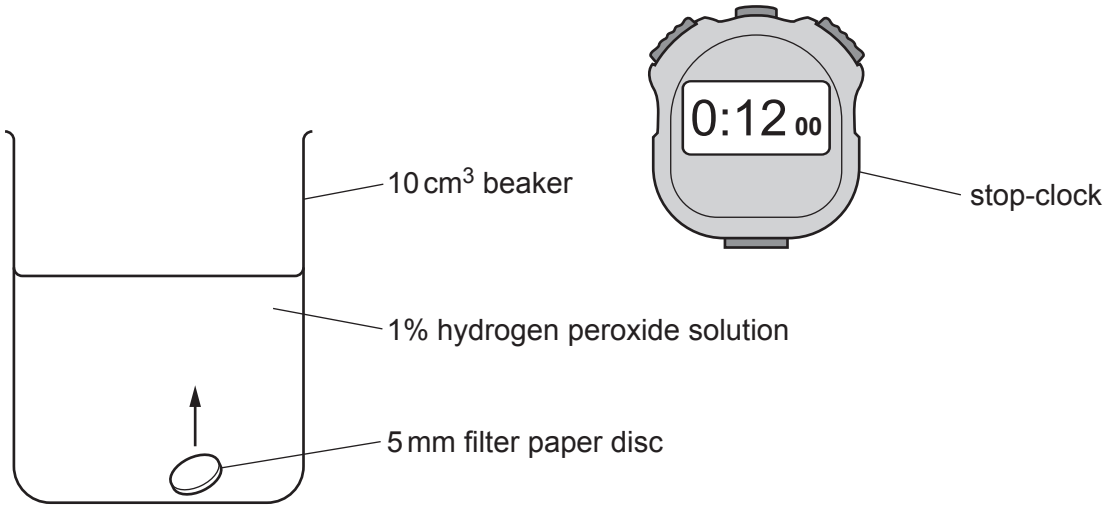



**Fig. 1.4**

**(b)** State the relationship between the time taken for the filter paper disc to rise to the surface of the hydrogen peroxide solution and the catalase activity of the liquid carrot extract.

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The student decided to investigate how catalase activity varies along the length of the carrot root.

Fig. 1.5 shows a carrot.

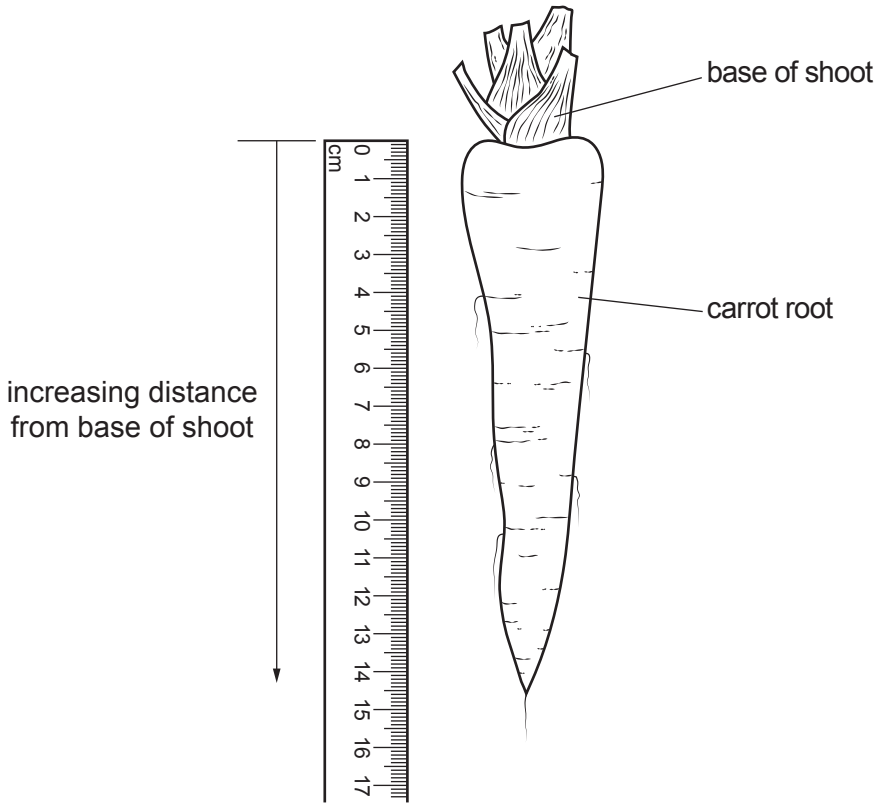



**Fig. 1.5**

**(c)** The student made the prediction:

*As the distance from the base of the shoot increases, the catalase activity of carrot root tissue increases.*

**(i)** Identify the **independent** variable in this investigation.

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.....

..... [1]

**(ii)** Describe a method that the student could use to test the prediction that:

As the distance from the base of the shoot increases, the catalase activity of carrot root tissue increases.

Your method should be set out in a logical order and be detailed enough to allow another person to follow it.

Details of how to use the centrifuge to prepare the liquid carrot extract should **not** be included.

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**(d)** In a different investigation, the student determined the effect of hydrogen peroxide concentration on the activity of catalase in yeast.

- $5\,cm^3$ hydrogen peroxide solution was placed in a test-tube at 25 °C.
- 0.2 g dried yeast was added to the test-tube, so that the yeast cells formed a suspension in the hydrogen peroxide solution.
- A gas syringe was quickly connected to the test-tube using a bung and delivery tube, as shown in Fig. 1.6.
- The volume of gas collected after one minute was measured.

Fig. 1.6 shows the apparatus used by the student.

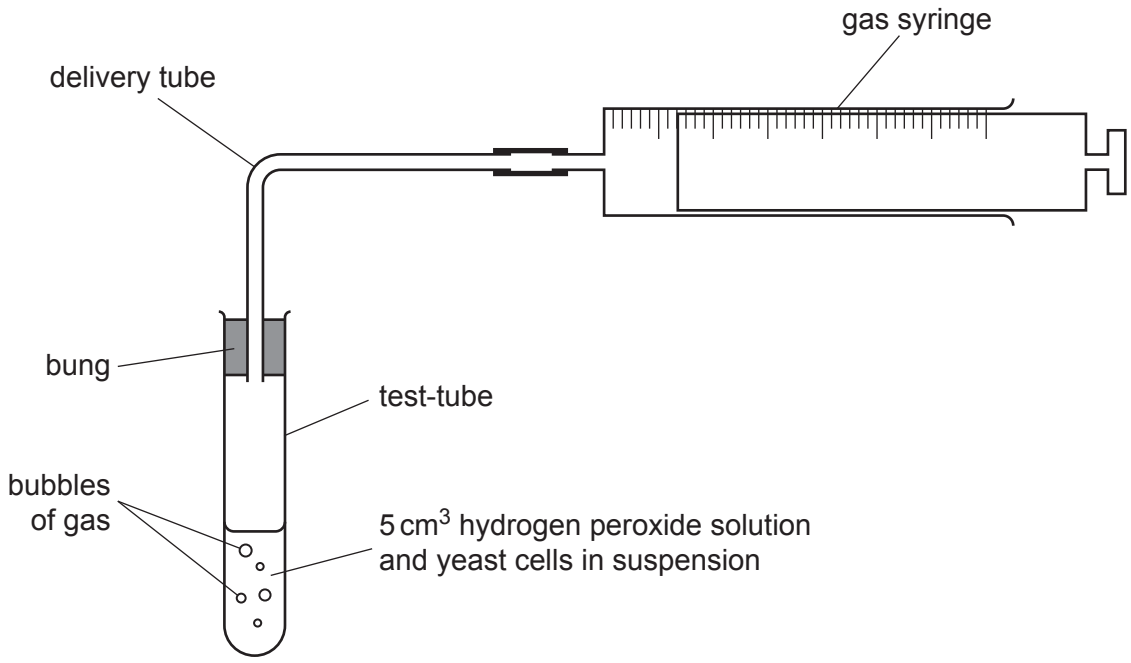



**Fig. 1.6**

**(i)** Identify the **dependent** variable in this investigation.

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..... [1]

**(ii)** To investigate the effect of hydrogen peroxide concentration on the activity of catalase in yeast, the student first prepared a range of known concentrations of hydrogen peroxide.

The student was given a 6.0% stock solution of hydrogen peroxide. The student decided to use the stock solution to make hydrogen peroxide solutions with concentrations of 3.0%, 3.6%, 4.8% and 5.4%.

The student made 50 $cm^3$ of each solution.

Complete Table 1.1 to show how these solutions could be made by **proportional dilution** of the 6.0% stock solution of hydrogen peroxide.

**Table 1.1**

| **percentage concentration of hydrogen peroxide** | **volume of stock solution / $cm^3$** | **volume of ..... / $cm^3$** |
|---|---|---|
| 3.0 | | |
| 3.6 | | |
| 4.8 | | |
| 5.4 | | |

[2]

Use this space for your working.

**(iii)** Fig. 1.7 shows the results of the investigation.

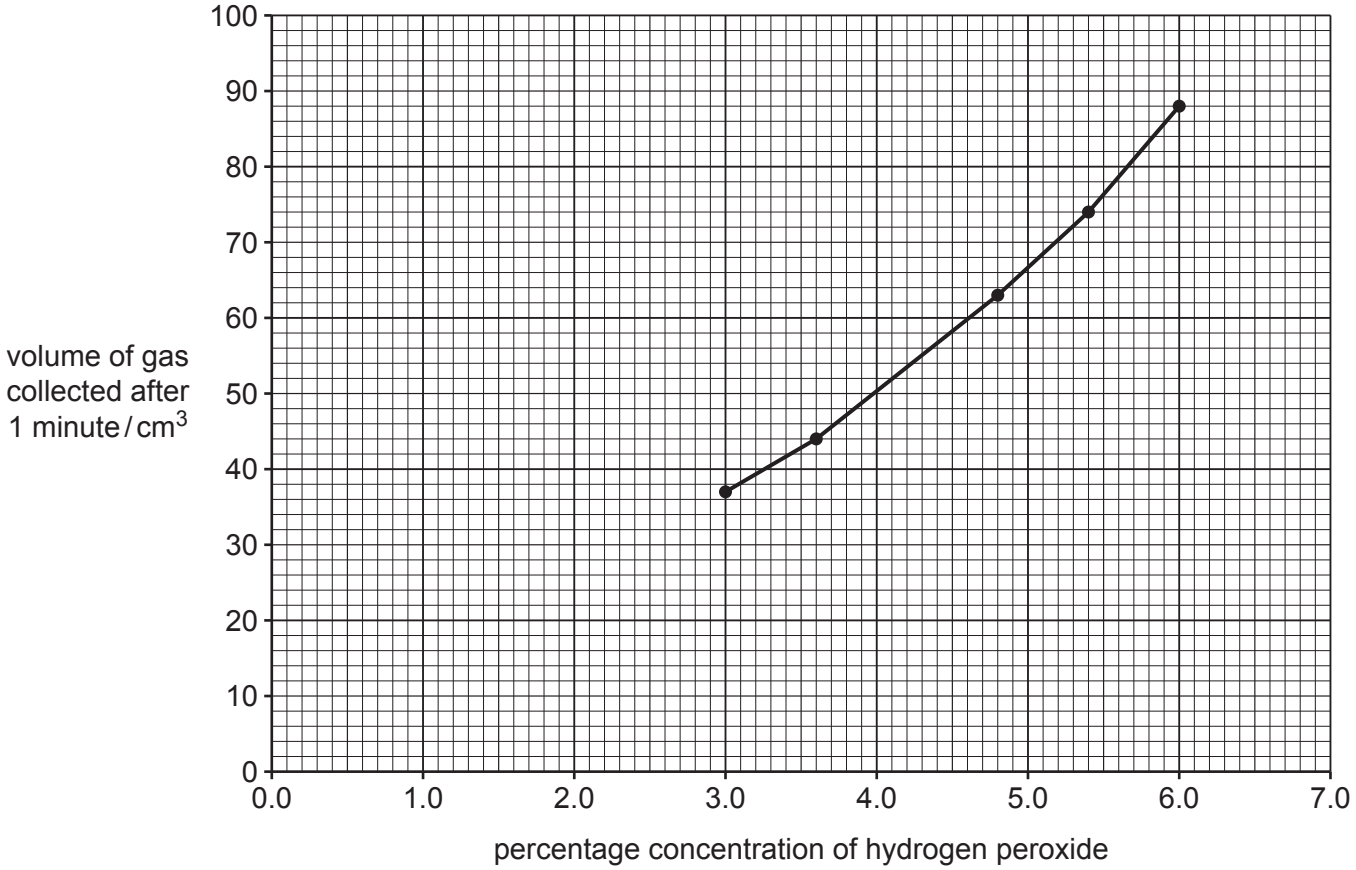



**Fig. 1.7**

The student made two conclusions:

- As the concentration of hydrogen peroxide increases, the volume of oxygen produced after one minute increases.
- The $V_{max}$ of catalase is 88 $cm^3$.

Use the information shown in Fig. 1.7 to evaluate these conclusions.

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..... [3]

[Total: 15]

**2** Sea trout, *Salmo trutta*, are found in rivers and coastal seawaters in many regions of the world.

Sea trout lay their eggs in rivers and the young fish remain in this freshwater environment. After living for 1–8 years in freshwater rivers, sea trout migrate to the sea. Adult sea trout feed in coastal seawater regions, usually no more than 80 km from their home river.

Fish farms that produce Atlantic salmon, *Salmo salar*, may be located in the coastal seawater regions where wild sea trout are also found.

Fig. 2.1 shows one cage at a fish farm.

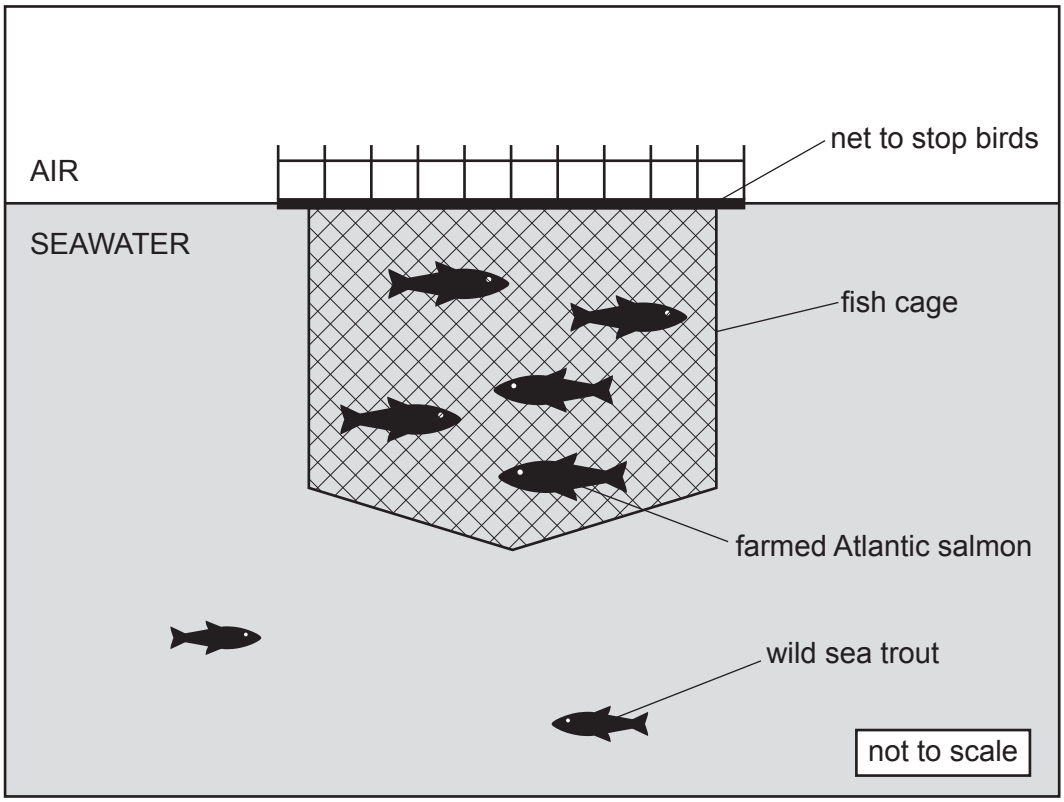



**Fig. 2.1**

The increase of fish farming is thought to have caused more infections by salmon lice, *Lepeophtheirus salmonis*, in wild fish such as sea trout. When sea trout enter coastal seawater regions, they can become infected with salmon lice.

Salmon lice larvae live in seawater and can move freely between fish cages and open seawater. Salmon lice attach to the skin of sea trout and feed on their skin and blood. The resulting tissue damage can sometimes cause the death of sea trout.

Fig. 2.2 shows a sea trout infected with salmon lice.

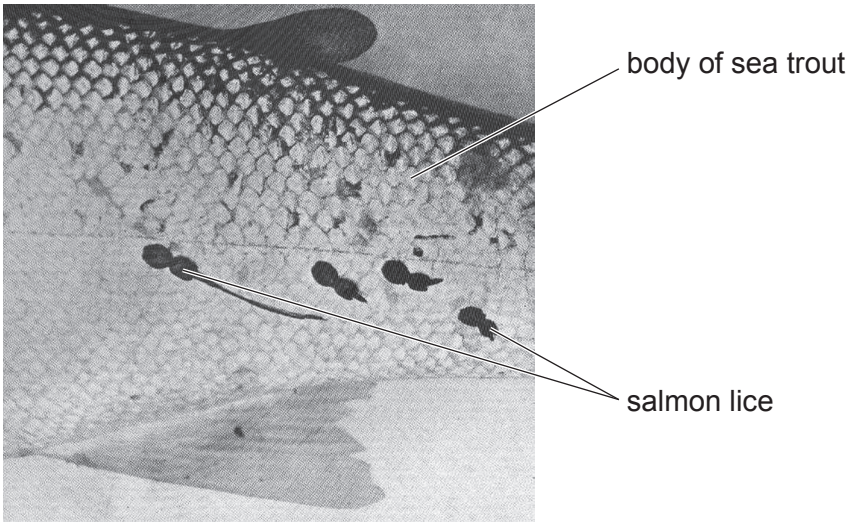



**Fig. 2.2**

**(a)** Some scientists found out from a published source that 13 or more attached salmon lice usually cause the death of a sea trout kept in laboratory conditions.

The scientists decided that each **wild** sea trout with 13 or more salmon lice is at risk of physiological stress and potential death.

Outline a laboratory method that could be used to determine the number of salmon lice needed to cause the death of a sea trout.

Suggest a suitable control that could be used to confirm that it is the salmon lice that are causing the death of the sea trout.

method that could be used .....

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suitable control .....

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[3]

**(b)** The scientists investigated the relationship between fish farming and infections by salmon lice on wild sea trout in coastal seawaters at Shieldaig on the west coast of Scotland in north-west Europe.

Fish farms use a two-year production cycle for Atlantic salmon. After hatching in freshwater tanks, the young salmon are transferred to seawater cages. Atlantic salmon spend two years growing in the seawater cages before they are harvested.

Infections by salmon lice on the farmed salmon are known to be higher in the second year of the two-year production cycle.

The scientists wanted to test the hypothesis:

Infections by salmon lice on wild sea trout in coastal seawaters at Shieldaig will be higher in the second year of the two-year production cycle of the fish farm near Shieldaig.

Electrofishing was used to sample the wild sea trout population in coastal seawater regions near the fish farm.

- A boat was used to travel to the sample location.
- An electric current was applied to the water around the boat. This causes some fish in the area to stop moving temporarily.
- A hand net was used to catch the fish that were not able to move.
- The number of sea trout caught was recorded.
- The number of salmon lice attached to each sea trout was also recorded.
- The fish were then returned to the sea.
- Sampling was repeated once a year for 10 years.

**(i)** State **one** variable that should be standardised in this procedure, **other than** the boat and the hand net.

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..... [1]

**(ii)** Electrofishing is more likely to prevent movement in larger fish.

State why this systematic error may give results that are **not** representative of the wild sea trout population.

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..... [1]

**(c)** The scientists collected data on infections by salmon lice on wild sea trout in coastal seawaters at Shieldaig every year from 2000 to 2009. During this time the fish farm near Shieldaig completed their two-year production cycle five times.

The data are shown in Table 2.1.

**Table 2.1**

| year | year of production cycle | number of sea trout sampled | percentage of sea trout with attached salmon lice | percentage of sea trout with ⩾ 13 attached salmon lice |
|---|---|---|---|---|
| 2000 | 1 | 15 | 13 | data not collected |
| 2001 | 2 | 87 | 31 | data not collected |
| 2002 | 1 | 31 | 6 | 3 |
| 2003 | 2 | 44 | 20 | 14 |
| 2004 | 1 | 15 | 0 | 0 |
| 2005 | 2 | 26 | 0 | 0 |
| 2006 | 1 | 39 | 8 | 5 |
| 2007 | 2 | 30 | 87 | 70 |
| 2008 | 1 | 14 | 0 | 0 |
| 2009 | 2 | 21 | 33 | 19 |

**(i)** Explain why the scientists calculated the percentages of sea trout with attached salmon lice.

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..... [2]

The scientists then calculated the mean percentage of sea trout with attached salmon lice in the first and second years of the fish farm production cycle.

These means are shown in Table 2.2.

**Table 2.2**

| year of production cycle | mean percentage of sea trout with attached salmon lice | mean percentage of sea trout with ⩾ 13 attached salmon lice |
|---|---|---|
| 1 | 6.1 | 2.6 |
| 2 | 33.2 | 14.9 |

The scientists concluded that greater numbers of wild sea trout in coastal seawaters at Shieldaig are at risk of death in the second year than in the first year of the two-year production cycle of the fish farm near Shieldaig.

**(ii)** Use Table 2.2 to describe the evidence that supports this conclusion.

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..... [1]

**(iii)** Suggest limitations of the data shown in Table 2.1 and Table 2.2 that reduce confidence in this conclusion.

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..... [2]

**(d)** The scientists then decided to use published data to investigate the effect of distance from fish farms on infection of wild sea trout by salmon lice in north-west Europe.

- 8 locations in coastal seawater regions of Scotland and 17 locations in coastal seawater regions of Ireland were sampled over several years.
- The number of salmon lice attached to each wild sea trout sampled was recorded.
- For each location, the distance from the nearest fish farm was recorded.

The scientists predicted that the number of attached salmon lice on wild sea trout will decrease as the distance from the nearest fish farm increases.

**(i)** State a null hypothesis the scientists would make before carrying out statistical analysis.

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..... [1]

The scientists then carried out statistical tests on the data to see if the relationship between the number of attached salmon lice on wild sea trout and the distance from the nearest fish farm was significant.

The probability values (*p*) from the results of the statistical tests are shown in Table 2.3.

**Table 2.3**

| location | value of *p* | significance |
|---|---|---|
| Ireland | 0.001 | ..... |
| Scotland | 0.559 | ..... |

**(ii)** Complete Table 2.3 by indicating if the results of the statistical tests are significant **or** not significant. [1]

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Fig. 2.3 shows the distance from the nearest fish farm plotted against the mean number of attached salmon lice per wild sea trout.

The error bars in Fig. 2.3 show 95% confidence intervals (95% CI).

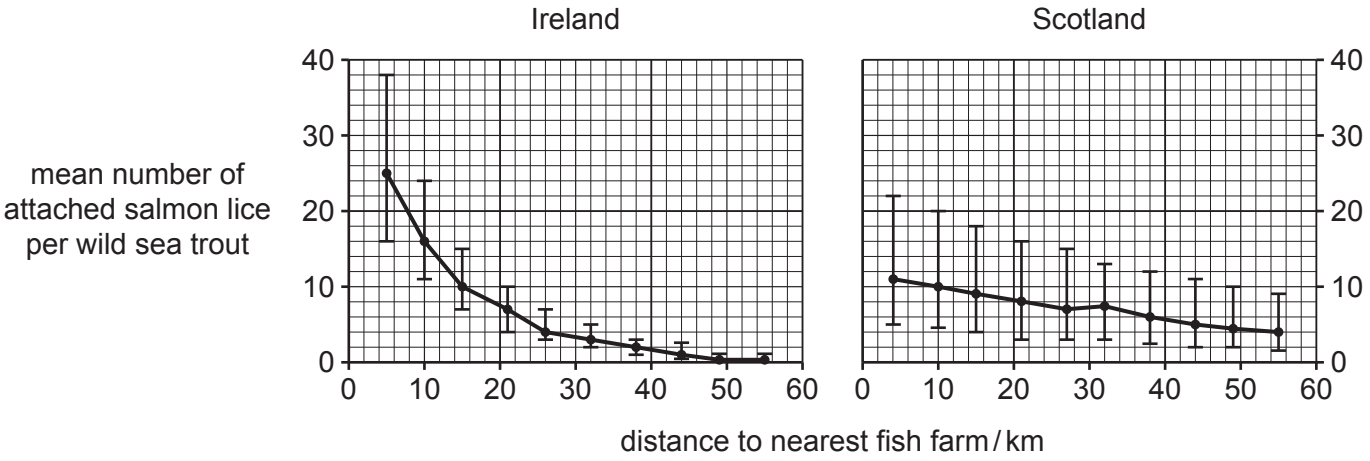



**Fig. 2.3**

**(iii)** With reference to Fig. 2.3, state the relationship between the distance from the nearest fish farm and the mean number of attached salmon lice per wild sea trout in the coastal seawater regions of Ireland.

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..... [1]

**(iv)** With reference to Fig. 2.3, suggest why the scientists calculated the 95% confidence intervals for their data.

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..... [2]

[Total: 15]

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# Cambridge International AS & A Level

CANDIDATE NAME

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CANDIDATE NUMBER

*9992649520*

**BIOLOGY** **9700/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2023**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- Answer **all** questions.
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- You may use a calculator.
- You should show all your working and use appropriate units.

**INFORMATION**

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **12** pages.


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**1** Polyphenol oxidase is an enzyme involved in the browning of fruit.

Fig. 1.1 shows browning of the skin of bananas.

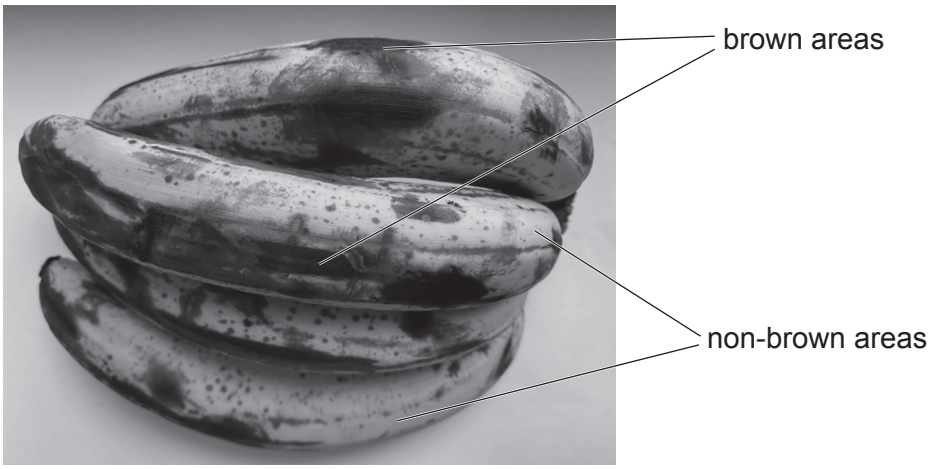



**Fig. 1.1**

A student extracted polyphenol oxidase enzyme from ripened bananas. The student used this enzyme extract to investigate the factors affecting the activity of the enzyme.

The student initially found that the enzyme extract was too concentrated, so the student made a 1:10 dilution of the enzyme extract.

**(a)** Describe how the student made a 1:10 dilution of the enzyme extract.

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..... [1]

**(b)** The student studied the effect of pH on the activity of polyphenol oxidase enzyme.

Dopamine hydrochloride solution was used as a substrate for the enzyme. The product of this reaction is red in colour.

A colorimeter can be used to follow the progress of this enzyme-catalysed reaction.

The student set up:

- 7 colorimeter tubes containing a solution of the substrate, dopamine hydrochloride
- 6 colorimeter tubes containing diluted polyphenol oxidase extract, each in a different buffered solution: pH 3.0, pH 4.0, pH 5.0, pH 6.0, pH 7.0, pH 8.0
- 1 colorimeter tube containing water in pH 7.0 buffer.

The colorimeter tubes were equilibrated at a set temperature.

A colorimeter was set up with a filter transmitting light at 470 nm.

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At time 0 seconds, the substrate solution and the polyphenol oxidase solution at pH 3.0 were mixed in one colorimeter tube. The colorimeter tube was then immediately put into the colorimeter.

The absorbance was measured at 15 second intervals over the first three minutes of the reaction.

The procedure was repeated for the remaining buffered solutions and the water at pH 7.0.

**(i)** Identify the **independent** variable in this experiment.

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..... [1]

**(ii)** Identify **one** variable that the student has standardised.

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..... [1]

**(c)** The student then plotted a graph of the results, showing the increase in absorbance. Absorbance is measured in absorbance units (au).

Fig. 1.2 shows the results for the increase in absorbance at **pH 5.0**.

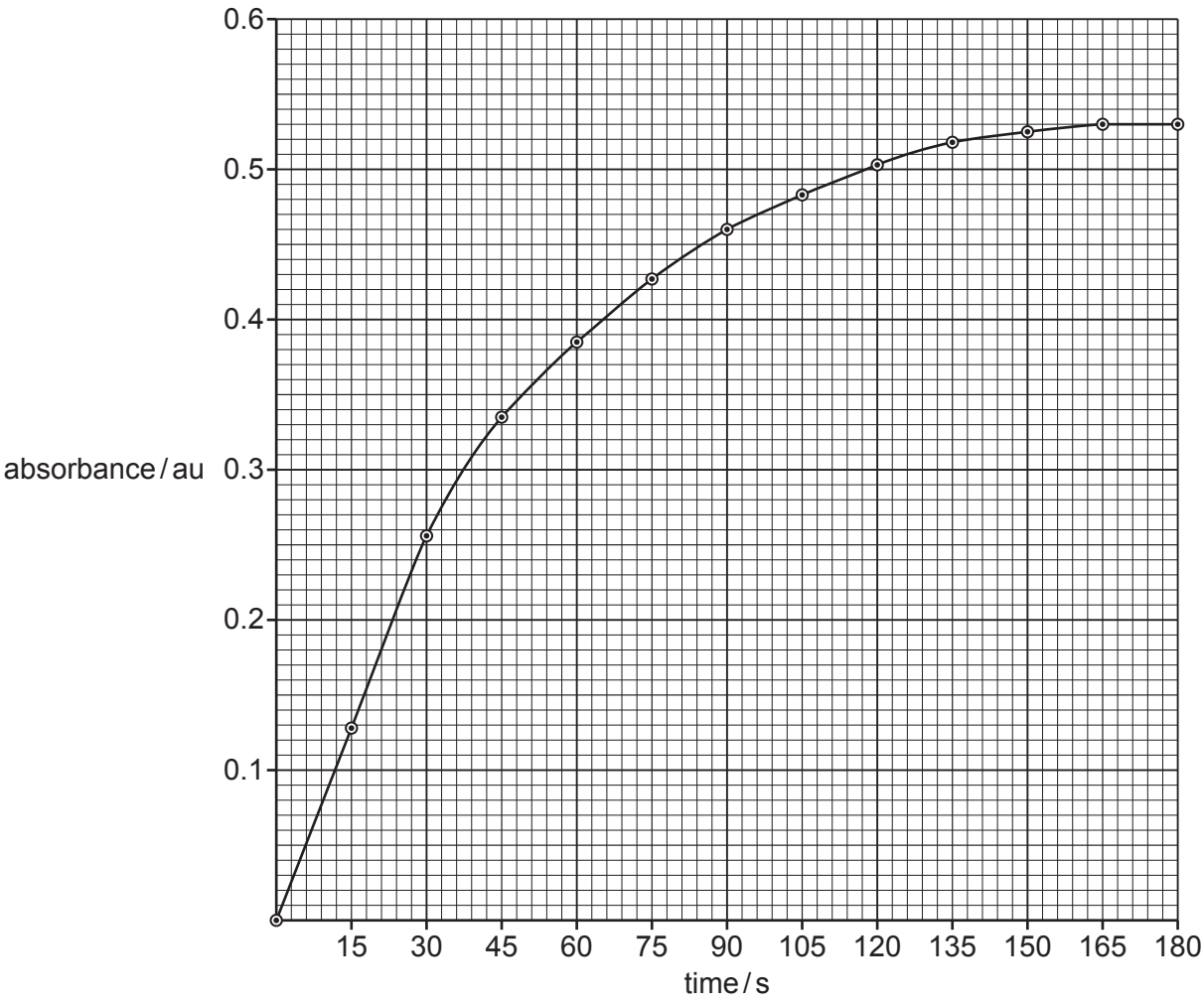



**Fig. 1.2**

**(i)** Use Fig. 1.2 to calculate the initial rate of this reaction in absorbance units per second ($au\,s^{-1}$).

Show your working.

initial rate of reaction = ..... $au\,s^{-1}$ [2]

**(ii)** Using the internet, the student found that pH 7.0 is the optimum pH for polyphenol oxidase.

On Fig. 1.2, sketch the line you would expect to get for the rate of reaction at **pH 3.0**. [1]

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**(d)** The student wanted to determine the effect of the concentration of the substrate, dopamine hydrochloride solution, on the rate of the enzyme-catalysed reaction.

The student was provided with a stock solution of 0.2% dopamine hydrochloride solution and the diluted enzyme extract prepared in **(a)**.

Describe a method the student could use to collect the data that is needed to determine the effect of the concentration of dopamine hydrochloride solution on the rate of the enzyme-catalysed reaction.

Your method should be set out in a logical order and be detailed enough to let another person follow it.

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..... [7]

**(e)** The browning of fruit such as bananas can make them more difficult to sell. One way to prevent browning of bananas is to use an anti-browning agent.

The student searched the internet and found data from different scientific papers on the inhibitory effect of various anti-browning agents on polyphenol oxidase from different plants.

The student processed and ranked these data, as shown in Table 1.1.

**Table 1.1**

| **anti-browning agent** | **percentage of maximum activity of polyphenol oxidase** | **plant source of polyphenol oxidase** |
|---|---|---|
| heated onion extract | 17.0 | potato |
| fresh onion extract | 44.4 | potato |
| ascorbic acid | 60.0 | sorrel |
| L-cysteine | 70.0 | sorrel |
| potassium sorbate | 76.8 | potato |
| citric acid | 80.4 | potato |
| EDTA | 88.0 | red poppy |
| no anti-browning agent (control) | 100.0 | potato |

The student concluded that heated onion extract was the most effective anti-browning agent and that EDTA was the least effective.

Use the information to suggest why this conclusion may **not** be supported.

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..... [2]

**(f)** The student found that a sulfur-containing molecule in the heated onion extract acted as a non-competitive inhibitor to the enzyme polyphenol oxidase.

Fig. 1.3 is a graph showing how the substrate concentration affects the rate of polyphenol oxidase activity.

On Fig. 1.3 sketch the curve that shows the rate of activity for polyphenol oxidase treated with the heated onion extract.

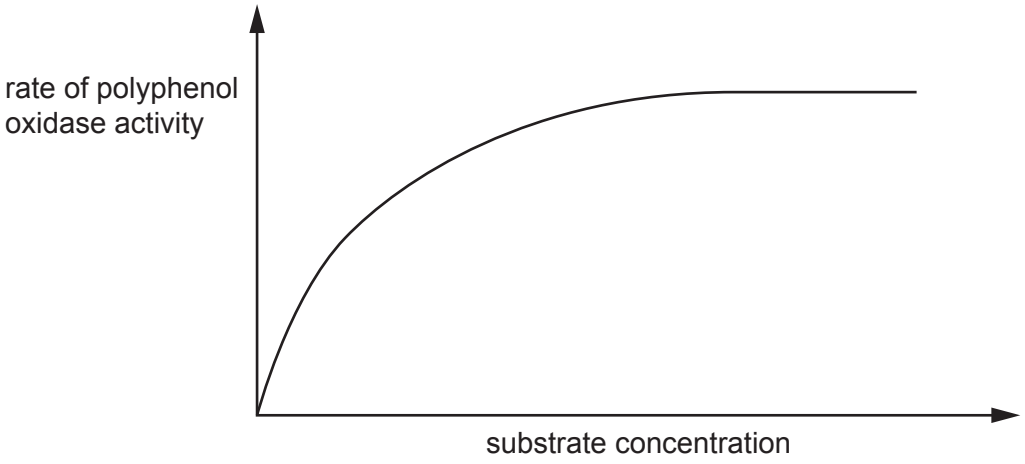



**Fig. 1.3**

[1]

[Total: 16]

**2** Air pollution due to motor vehicles is an environmental issue that needs constant monitoring.

Lichens consist of protoctists and fungi living in close association. The protoctists and fungi each benefit from this association. Lichens are found in a large range of habitats, including on the surface of tree trunks (tree bark), as shown in Fig. 2.1.




**Fig. 2.1**

Lichens are sensitive to air pollution. The abundance of lichens decreases with increasing levels of air pollution and so lichens can be used to monitor levels of air pollution.

Some scientists investigated the relationship between distance from a road and levels of air pollution. The scientists investigated this relationship by measuring the abundance of lichens on the tree trunks in a woodland beside a busy road.

The scientists used the grid shown in Fig. 2.2 to determine the abundance of lichens on the tree trunks.

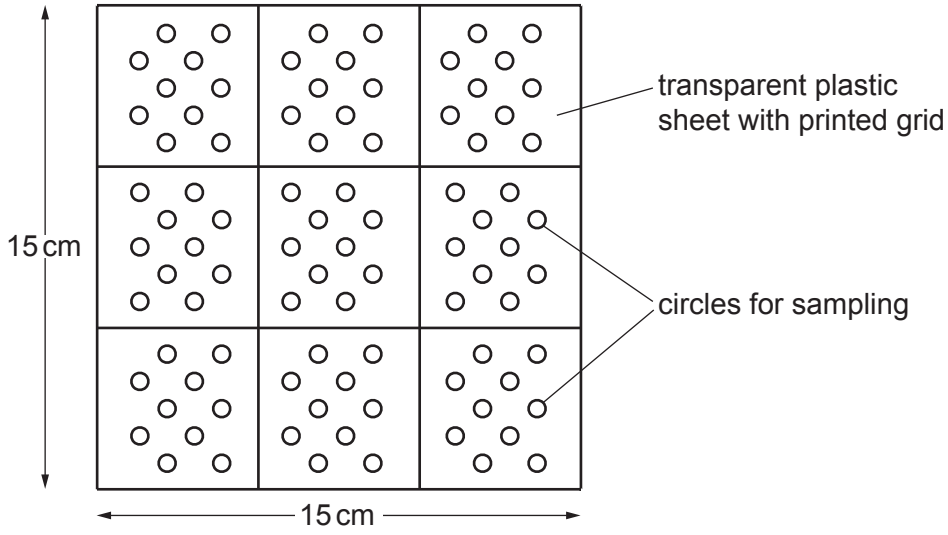



**Fig. 2.2**

For each tree sampled, the scientists:

- placed the grid against the tree trunk
- counted the number of circles that contained lichen
- used the number of circles that contained lichen to calculate the percentage cover of lichen on the tree
- measured the distance from the tree to the road.

**(a) (i)** State **two** variables that the scientists should standardise in this investigation.

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..... [2]

**(ii)** State **one** risk **and** the safety precaution that the scientists should take when measuring the abundance of the lichens on the tree trunks.

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..... [2]

**(b)** The scientists recorded the presence of lichens by shading in the circles on the grid where lichens were observed.

The results are shown in Fig. 2.3.

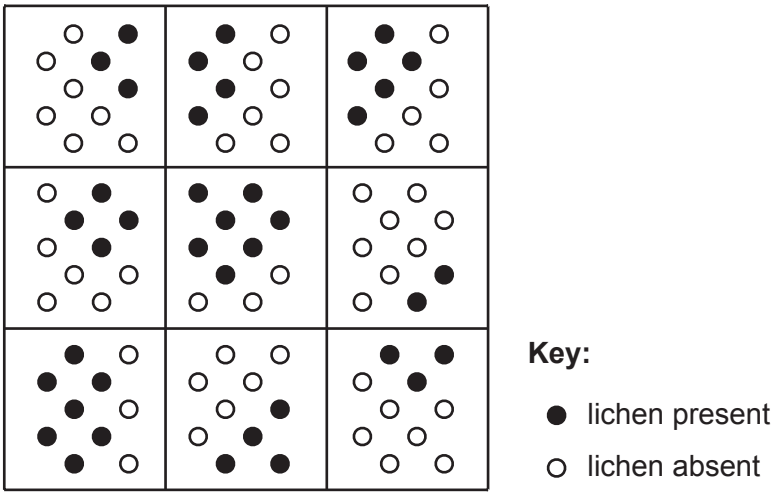



**Fig. 2.3**

Use the grid in Fig. 2.3 to calculate the percentage cover of the lichen on the tree trunk.

Show your working.

percentage cover of lichen = ..... % [2]

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**(c)** The scientists measured the percentage cover of lichens on 10 trees, each growing at a different distance from the road.

The scientists carried out a Spearman's rank correlation analysis to find out if there was a correlation between the distance from the road and the percentage cover of lichens on the tree trunks.

Table 2.1 shows part of the table used to determine the data needed for the Spearman's rank correlation equation.

**(i)** Complete Table 2.1 for tree number 10.

**Table 2.1**

| **tree number** | **distance from road / m** | **rank for distance from road** | **percentage cover of lichen** | **rank for percentage cover of lichen** | **difference in rank ($D$)** | **$D^2$** |
|---|---|---|---|---|---|---|
| 10 | 5.6 | 7 | 74 | 5 | | |

[1]

The formula for calculating Spearman's rank correlation coefficient ($r_s$) is:

$$r_s = 1 - \left( \frac{6 \times \Sigma D^2}{n^3 - n} \right)$$

Key to symbols:

$D$ = difference in rank between each pair of measurements

$n$ = number of pairs of items in the sample

**(ii)** The scientists calculated the value of $\Sigma D^2$ as **39.75**.

Calculate the Spearman's rank correlation coefficient ($r_s$) value to **three** significant figures.

Use this space for working.

Spearman's rank correlation coefficient ($r_s$) = ..... [2]

**(iii)** State the conclusions that can be made from the calculated value of Spearman's rank correlation coefficient ($r_s$).

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..... [3]

**(iv)** State how the scientists could use the calculated value of $r_s$ to determine whether or not the correlation is due to chance.

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..... [2]

[Total: 14]

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Cambridge Assessment International Education

# Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

*3265335577*

**BIOLOGY** **9700/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2023**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

**INFORMATION**

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **12** pages.


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**1** Hydrogencarbonate indicator is a water-soluble solution that can act as a source of carbon dioxide for aquatic photosynthetic organisms. The solution changes colour depending on the concentration of carbon dioxide in the solution. These colours are related to different pH values, as shown in Table 1.1.

**Table 1.1**

| colour of hydrogencarbonate indicator solution | pH | concentration of carbon dioxide in the solution |
|---|---|---|
| yellow | 7.6 | ↑ increasing carbon dioxide concentration |
| yellow-orange | 7.8 | |
| orange | 8.0 | |
| orange-red | 8.2 | |
| red | 8.4 | atmospheric concentration |
| red-magenta | 8.6 | ↓ decreasing carbon dioxide concentration |
| magenta | 8.8 | |
| magenta-purple | 9.0 | |
| purple | 9.2 | |

*Chlorella vulgaris* is a protoctist that is single-celled, aquatic and photosynthetic. It can be immobilised in alginate beads.

Alginate beads with immobilised *C. vulgaris* can be used to measure the rate of photosynthesis.

**(a)** A student noticed that a colour change occurred, from red to magenta, when the alginate beads with immobilised *C. vulgaris* were left in a container of hydrogencarbonate indicator solution and exposed to light.

Explain why this colour change occurred.

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**(b)** The student used the alginate beads with immobilised *C. vulgaris* in hydrogencarbonate indicator solution to investigate the rate of photosynthesis in different light intensities.

Fig. 1.1 shows some of the apparatus and reagents the student used.

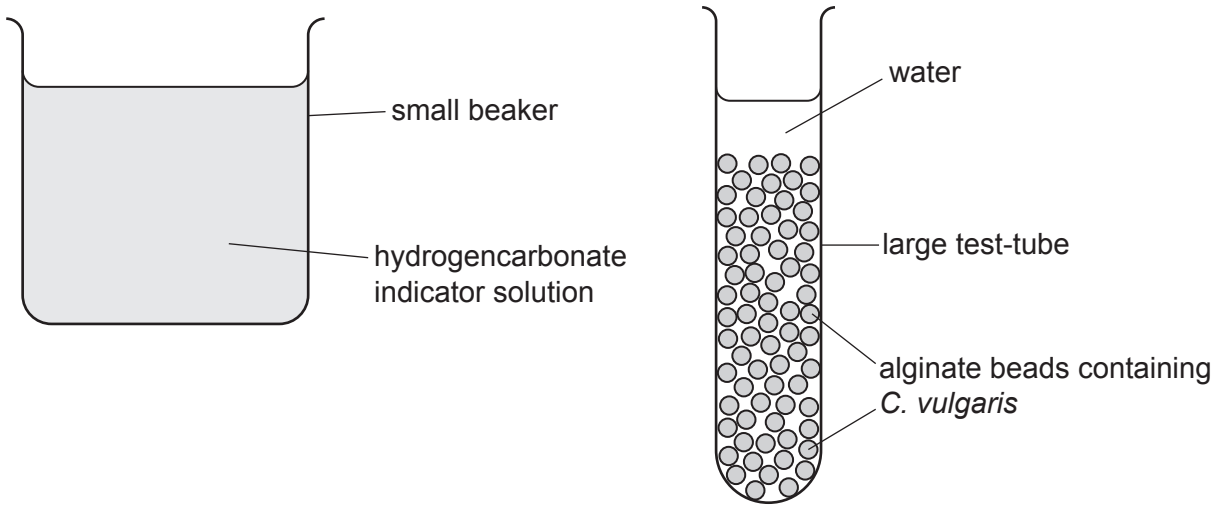



**Fig. 1.1**

**(i)** Identify the **independent** variable in this investigation.

..... [1]

**(ii)** The student was provided with a supply of alginate beads containing immobilised *C. vulgaris*.

Describe a method the student could use to collect data to determine the effect of light intensity on the rate of photosynthesis of *C. vulgaris* using hydrogencarbonate indicator and the experimental set-up in Fig. 1.1.

Your method should be set out in a logical order and be detailed enough to let another person follow.

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**(c)** The student set up a large test-tube containing alginate beads with immobilised *C. vulgaris* in hydrogencarbonate indicator solution at **pH 8.4** (red).

The student kept this set-up in the dark for 12 hours.

Predict and explain the results that will be observed after 12 hours in the dark.

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**(d)** Some scientists wanted to culture cells of *C. vulgaris* on a large scale for use as a biofuel.

To determine the optimal growing conditions for *C. vulgaris*, the scientists needed to determine the number of cells per $cm^3$ of suspension to monitor the population growth.

They tried two methods to determine the number of cells per $cm^3$ of suspension.

The first method used a Secchi stick, as shown in Fig. 1.2.

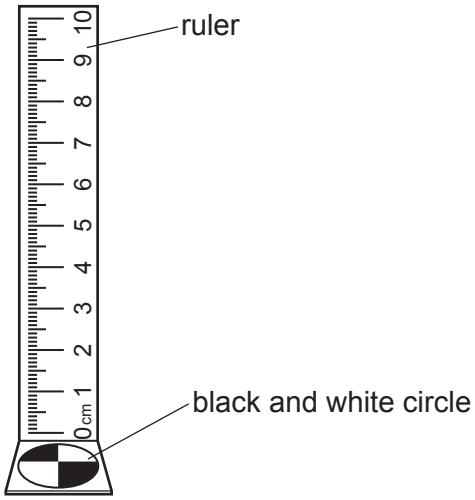



**Fig. 1.2**

The Secchi stick is lowered into the suspension of cells until the black and white circle is not able to be seen from above.

The depth in cm is recorded from the ruler, as shown in Fig 1.3.

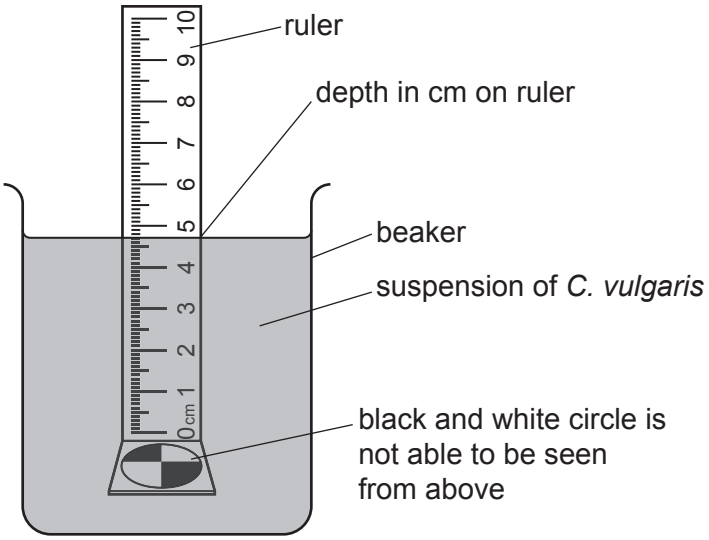



**Fig. 1.3**

The $\log_{10}$ ($l$g) of the number of cells is determined from a graph of $\log_{10}$ of cells counted per $cm^3$ suspension against Secchi depth (cm), as shown in Fig 1.4.

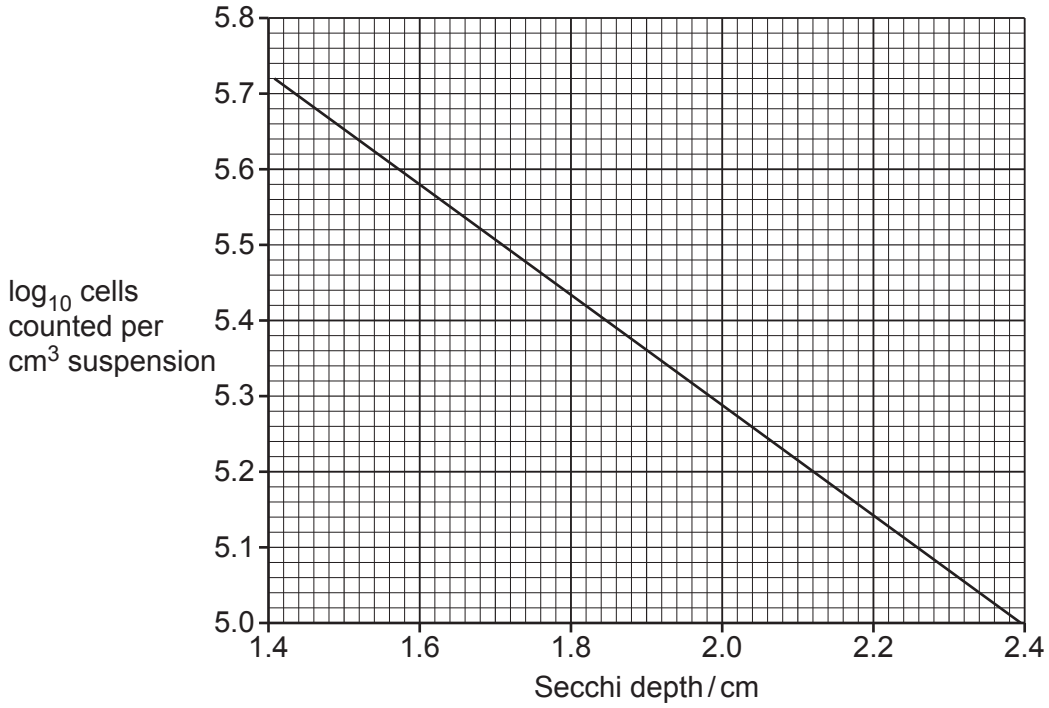



**Fig. 1.4**

**(i)** When the scientists inserted the Secchi stick into a sample from their cell suspension, the circle (on the Secchi stick) was not able to be seen at a depth of **1.9 cm**.

Using the graph in Fig. 1.4, calculate the actual number of cells per $cm^3$ of suspension.

Show your working and give your answer to the nearest 1000 cells.

number of cells per $cm^3$ of suspension ..... [2]

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The second method used a counting chamber to determine the number of cells per $cm^3$ of suspension.

Fig. 1.5 shows a section of a counting chamber with cells present, as viewed using the high power of a light microscope.

The depth of the 1 mm × 1 mm counting chamber is **0.1 mm**.

The scientists counted the number of cells in several sections of a counting chamber.

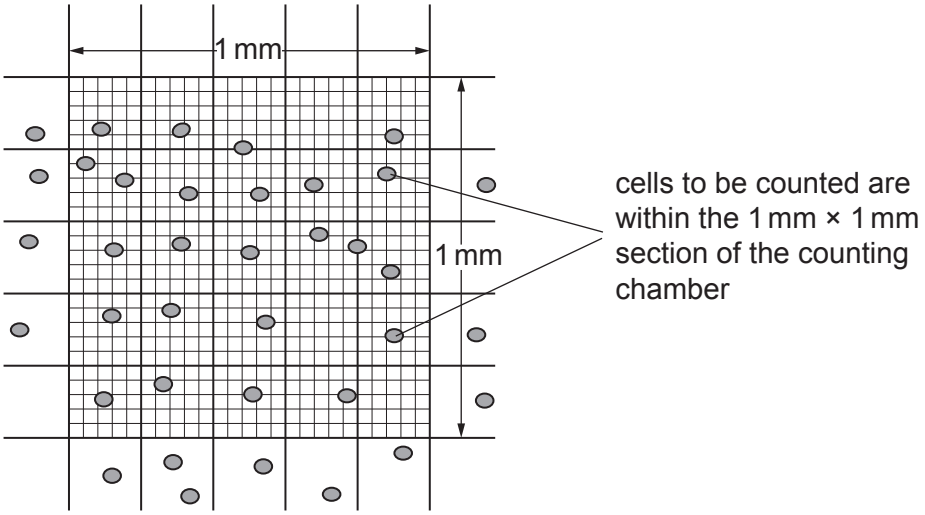



**Fig. 1.5**

**(ii)** Count the number of cells in the 1 mm × 1 mm section of the counting chamber shown in Fig. 1.5.

Use your answer to calculate the number of cells per $cm^3$ of the suspension.

Show all your working.

number of cells per $cm^3$ of suspension ..... [3]

**(iii)** The scientists decided that using the Secchi stick was a less accurate method for determining the number of cells per $cm^3$ of suspension.

Give **two** reasons why using the Secchi stick is less accurate than using a counting chamber.

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[Total: 20]

**2** Lichens consist of protoctists and fungi living in close association. Both types of organism benefit from this association. Lichens are found in a large range of habitats, including on the trunks of trees.

Fig. 2.1 shows an example of a lichen, the salted shield lichen, *Parmelia saxatilis*, on the trunk of a tree.

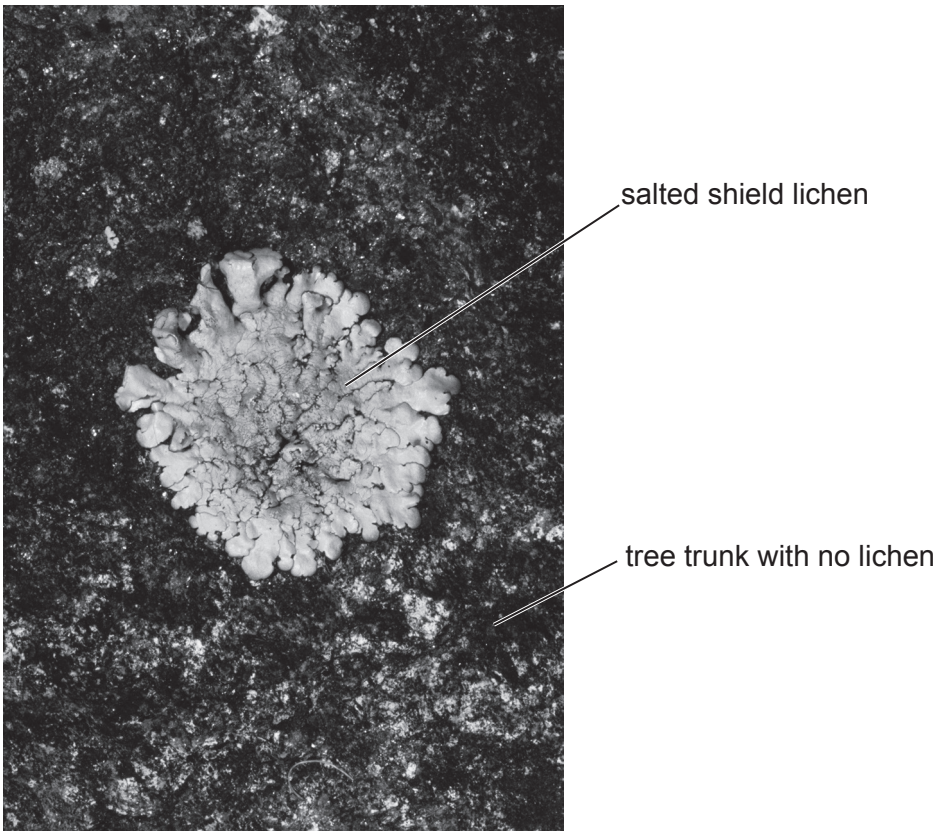



**Fig. 2.1**

The red deer, *Cervus elaphus*, is found in many parts of the world including north-west Europe. Red deer are found in a large range of habitats, including mixed woodlands. Mixed woodlands contain many different tree species.

Fig. 2.2 shows a male red deer.



**Fig. 2.2**

Red deer have increased in numbers in the mountainous regions of Scotland in north-west Europe since the 1960s.

Scientists think that grazing of plants by red deer has affected the abundance of certain lichens found growing on the trunks of trees in mixed woodlands.

To investigate this, the scientists excluded red deer from certain mixed woodland areas (exclosures) in 1995, allowing the exclosures to remain ungrazed.

In 2013, the scientists compared the abundance of the salted shield lichen in the exclosures and in the grazed areas.

The scientists used the grid shown in Fig. 2.3 to determine the abundance of the salted shield lichen on the tree trunks.

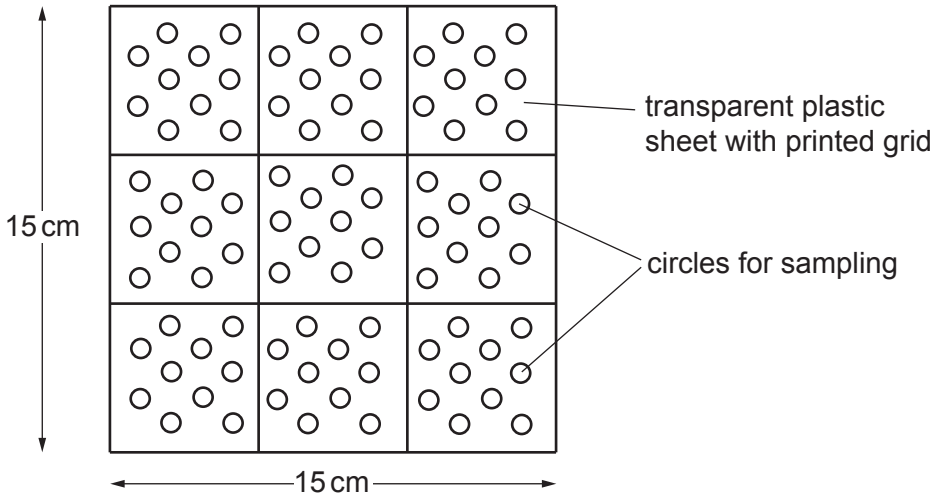



**Fig. 2.3**

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For each tree sampled:

- The grid was placed against the tree trunk at three different heights: base, middle and upper.
- The scientists counted the number of circles that contained the salted shield lichen.
- The number of circles that contained the salted shield lichen was used to calculate the percentage cover of salted shield lichen on the tree.

This study was carried out over the course of the three months (June, July and August) in the summer of 2013 in the exclosures and the grazed areas.

**(a) (i)** Suggest **two** variables that the scientists should have standardised in this investigation.

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**(ii)** State **one** risk **and** the safety precaution that the scientists should take when measuring the abundance of salted shield lichen on the tree trunks.

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**(b)** The scientists calculated a percentage cover for the salted shield lichen as **63.3%** on one of the trees, using the grid in Fig. 2.3.

Calculate how many circles on the grid contained salted shield lichen.

Show your working and give your answer to the nearest whole number.

number of circles with salted shield lichen = ..... [2]

**(c)** The scientists performed a *t*-test to compare the abundance of the salted shield lichen in the exclosures and the grazed areas.

**(i)** State a null hypothesis for the *t*-test.

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Table 2.1 shows the mean results and values of *t* the scientists obtained.

**Table 2.1**

| position of grid on tree trunk | mean percentage cover in exclosures | mean percentage cover in grazed areas | *t* | significance at $p = 0.05$ |
|---|---|---|---|---|
| base | 1.7 | 3.2 | 0.730 | not significant |
| middle | 3.4 | 9.8 | 2.117 | significant |
| upper | 8.5 | 22.0 | 2.071 | significant |

**(ii)** State **one** conclusion that can be made from the data in Table 2.1.

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**(iii)** State **two** improvements the scientists could make to their study to determine the effect of grazing of red deer on the abundance of salted shield lichen in mixed woodland areas.

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[Total: 10]

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