EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examinations 2024
General Certificate of Education Advanced Level
Higher 2

| CANDIDATE NAME | **ANSWERS** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CIVICS GROUP | **2** | **3** | **-** | | | REGISTRATION NUMBER | | |

# BIOLOGY

**9744/04**

Paper 4 Practical

**22 August 2024**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and registration number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use stapler, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided in the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

| **For Examiner's Use** | |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **Total** | **55** |

This document consists of **22** printed pages and **2** blank pages.

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Answer **all** questions.

**1** You will be investigating the effect of salt concentration on the movement of water in potatoes.

You are provided with the materials shown in Table 1.1.

**Table 1.1**

| labelled | contents | hazard | volume / $cm^3$ |
|---|---|---|---|
| **P** | 5 lengths of potato | none | – |
| **W** | distilled water | none | 150 |
| **S** | 1 mol $dm^{-3}$ salt solution | none | 150 |

It is recommended that you wear suitable eye protection.

**(a)** You will need to make different concentrations of salt solution using simple dilution of the 1.00 mol $dm^{-3}$ salt solution, **S**.

You will need to prepare 40 $cm^3$ of each concentration.

Table 1.2 shows two of the concentrations you will use.

Decide which other concentrations of salt solution you will use.

**(i)** Complete Table 1.2 to show how you will prepare the other concentrations.

**Table 1.2**

| final concentration of salt solution / mol $dm^{-3}$ | volume of **S** / $cm^3$ | volume of distilled water, **W** / $cm^3$ |
|---|---|---|
| 1.00 | 40 | 0 |
| 0.75 | 30 | 10 |
| 0.50 | 20 | 20 |
| 0.25 | 10 | 30 |
| 0.00 | 0 | 40 |

[2]

1. At least **3 more concentrations (evenly spaced)** (A: 4, e.g. 0.80, 0.60, 0.40, 0.20) **and** 2 d.p.
2. **All volumes** of S and W **add up to 40**

NOTE: In the event that you come across the term “proportional dilution”, you can assume that it is referring to “simple dilution”. In addition, doing serial dilution will not give you a 0.00 with 5 concentrations.

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Carry out step 1 to step 11.

step 1 Prepare the concentrations of salt solution, as shown in Table 1.2, in the beakers provided.

step 2 Cut 10 discs of potato for each of the concentrations prepared in step 1.

Each disc should be approximately 3 mm thick.

step 3 Place 10 discs in a line as shown in Fig. 1.1.

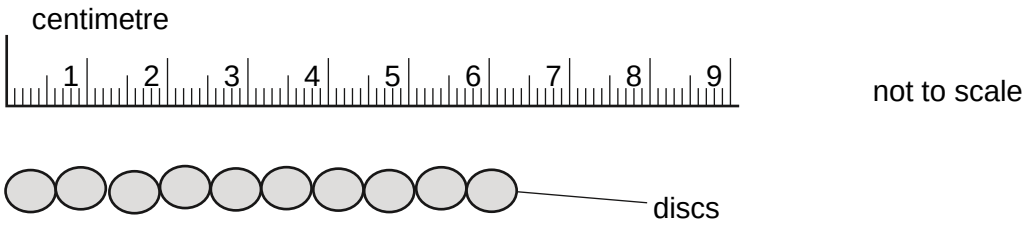


**Fig. 1.1**

step 4 Measure the total length of the 10 discs and record this value in **1(a)(ii)**.

step 5 Put the 10 discs into the beaker containing 1 mol $dm^{-3}$ salt solution.

step 6 Repeat step 3 to step 5 with the other discs and the salt solutions you prepared in step 1.

step 7 Start timing and leave for 30 minutes. Use this time to continue with other parts of Question 1.

step 8 After 30 minutes (step 7), discard the 1 mol $dm^{-3}$ salt solution from around the discs and tip the discs onto some paper towel.

step 9 Place the 10 discs in a line as in Fig. 1.1 and measure their total length. Record this value in **1(a)(ii)**.

step 10 Repeat step 8 and step 9 for the other salt concentrations.

step 11 Calculate the **change** in length for each line of 10 discs.

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**(ii)** Record your results in an appropriate table, including raw results **and** processed results.

| Concentration of salt / mol $dm^{-3}$ | Initial length of potato discs / mm | Final length of potato discs / mm | Change in length / mm |
|---|---|---|---|
| 1.00 | 101 | 90 | -11 |
| 0.75 | 100 | 92 | -8 |
| 0.50 | 98 | 91 | -7 |
| 0.25 | 100 | 100 | 0 |
| 0.00 | 100 | 107 | 7 |

1. **Headings**: for **concentration of salt** with units in **mol $dm^{-3}$** + **initial length** and **final length** with units in **mm**
2. **Data**: records result for each concentration prepared
3. **Processed data**: in the form of **changes in length** (R: no '-' sign if length decreases)
4. **Precision:** in **whole number** for lengths (I: concentration as it has been assessed in (i) earlier)
5. **Trend**: lowest concentration has greatest increase

[5]

**(iii)** Explain your results for the 0.0 mol $dm^{-3}$ salt solution (distilled water). [2]

1. 0.00 mol $dm^{-3}$ salt solution has **higher water potential than potato** cells.
2. **water moves into potato <u>cells</u> by <u>osmosis</u>**. (R: diffuse) (A: cell sap)

**(iv)** Suggest why a line of 10 discs was measured instead of a single disc. [1]

1. Measuring the change in length of **a single disc more inaccurate** than measuring a line of 10 discs. (OWTTE) (R: average length) (R: idea of more intense / maximum results) (I: replicates without explaining how it is linked to accuracy) (R: ref. to reliability / precision)

**(v)** Identify **one** significant source of error in this investigation. [1]

1. Not all the discs were exactly 3 mm in thickness.
2. Knife and ruler not precise / accurate in cutting 3mm discs.

[Any one]

**(vi)** Use your results to estimate a salt concentration where there is **no net movement** of water into or out of the potato.

1. Correct estimate of salt concentration where there was no net movement of water into or out of the potato based on students' results.

salt concentration **<u>0.25</u>** mol $dm^{-3}$ [1]

**(vii)** Describe **two** improvements to your procedure that would make the estimate in **1(a)(vi)** more accurate. [2]

1. Using **smaller intervals** of **salt concentrations around the value of the candidates' estimate**
   (R: stating smaller intervals between 1.00 to 0.00, i.e. the entire range)
   (R: use a wider range)
2. Use a **more precise** method of cutting discs, e.g. **template cutter** (R: cork borer because that was the instrument used to cut the potato cylinders that candidates were given)

**(b)** The salt content of unprocessed food was measured.

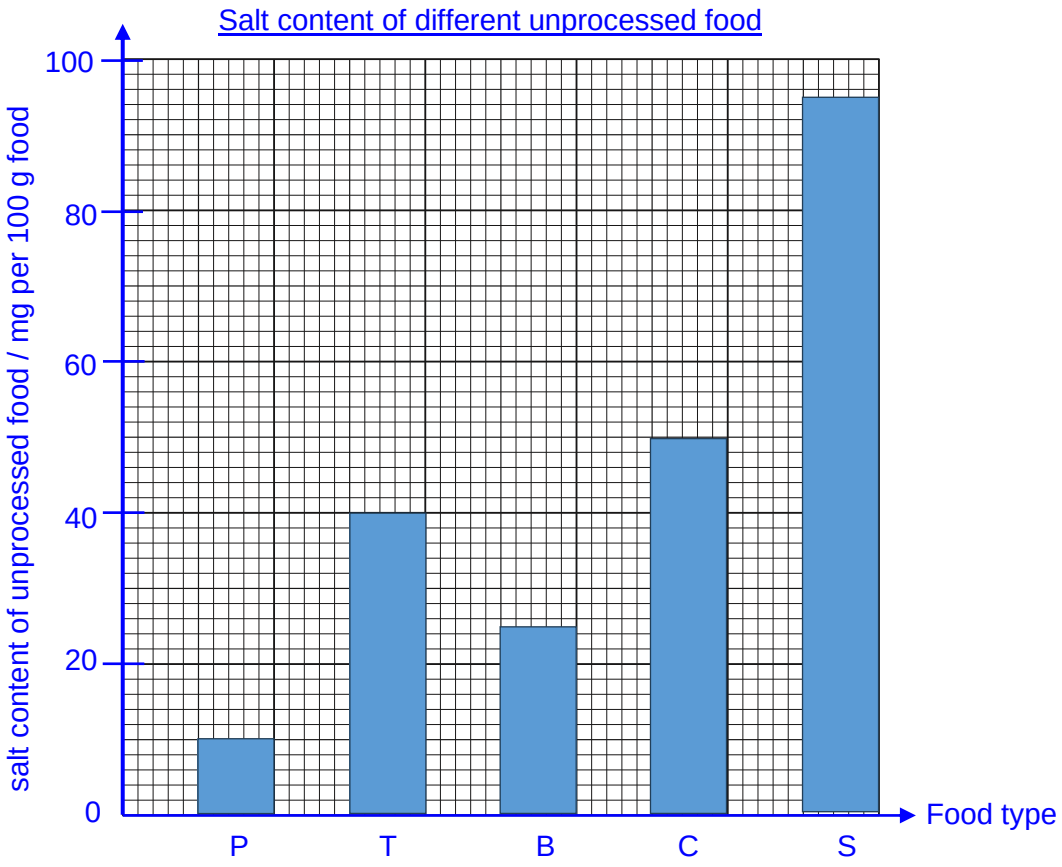
The values are shown in Table 1.3.

**Table 1.3**

| food type | salt content of unprocessed food / mg per 100 g food |
|---|---|
| potatoes (P) | 10.0 |
| tuna (T) | 40.0 |
| bran (B) | 25.0 |
| chicken (C) | 50.0 |
| salmon (S) | 95.0 |

**(i)** Plot a bar chart of the data shown in Table 1.3 on the grid in Fig. 1.2.

Use a sharp pencil.




[4]

**Fig. 1.2**

1. **Scale**: **even width of bars** and **scale on y-axis: 20 units to 10 small squares**, **labelled at least every 2 cm**
2. **Axis**: labels on **x-axis: food type** **and** labelled **P, T, B, C, S** **and** label on **y-axis: salt content of unprocessed food / mg per 100 g food**
3. **Plots**: **correct plotting** of 5 bars, **evenly spaced** (R: if no spacing between bars)
4. **Line**: **separate bars drawn with vertical lines and meeting horizontal lines exactly**

(I: no title)

The salt content of the same foods that had been processed was also measured.

The values are shown in Table 1.4.

**Table 1.4**

| food type | salt content of processed food / mg per 100 g food |
|---|---|
| potatoes (P) | 200.0 |
| tuna (T) | 300.0 |
| bran (B) | 1000.5 |
| chicken (C) | 350.5 |
| salmon (S) | 1800.0 |

**(ii)** Calculate the percentage increase in salt content when salmon is processed.

Show your working and write your answer to **two** significant figures.

[(1800 – 95) / 95] X 100%
= 1794.73
= **1800%** (2 s.f.)

1. shows (1800 – 95) divided by 95 **and** multiplied by 100
2. correct answer to **two** significant figures.
   (Allow ecf if calculation is correct + 2 s.f.)

increase in salt content **1800** % [2]

[Total: 20]

**2** 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 2.1.

**Table 2.1**

| 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. [2]

1. (red to magenta shows) **decrease in concentration of carbon dioxide** leads to **increase in pH** (I: increase in concentration of carbon dioxide leads to decrease in pH, because question is about change from red to magenta)
2. **in** the presence of **light**, ***C. vulgaris* uses up carbon dioxide for photosynthesis** leads to decrease in concentration of carbon dioxide (NOTE: not marking for decrease in concentration of carbon dioxide as it was marked in point 1)

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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. 2.1 shows some of the apparatus and reagents the student used.

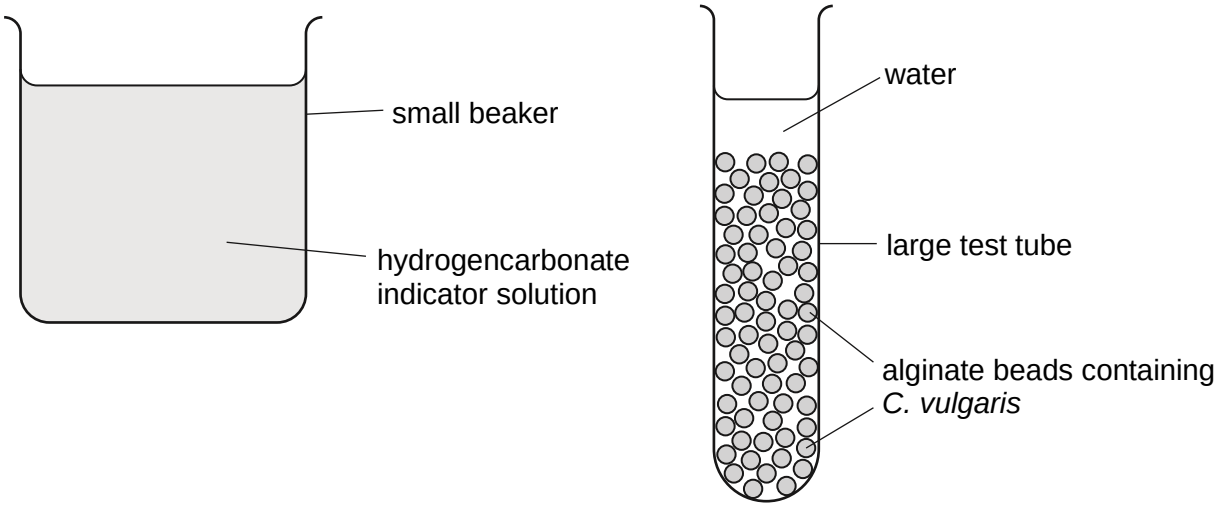


**Fig. 2.1**

**(i)** Identify the **independent** variable in this investigation. [1]

1. **Light intensity**

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

Plan an investigation 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. 2.1.

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- a description of the method used including the scientific reasoning behind the method
- be illustrated by relevant diagram(s), if necessary
- identify the key variables
- describe the method so that the results are as accurate and repeatable as possible
- include the layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific forms
- include reference to safety measures to minimise the any risks associated with the proposed experiment.

1. Independent variable:
   **use lamp** at **minimum of 5 different distances** from alginate beads (R: distances above 50.0cm)
   OR
   **use lamp** with **minimum 5 different power ratings** / **wattages** (**at same distances**)

2. Dependent variable: **rate of photosynthesis** as determined by the
   **colour** / **pH** (of the indicator) **after a set** or **stated time**
   OR
   **time taken** (for the indicator) **to be a set** or **stated colour** / **pH**

3. Replicates: at least **3** + mean + purpose: **check for anomalous data** (R: ensure no anomalous data)

4. Controlled variable: [Any 2]
   **same** or **stated mass** / **number** / **size** of **alginate beads**
   **same** or **stated volume** / **concentration** of **hydrogencarbonate indicator**
   **same starting colour** / **pH** of **hydrogencarbonate indicator**

5. (negative) Control: [Any 1]
   **Carry out the experiment in a darkened environment** (e.g. wrapping beaker / test tube with aluminium foil)
   OR
   **Keeping all other variables constant, replace alginate beads containing live *C. Vulgaris* with**
   - **same number of alginate beads containing boiled & cooled *C.vulgaris***
   - **empty alginate beads of identical mass / size (if alginate beads do not have *C.vulgaris*)**
   - **pebbles / empty glass beads of identical mass / size**

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6. Risk and precaution: [Any 1]

| hazard | risk | mitigation |
|---|---|---|
| hydrogencarbonate indicator | irritant / allergy | gloves / goggles / mask / PPE / medication |
| alginate beads / *C. vulgaris* | irritant / allergy | gloves / goggles / mask / PPE / medication |
| heat (from bulb) | burns / injury | do not touch |

R: corrosive

7. Theory: [Any 2]

- **Increasing light intensity** (up to saturation point) will **increase rate of photosynthesis**, while beyond the light saturation point, rate of photosynthesis will plateau. (A: if no saturation point mentioned)
- **Higher** the **rate of photosynthesis**, **faster the change in pH / colour** (per unit time)
- Brief description of light-dependent stage of photosynthesis
- AVP – theory behind pH change

8. Table of results: **headings with units** + **closed table**

9. Graph: **appropriate axes** + **predicted trend** based on student's range of temperatures

10. Repeats: Carry out at least **2 more repeats** of the whole experiment to **check for reproducibility** of results

11. Appropriate sequence of steps: **sensible steps** + **appropriate volumes** [max of 250cm$^3$ of hydrogencarbonate used for 5 distances + 3 sets of data per distance]

12. Appropriate use of apparatus:
    [Compulsory point]
    - **Description of setup / appropriate diagram drawn to show setup** + [Any 2 below]
    - **light source**
    - **stopwatch**
    - **colorimeter / spectrophotometer**

    (R: thermostatically-controlled water bath unless set up show light source not blocked by the water bath – see photo below for how a thermostatically-controlled water bath looks like)

[Any 8 points]

**(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. [2]

1. It will **turn orange** / **yellow** OR **pH decreases**.
2. Due to aerobic **respiration**, which **produces carbon dioxide**.

**(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. 2.2.

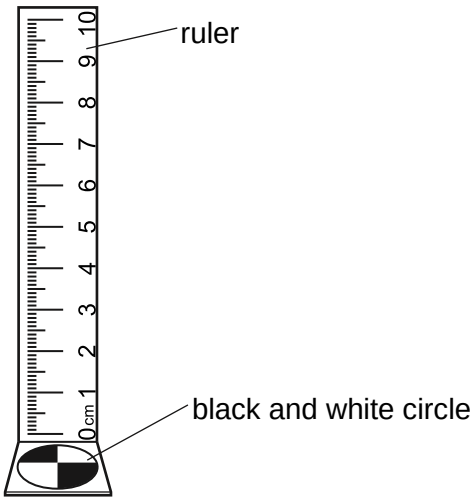


**Fig. 2.2**

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 2.3.

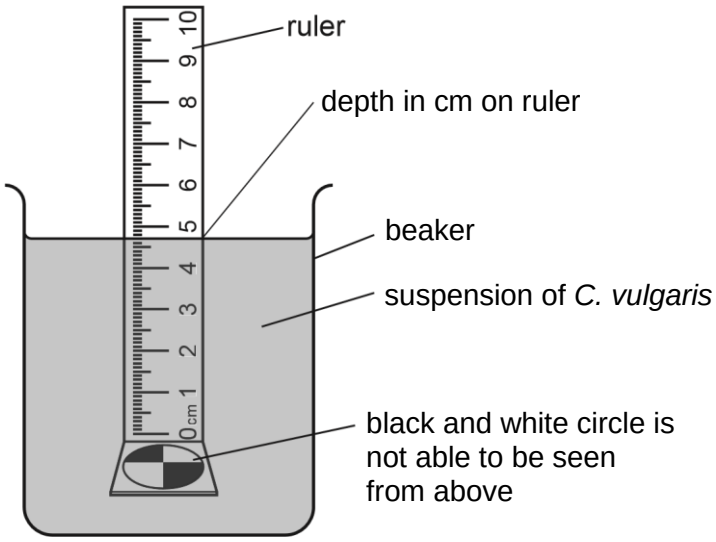


**Fig. 2.3**

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 2.4.

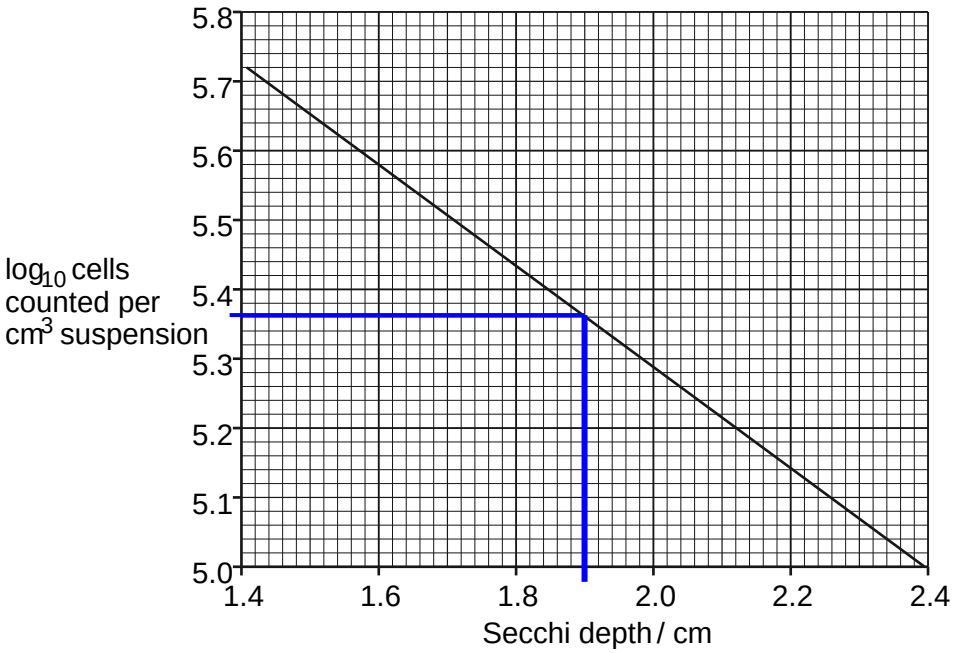


**Fig. 2.4**

**(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. 2.4, calculate the actual number of cells per $cm^3$ of suspension.

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

From graph log10 cells counted per cm3 suspension = 5.36,
1. $10^{5.36} = 229086$
2. = 229000 (nearest 1000 cells)

number of cells per $cm^3$ of suspension **229000** [2]

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

Fig. 2.5 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.

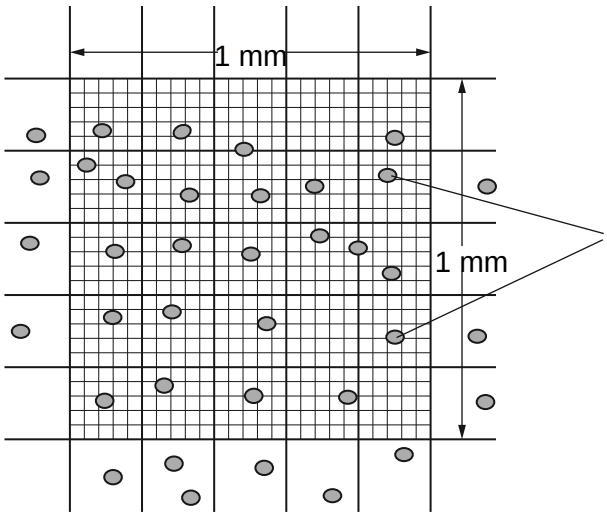


**Fig. 2.5**

**(ii)** Count the number of cells in the 1 mm · 1 mm section of the counting chamber shown in Fig. 2.5.

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

Show all your working.

1. correct number of cells counted = 24 in 0.1mm x 1mm x 1mm volume = 24 cells per 0.1 $mm^3$
2. correct calculation of number of cells per $cm^3$ = 24 x 10 x 1000 = **240000** ($1cm^3$ = $1000mm^3$)

number of cells per $cm^3$ of suspension **240000** [2]

**(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 **one** reason why using the Secchi stick is less accurate than using a counting chamber. [1]

1. subjective to determine when circle is no longer visible
2. error of ± 0.5 mm in the ruler
3. Secchi stick not held vertical
4. no replicates / no repeats of investigation / no mean calculated
5. *idea that* Secchi stick used is different / AW, from Secchi stick used for calibration curve
6. *idea that* inserting Secchi stick mixes / disturbs / AW, suspension

[Any one]

[Total: 18]

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**3** **L1** is a slide of a stained transverse section through a plant stem.

You are not expected to be familiar with this specimen.

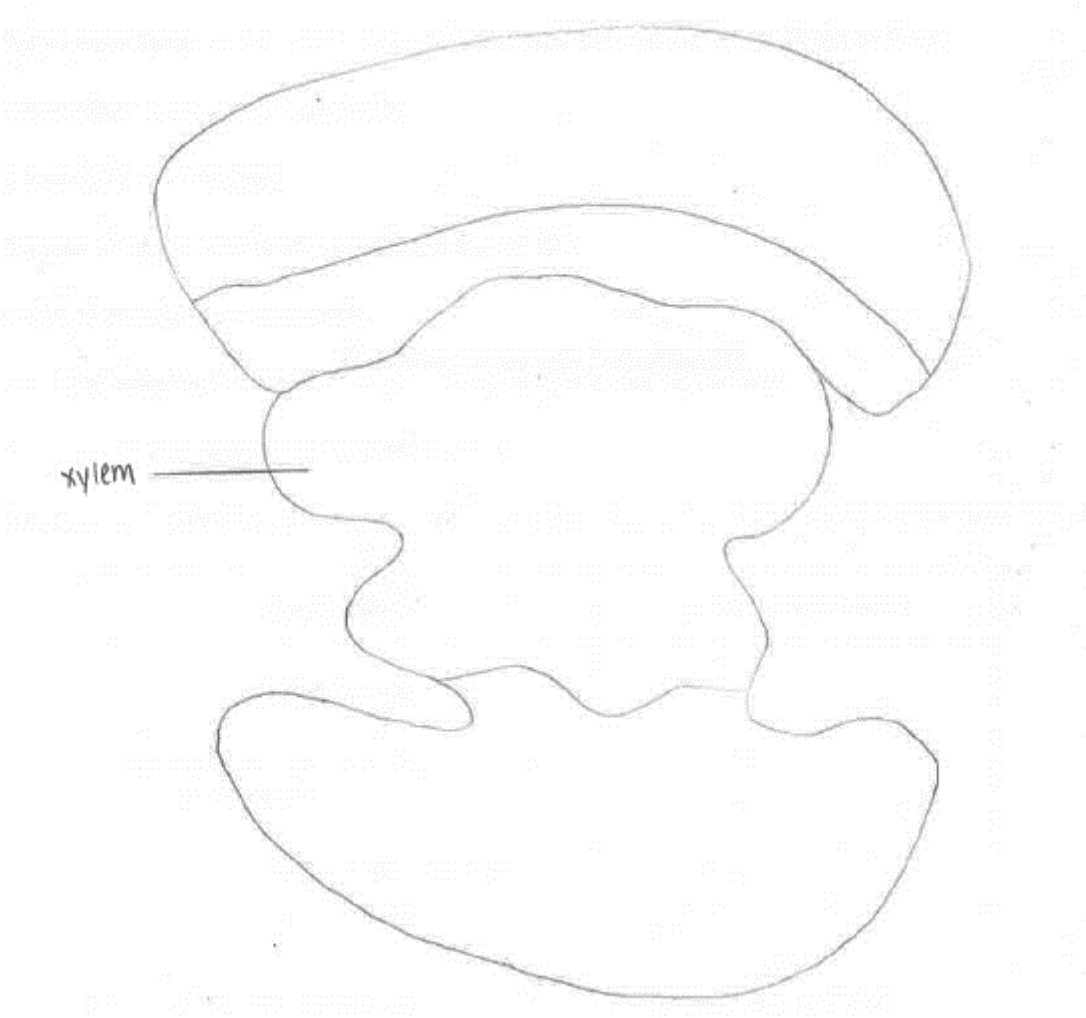
**(a)** Select a field of view so that you can observe a vascular bundle on **L1**.

Use a sharp pencil for drawing.

You are expected to draw the correct shape and proportions of the different tissues.

**(i)** Draw a large plan diagram of a vascular bundle on **L1**.

Use **one** ruled label line and label to identify the xylem.

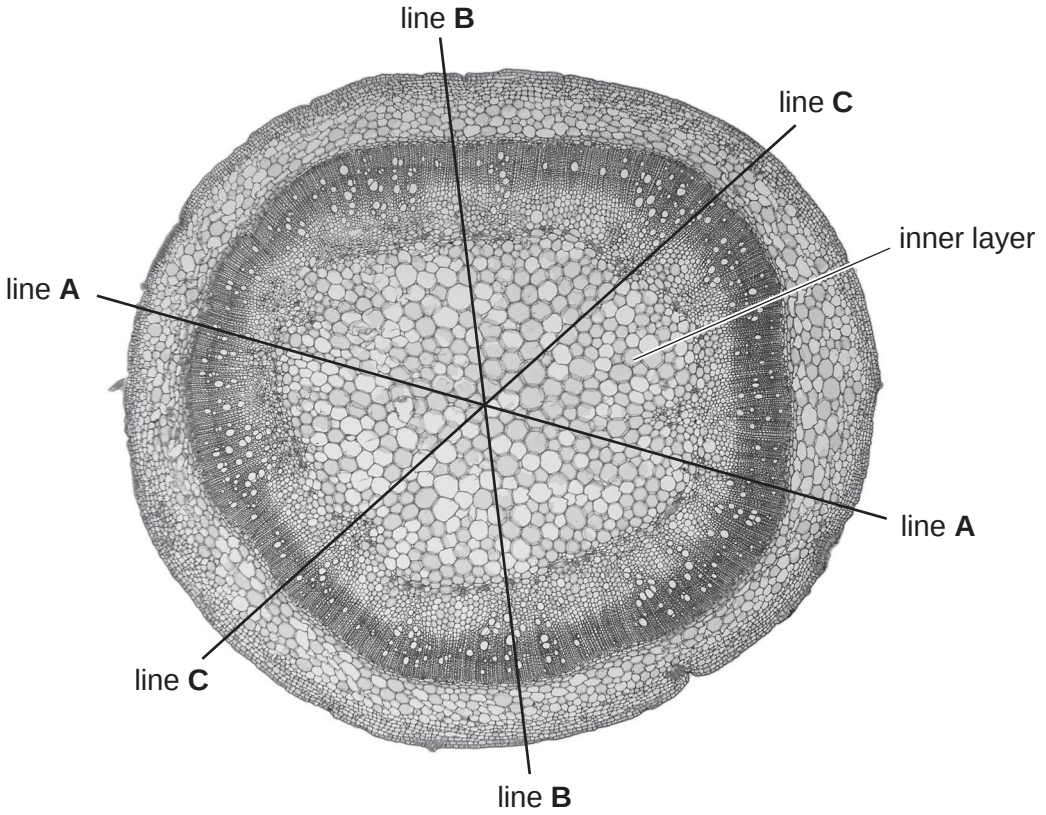



[5]

| | |
|---|---|
| **S** | **S**mooth, thin, sharp, continuous lines + no shading<br>**S**ize of drawing suitable |
| **D** | **D**raws vascular bundle **only** + no cells drawn |
| **P** | At least 4 layers/regions drawn as shown in mark scheme + **P**roportion of each layer/region accurately represented |
| **M** | **M**agnification calculated correctly (A: size of vascular bundle around 500 to 2000μm) |
| **L** | **L**abel line and label to xylem region correctly |

**(b)** Fig. 3.1 is a photomicrograph of a stained transverse section through a stem of a different type of plant.

You are not expected to be familiar with this specimen.




magnification ×32

**Fig. 3.1**

Use line **A**, line **B** and line **C** to determine:

- the mean actual diameter of the inner layer (pith).

Show all the steps in your working.

Diameter of inner layer [Any 1]

**58 mm** + **45 mm** + 47 mm = **150 mm**
**58 mm** + 46 mm + 47 mm = **151 mm**
**59 mm** + **45 mm** + 47 mm = **151 mm**
**59 mm** + 46 mm + 47 mm = **152 mm**

Mean actual diameter of inner layer [Any 1]

**150000 µm** / 3 / 32 = **1563 µm**
**151000 µm** / 3 / 32 = **1573 µm**
**152000 µm** / 3 / 32 = **1583 µm**
(A: correct answers to 3 s.f.)

1. **Total diameter of inner layer**
2. **Divide by 3 and 32**
3. **Final answer to nearest whole number** (A: to 3 s.f) **+ units as µm**

mean actual diameter of inner layer **1563 / 1573 / 1583 µm** [3]

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**(c)** Fig. 3.2 is a photomicrograph of the same stem section that is in Fig. 3.1.

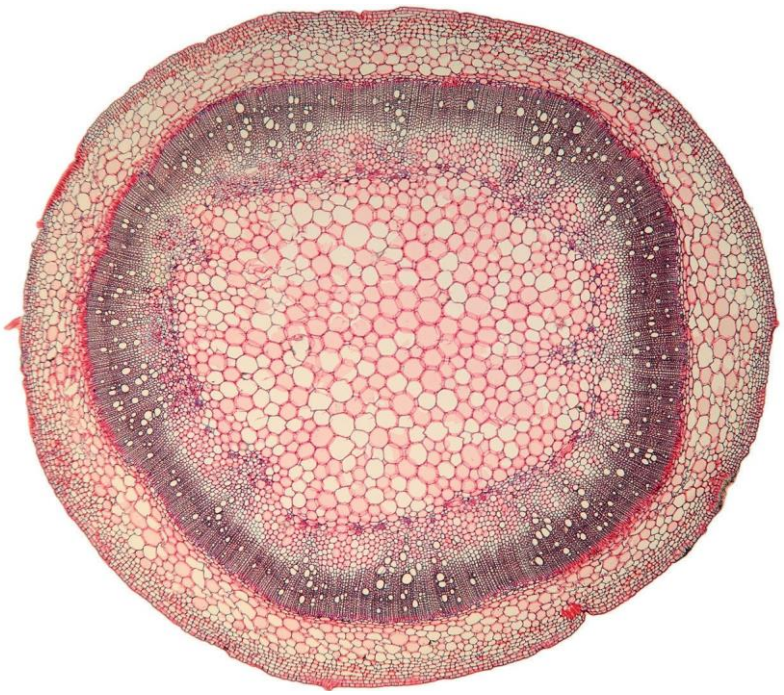

**Fig. 3.2**

Identify the observable differences between the stem section in Fig. 3.2 and the stem section on **L1**.

Record **two** observable differences in Table 3.1. [2]

**Table 3.1**

| feature | Fig. 3.2 | L1 |
|---|---|---|
| arrangement of vascular bundles | continuous | distinct<br>A: discontinuous |
| shape of stem | circular | irregular<br>R: flower, star, pentagon |
| cavity in pith/inner region<br><br>A: presence or absence of pith | absent<br>(no hollow pith)<br><br>present | present<br>(hollow pith)<br><br>absent |

R:
- comparison of number of vascular bundles
- comparison of size of stem / vascular bundles
- comparison of epidermis thickness

**(d)** In plants the growth regulator, auxin, is synthesised in the stem tip and moves away from the tip. The movement of auxin through plant tissues was investigated using bean seedlings as shown in Fig. 3.3.

The following procedure was used.

- Stems were cut into 60 mm lengths.
- Agar blocks containing radioactive auxin were placed on the apical surfaces of two groups of stem lengths.
- The basal ends of the stem lengths were placed on agar blocks without any auxin to provide support.

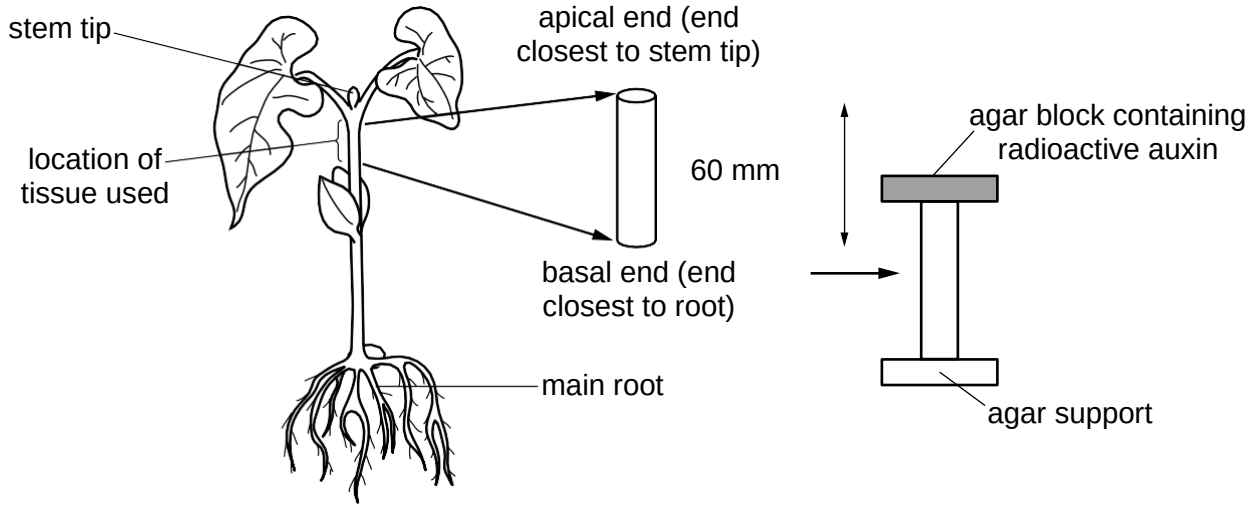


**Fig. 3.3**

- After 10 minutes the agar blocks at the apical ends were removed.
- One group of stem lengths was placed in air and the other group in an atmosphere of nitrogen.
- Both groups were left in light for 30 minutes after removing the agar blocks.
- The position of the radioactivity was located.

Fig. 3.4 shows the results of the investigation.

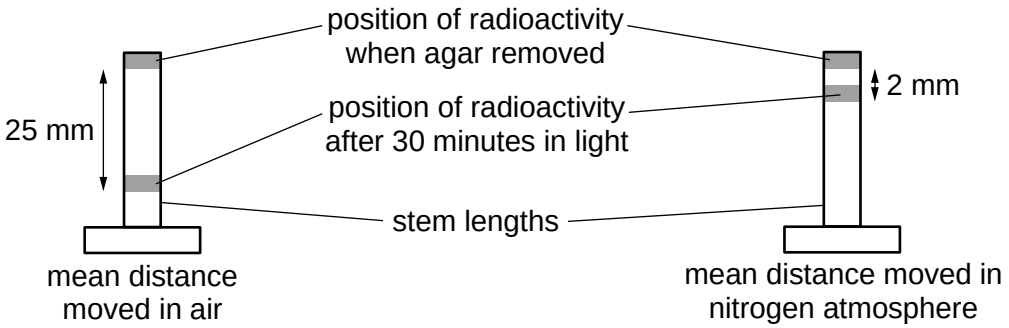


**Fig. 3.4**

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**(i)** Suggest **one** conclusion that can be made from these results. [1]

1. **oxygen / air** is required for the movement of auxin
   (A: rate of movement of auxin is faster in air than nitrogen / distance moved by auxin is faster in air than nitrogen)
2. **energy / ATP / respiration** is required for the movement of auxin
3. movement of auxin involves **active transport**

**(ii)** Calculate the rate in mm $h^{-1}$ of movement of auxin for the setup placed in air. [1]

1. 25mm/0.5h = 50mm$h^{-1}$ (must show working)

A similar investigation was carried out to test the hypothesis:

*The rate of movement of auxin will be faster in plants grown in the light than plants grown in the dark.*

Table 3.2 shows the results of this investigation.

**Table 3.2**

| **plants grown in light** | | | | | | | | | | **plants grown in the dark** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sample number | | | | | | | | | | sample number | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **rate of movement / mm $h^{-1}$** | | | | | | | | | | | | | | | | | | | |
| 56 | 61 | 66 | 52 | 50 | 68 | 76 | 51 | 55 | 64 | 45 | 52 | 42 | 35 | 55 | 38 | 32 | 37 | 45 | 51 |
| mean ± standard deviation *(s)* = 59.9 ± 8.5 | | | | | | | | | | mean ± standard deviation *(s)* = 43.2 ± 7.7 | | | | | | | | | |

**(iii)** Describe how the following evidence from Table 3.2 supports the hypothesis. [2]

mean — **mean rate of movement in light is faster** than that in **dark**;

standard deviation — **No overlap** in terms of using the range of values **within one standard deviation away from the mean**

(A: the lowest rate of movement of auxin for plants grown in light is 51.4 mm$h^{-1}$, which is still higher than the highest rate of auxin movement in plants grown in the dark of 50.9 mm$h^{-1}$)

**(iv)** A *t*-test was carried out to see if the difference in the rates of movement of auxin in plants grown in the light and plants grown in the dark was significant.

Suggest a null hypothesis for this statistical test. [1]

There is **no significant difference** in the rate of movement (of auxin) for, plants grown in light and (plants grown) in dark /between the 2 treatments. (R: insignificant / not significant difference)

**(v)** Explain how the student should use the value for *t* to find out if the difference in the rates of movement of auxin is significant. [2]

1. finding / using **degrees of freedom (df) = 18**;
2. from table of probabilities, **determine p-value based on degrees of freedom and calculated t-value**. (A: description of comparing p-value or t-value)
   A: compare the calculated t-value with the critical value at 5% significance level;
3. **Reject null hypothesis if p < 0.05** at 5% significance level (A: if calculated t-value is higher than critical value, reject null hypothesis).

[Any 2]

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