TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME

CIVICS GROUP

H2 BIOLOGY

Suggested Answers

9744/04

Practical Paper

22 Aug 2024

2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index 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 and graphs.
Do not use staples, paper clips, glue or correction fluid/tape.

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

The use of 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.

At the end of the practice, fasten all your work securely together.

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

Shift
Laboratory

For examiner's Use	
1	/ 22
2	/ 16
3	/ 17
Total	**/ 55**

Answer **all** questions.

1 Agar stained with universal indicator can be used to investigate diffusion.

When hydrochloric acid diffuses into the agar it changes the colour from grey to pink.

You will investigate the diffusion of different concentrations of hydrochloric acid in agar.

You are provided with the materials shown in Table 1.1.

Table 1.1

labelled	contents	hazard	volume / cm^3
H1	2.0 mol dm^{-3} hydrochloric acid	irritant	20
W	distilled water	None	30
-	2 Petri dishes containing agar	-	-
sheet T	sheet T	-	-

If **H1** comes into contact with your skin, wash off immediately with cold water.

It is recommended that you wear suitable eye protection.

You will need to:

- prepare different concentrations of hydrochloric acid, **H1 − H4**
- measure the diffusion distance for each concentration of hydrochloric acid **and** for an unknown concentration of hydrochloric acid, **U**.

You will need to carry out a **serial** dilution of the 2.0 mol dm^{-3} hydrochloric acid, **H1**, to reduce the concentration by **half** between each successive dilution.

You will need to prepare **three** concentrations of hydrochloric acid, **H2, H3** and **H4**, in addition to 2.0 mol dm^{-3} hydrochloric acid, **H1**.

After the serial dilution is completed, you will need to have 5 cm^3 of each concentration available to use.

(a) (i) Complete the table below to show how you will prepare your serial dilution. [3]

Solution	Concentration of hydrochloric acid / mol dm^{-3}	Solution to be diluted	Volume of solution to be diluted /cm^3	Volume of water /cm^3
H1	2.0	-	-	-
H2	**1.0**	**H1**	**5.0**	**5.0**
H3	**0.5**	**H2**	**5.0**	**5.0**
H4	**0.25**	**H3**	**5.0**	**5.0**

1. Correct concentrations: 1.0, 0.5, 0.25
2. Correct solutions to be diluted + volume of these solutions = 5.0cm^3 + volume of water to be added = 5.0cm^3
3. Volumes expressed to 1 d.p.

GENERAL COMMENTS:

Always take into account the precision of instruments used for measurements! Refer to practical 1 in JC1.

What is the precision of the 10cm^3 syringe that was used in this procedure?

……

1 Prepare the concentrations of hydrochloric acid, as decided in **(a)(i)**, in the beakers provided.

The different concentrations of hydrochloric acid will be put into wells cut into the agar.

The position of one well is shown in Fig. 1.1.

You need to decide where to put **four** more wells in the agar in each Petri dish so that the wells are positioned away from each other and away from the edge of the Petri dish. Hydrochloric acid will diffuse into the agar around each well.

(ii) Complete Fig. 1.1 by:

- drawing **four** small circles to show where you have decided the wells should be positioned in the agar
- labelling the **five** small circles in Fig. 1.1 with the concentrations of hydrochloric acid you prepared in step 1 **and** with a sample of unknown concentration of hydrochloric acid, **U**.

[1]

- draws four circles, with one in each quadrant, and labels each with the concentration of acid (not just H1, H2, H3, H4)

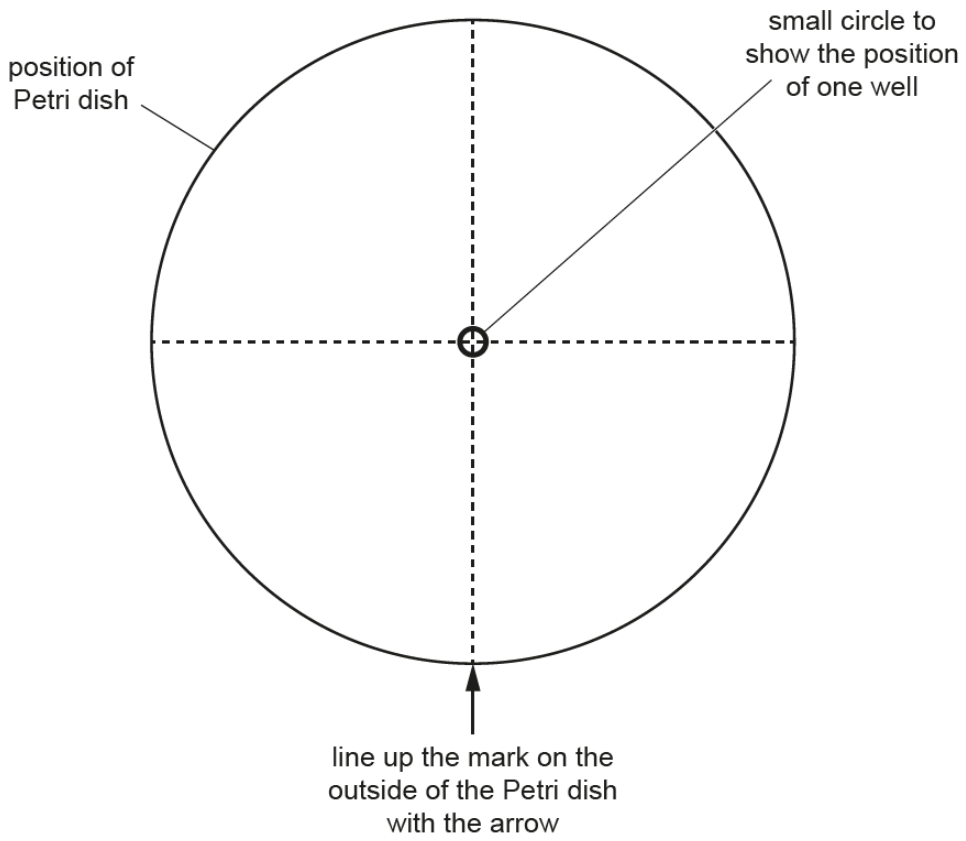


Fig. 1.1

Carry out steps **2** to **10**.

2 Draw a mark on the outside edge of the Petri dishes containing agar.

3 Put the Petri dish on Fig. 1.1 so that the mark on the edge of the Petri dish lines up with the arrow in Fig. 1.1. Keep the Petri dish in this position over Fig. 1.1 for the whole of step **4**.

4 Use a straw to cut wells in the agar at the positions of the small circles on Fig. 1.1:

- put the end of a straw on the surface of the agar over the centre small circle
- carefully push the straw into the agar
- lift up the straw to leave a well in the agar
- hold the straw over the container labelled **For waste**
- squeeze the straw gently to remove the agar from the end of the straw
- if the small circle of agar is **not** lifted by the straw, use a scalpel or mounted needle to carefully remove the agar and put it in the container labelled **For waste**.

5 Remove the Petri dish from Fig. 1.1 and place the Petri dish on the circle on **sheet T** so that the mark on the edge of the Petri dish lines up with the arrow.

6 With reference to Fig. 1.2, use a pipette to carefully fill the appropriate well in the agar with 2.0 mol dm^{-3} hydrochloric acid, **H1**, as labelled in Fig. 1.1.

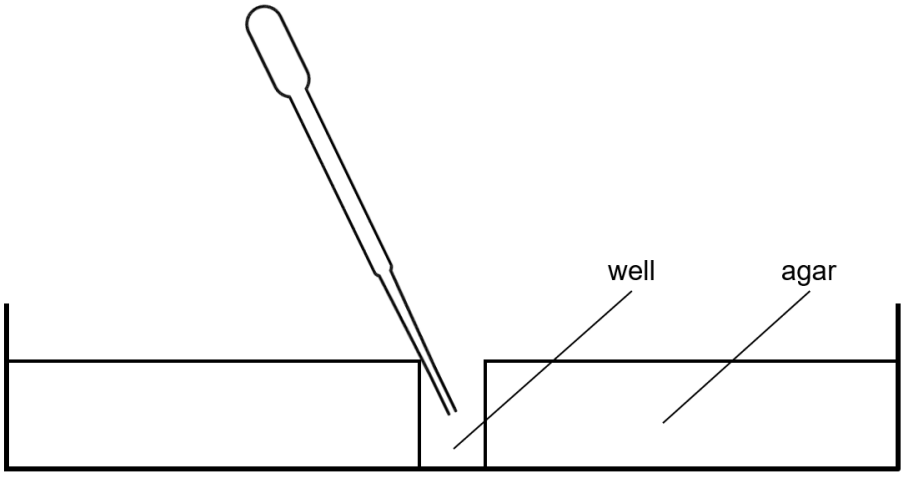


Fig. 1.2

7 Repeat step **6** for the other concentrations of hydrochloric acid labelled in Fig. 1.1.

Do **not** move the Petri dish after the wells have been filled with the hydrochloric acid.

8 Start timing.

Between step **8** and step **9**, you will be leaving the Petri dish on **sheet T** for 20 minutes.

Use this time to continue with other parts of Question **1**.

9 After leaving the Petri dish for 20 minutes, use a pipette to remove any remaining hydrochloric acid from all the wells in the Petri dish. Put this hydrochloric acid into the beaker labelled **For waste**.

10 Measure the diffusion distance, as shown in Fig. 1.3, for each concentration of hydrochloric acid and **U**.

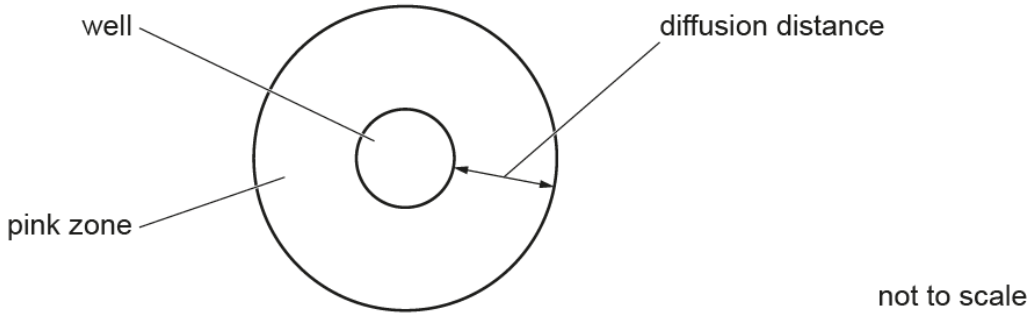


Fig. 1.3

11 Record your results in **(a)(iii)**.

(iii) Record your results in an appropriate table. [4]

Solution	Concentration of hydrochloric acid / mol dm^{-3}	Diffusion distance / mm
H1	2.0	9
H2	1.0	8
H3	0.5	7
H4	0.25	6
U	-	8

1. Heading for independent variable: concentration of hydrochloric acid / mol dm^{-3}
   +
   Heading for dependent variable: diffusion distance /mm

2. All 5 distances recorded + in whole mm / nearest 0.5mm consistently [Accept: cm]
   [Distance should be above 0mm, less than 11mm]

3. Correct trend with corresponding concentrations of HCl from 2.0 to 0.25 mol dm^{-3}

4. Distance of **U** falls between that of 0.5 to 1.0 mol dm^{-3} inclusive

(iv) Using your results in **(a)(iii)**, estimate the hydrochloric acid concentration of **U**. [1]
Correct concentration read off the results in the table [Accept: range of concentrations]

(v) Explain why the estimation in **(a)(iv)** may not be accurate **and** suggest how a more accurate estimation of **U** could be made from the results in **(a)(iii)**. [2]

- Only 4 concentrations to establish a trend.
- Use at least 5 concentrations to plot a more accurate trend.

- No replicates carried out.
- Calculate the average of 3 replicates for greater accuracy.

- *Idea that* the diffusion distance between two concentrations is not seen in the table.
- Plot a best-fit graph to estimate **U** from the graph.
  [Reject: use narrower intervals (since the distances are too close together)

- The diffusion distances around the wells are not equal / constant.
- Measure 3 diffusion distances around each well and calculate the average.

- The wells were filled with HCl for an unequal amount of time as the timer started only after the last well was filled.
- Stagger the filling of the wells so that diffusion occurred for an equal amount of time in each well.

- The distance moved by each HCl concentration is too close / similar.
- Allow diffusion to occur for a longer time e.g. 30 mins, on different plates for each concentration so that the zones do not overlap.

(vi) Calculate the ~~average~~ rate of diffusion for 2.0 mol dm^{-3} hydrochloric acid, **H1**.

Show your working and use appropriate units. [2]

1. Shows (distance for 2 mol dm^{-3}) divided by 20
2. Correct final value + units (mm min^{-1})
   Reject: distance expressed in m (the Petri dish is only 9cm/90mm!)

rate = ……

(vii) A student observed that the rate of diffusion was **not** constant during the investigation.

Suggest how the student could modify the procedure to investigate the change in the rate of diffusion. [2]

- Use one concentration of hydrochloric acid instead of 4.
- Record the diffusion distance for five time intervals e.g. 4, 8, 12, 16, 20 mins.
- *Idea that* Calculate the rate of diffusion for each time interval (by dividing the distance by the no. of minutes; mm min^{-1})

GENERAL COMMENTS:
Certain elements of the experiment should be kept the same:
- the diffusion of HCl in the **agar plate**
- overall timing of 20 mins

This question is **not** asking for an improvement in the procedure to estimate **U** in qn (v).

(b) A scientist studied the rate of absorption of the amino acid alanine through the wall of the small intestine.

A concentration gradient was maintained throughout the investigation and all other variables were kept constant.

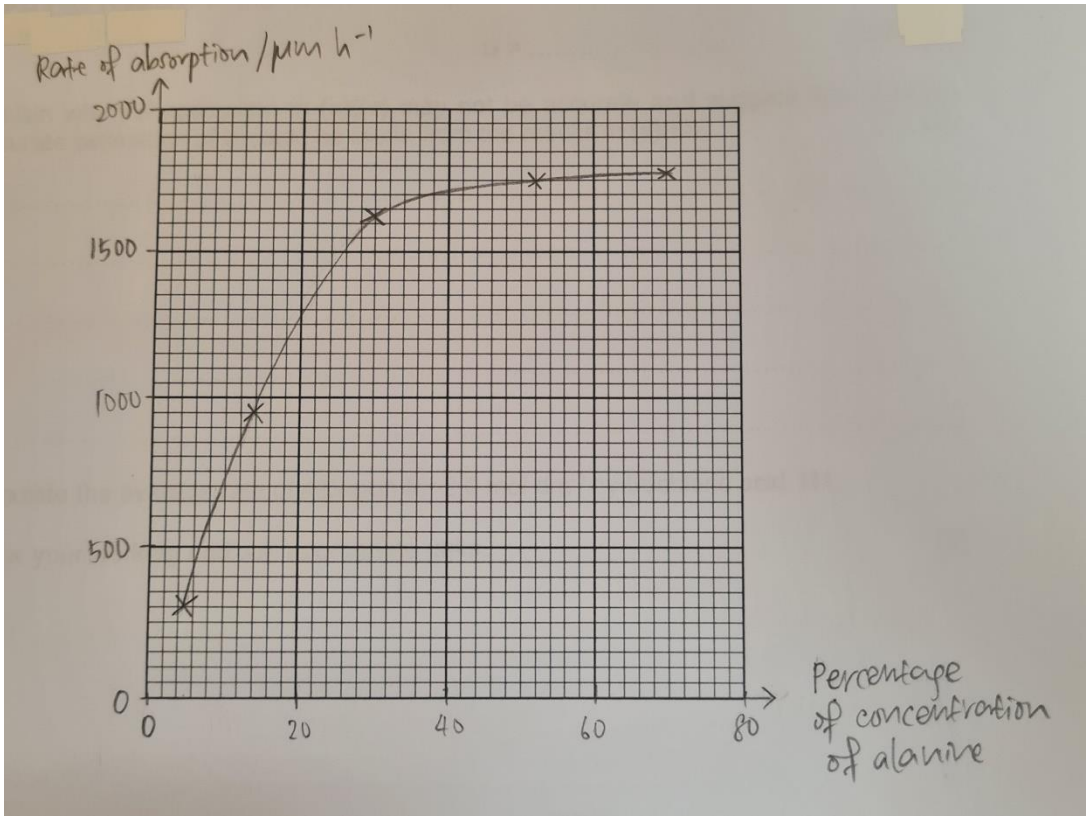
The results are shown in Table 1.2.

Table 1.2

percentage of concentration of alanine	rate of absorption / μm h^{-1}
5	300
14	950
30	1625
50	1750
70	1775

(i) Plot a graph of the data shown in Table 1.2 on the grid below.

Use a sharp pencil. [4]



1. label on *x*-axis: percentage concentration of alanine +
   label on *y*-axis: rate of absorption / μm h^{-1}
2. scale on *x*-axis: 20 to 2 cm, labelled at least every 2 cm +
   scale on *y*-axis: 500 to 2 cm, labelled at least every 2 cm
3. correct plotting of all five points using small crosses or dots in circles
4. five plots joined with thin line passing through all points and line is either a smooth curve or joined plot to plot

COMMON ERRORS:

- Using scales that do not allow for accurate plotting of data points
  e.g. 1 square = 40 μm h^{-1} → 950, 1625 will not be plotted accurately.
- Extrapolating the graph to zero → when is this allowed?

……

(ii) The transport of alanine does not use ATP.

Explain the shape of your graph drawn in the grid in **(b)(i)**. [3]

- The higher the concentration of alanine, the higher the rate of absorption.
- Due to steeper concentration gradient at higher concentration of alanine.
- Absorption occurs via carrier proteins / transport proteins that carry out **facilitated diffusion**.
- **[Compulsory]** The carrier proteins become **saturated at 50% concentration of alanine** and beyond, so rate of absorption plateaus / increases very gently.
  [Accept value between 50-70%]

COMMON ERRORS:

✗ *"Initially, the concentration gradient was steep."*

✓ **"Initially" refers to time. The x-axis is not time.**
The concentration gradient across the membrane was the least steep at low alanine concentrations! Gradient of the graph is not the concentation gradient.

✗ *"The graph starts to plateau because the concentration gradient reaches equilibrium."*

✓ **What would the rate of uptake be if there was equilibrium across the membrane?**

……

Additional advice: Please check your understanding of this concept in the 2023 A level Paper 2.

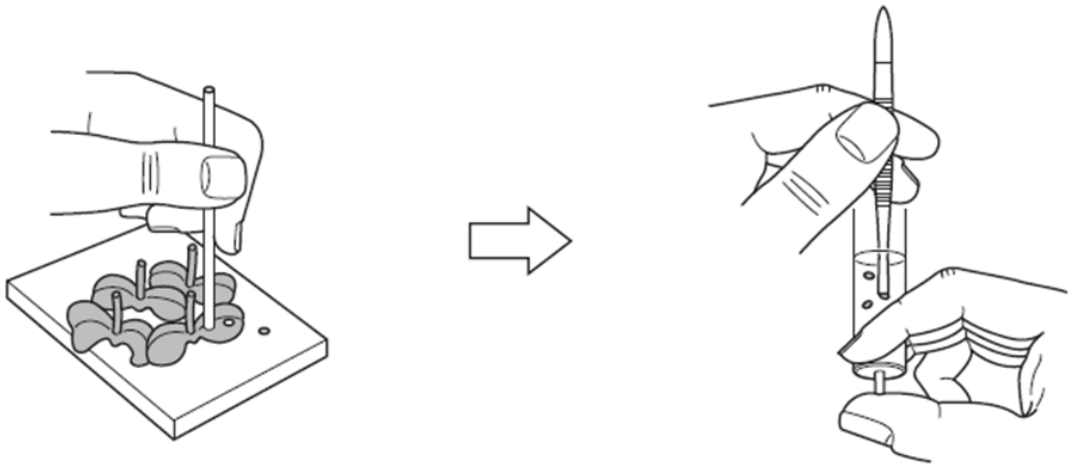
[Total: 22]

2 *Ficus insipida* is a tropical plant species which grows optimally at 30°C. The plant produces two types of leaves. One type is produced where the leaves develop in full sunlight and are called 'sun leaves'. The other type is produced where the leaves develop in the shade and are called 'shade leaves'.

The student would like to investigate the rate of photosynthesis of discs from both types of leaves to confirm the hypothesis that

Shade leaves have a higher rate of photosynthesis at lower light intensities than sun leaves.

The following steps show the preparation of leaf discs, which were used by the student in this investigation.



Step 1 Cut out leaf discs using a plastic straw.

Step 2 Use forceps to place six leaf discs into sodium hydrogen carbonate in a syringe barrel.

Fig. 2.1

Step 3 After replacing the plunger into the syringe, turn the syringe upside down and push in the plunger to force out all the air.

Step 4 place a finger over the open end of the syringe and pull down the plunger to create a vacuum to remove any air bubbles present in the leaf discs.

Step 5 repeat steps **3** and **4** until the leaf discs sink to the bottom of the syringe.

Fig. 2.2 shows the appearance of the leaf discs in sodium hydrogen carbonate solution as photosynthesis takes place.

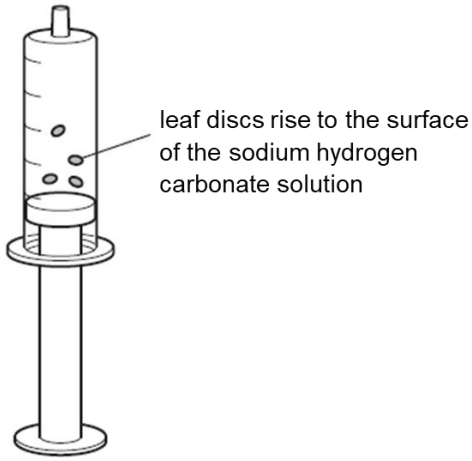


Fig. 2.2

(a) (i) Explain why the leaf discs rose to the surface in the presence of light. [1]

- **Oxygen is produced** during photosynthesis, which **decreases density / increase buoyancy** of leaf discs.

ERRORS:

✗ *The leaf discs rise to be closer to the light source to maximize light absorption.*

✓ **??**

The student carried out some preliminary experiments and found out that the maximum rate of photosynthesis is reached when 70% of light is transmitted.

Light intensity can be varied using neutral density filter sheets. The light transmission of these filter sheets is as follows:

Neutral density filter sheets	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Percentage of light transmitted	0	6	12	25	50	71	85	100

(ii) Use the information provided to plan a method by which the student could use to test the hypothesis.

Details of the preparation of the leaf discs are **not** required.

In addition to all standard laboratory equipment, you are also provided with:

- leaf discs from sun and shade leaves
- sodium hydrogen carbonate solution
- $12cm^3$ syringes
- neutral density filters sheets **A**-**H**
- tape
- bench lamp
- ruler
- stopwatch

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagrams, if necessary
- identify the independent variable, dependent variable and the variables that you will need to control
- use the correct technical and scientific terms
- indicate the results that you will need to collect to conclude if the hypothesis is true
- include any safety precautions to be taken.

You do **not** need to show **how** results will be analysed. [11]

1. Independent variable: light intensity **OR** percentage of light transmitted / % **[1]** (6,12,25,50,71%)
2. Dependent variable: time taken for leaf disc to rise to the surface **OR** start to rise / s **[1]**

3. Controlled variables: [**1m** for 2 identified variables]
   - concentration of sodium hydrogen carbonate *(use the same stock solution)*
   - volume of sodium hydrogen carbonate *(use syringe)*
   - diameter / size of leaf discs *(use the same plastic straw)*
   - number of leaf discs
   - distance of lamp from syringe *(use ruler)*

Method: [Max 7m]

4. Tape the neutral density filter sheet **B** around a syringe / on the bench lamp. **[1]**

5. Fill the syringe with 10 cm^3 [Accept 10-$12cm^3$] **[1]** of sodium hydrogen carbonate and 5 discs [Accept: 1] from shade leaves **[1]**.

6. Place the lamp 10 cm away [Accept 10-50cm] from the syringe. **[1]**

7. Switch on the lamp.

8. Start the stopwatch immediately. **[1]**
   Note: Acclimatisation at each light intensity is not suitable as discs may rise during this time.

9. Stop timing when leaf disc (the first disc **OR** the last disc) rises from the bottom of syringe / rise to the surface of the sodium hydrogen carbonate solution. **[1]**

10. Repeat steps 2 to 6 to obtain 3 replicates and calculate the average time taken for the discs to rise. **[1]**

11. Repeat the steps for the rest of neutral density filters (C, D, E, F) **[Reject: G, H]**, using fresh hydrogen carbonate solution for each measurement / same concentration of sodium hydrogen carbonate. **[1]**

12. Calculate the rate of photosynthesis using: rate of photosynthesis = $\frac{1}{\text{time taken for leaf disc to rise}}$ **[1]**

13. Repeat the entire experiment with leaf discs from sun leaves.

14. Set up a (negative) control using neutral density filter **A** to show that the discs rise due to photosynthesis occurring. **[1]**

15. Plot a graph of rate against % of light transmitted for sun and shade leaves to compare their rates to see if the hypothesis is true. **[1]**

Safety precaution

16. Sodium hydrogen carbonate is a skin / eye irritant. Wear goggles / gloves. **[1]**

ERRORS:

✗ *Independent variable: Type of natural filter.*

✓ **Isn't percentage of light transmitted more appropriate?**

✗ *Dependent variable: distance travelled by the leaf discs after a fixed time.*

✓ **You mean, the leaf disc will float and stop halfway??**

GENERAL COMMENTS:

- **You must refer to Fig. 2.2 when planning the experiment.**
  - ☐ **Some of you wanted to measure the amount of oxygen gas collected using a gas syringe.**
  - ☐ **Some of you wanted to measure the time taken for the leaf disc to sink (???????)**
  - ☐ **Some of you wanted to count the number of oxygen bubbles formed on the leaf discs.**

- **Almost all of you did not note that the rate of photosynthesis is already at the maximum at 70% light intensity. As a result, you continued to use Filter G and H.**

- **Many of you did not note that Filter A does not allow light to pass through, thus it should serve as a negative control. As a result, many of you went on to propose your own control.**

(b) The student wanted to further investigate the effect of temperature on the rate of photosynthesis of shade leaves.

He placed shade leaves in water and decided to use a hydrogencarbonate indicator solution to determine the pH in the sodium hydrogen carbonate solution after the shade leaves carried out photosynthesis at 15°C, 30°C, and 65°C.

Table 2.1 shows the colour range of the indicator. The indicator is red when at equilibrium with atmospheric carbon dioxide.

Table 2.1

acidic ←				→ alkaline
yellow	orange	red	magenta	purple

You are provided with three samples of water, **P**, **Q** and **R**. Each sample was taken from one of the three syringe barrels containing a shade leaf after exposure to the different temperatures.

You are also provided with hydrogencarbonate indicator, in a plastic vial labelled **G**.

You are required to identify the temperature at which the shade leaves were exposed to.

Proceed as follows:

1 Put 2 drops of **P** into a well on the spotting tile.

2 Put 2 drops of **G** (hydrogencarbonate indicator) into the same well on the spotting tile and observe the results.

3 Repeat steps **1** and **2** with the other two samples, **Q** and **R.**

(i) Complete Table 2.2 by recording the colour of the mixtures using only the names of colours shown in Table 2.1 **and** identify the temperature at which each shade leaf was exposed to. [2]

Table 2.2

sample	colour	temperature
P	**magenta**	**15 °C**
Q	**orange**	**65 °C**
R	**purple**	**30 °C**

1. Correct colours
2. Correct temperatures

(ii) Use your biological knowledge to explain how you identified the temperature that sample **Q** was subjected to. [2]

- **Enzymes were denatured** at 65°C, so **photosynthesis could not occur.**
- **No CO_2 taken up** from water for the Calvin cycle, so **solution remains acidic.**

ERRORS:

✗ *At 65℃, enzymes in photosynthesis is denatured. Respiration continues to produce CO_2.*

✓ **You mean 65°C selectively denatures only photosynthesis enzymes????**

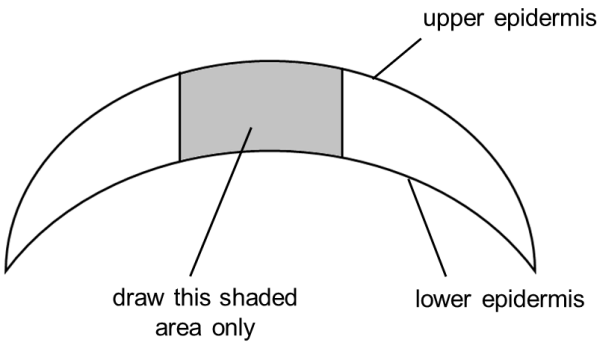
✗ *Photolysis of water releases H^+ that lowers pH (more acidic).*

✓ **The H^+ are kept WITHIN the chloroplast. It does not exit the plant cell into the water.**

[Total:16]

3 During this question you will require access to microscope and slide **L1**. **L1** is a slide of a stained transverse section through a plant leaf.

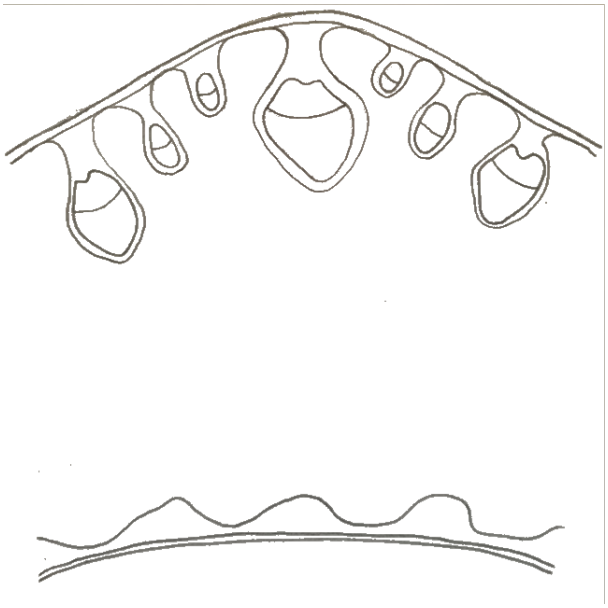
(a) (i) Draw a large plan diagram of the part of the leaf on slide **L1** shown by the shaded area.

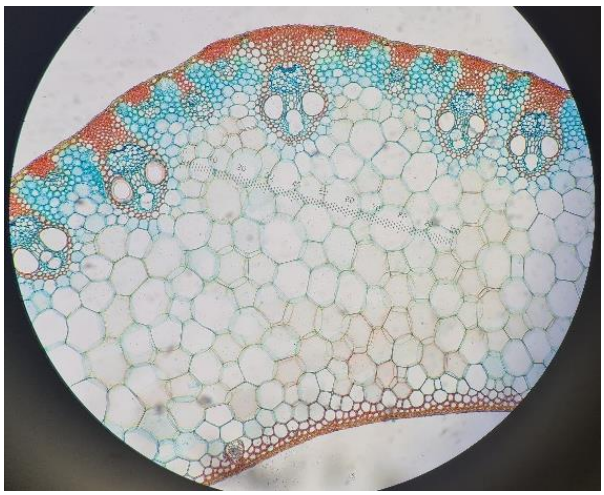


A plan diagram shows the arrangement of different tissues. Your drawing should show the correct shapes and proportions of the different tissues.

No cells should be drawn.

Labels are **not** required. [4]





1. Large drawing (most of the given area) **+** clear, smooth lines **+** No cells drawn
2. Correct overall shape **+** proportion of tissues (thin epidermal layers at the top and bottom, largest vascular bundles about 1/3 – 1/4 of leaf thickness
3. At least 3 layers of tissues (upper & lower epidermal layers, tissue above lower epidermis)
4. At least 2 large vascular bundles **+** 1 to 3 small vascular bundles in between
5. Each vascular bundle divided into 2 to 3 tissues

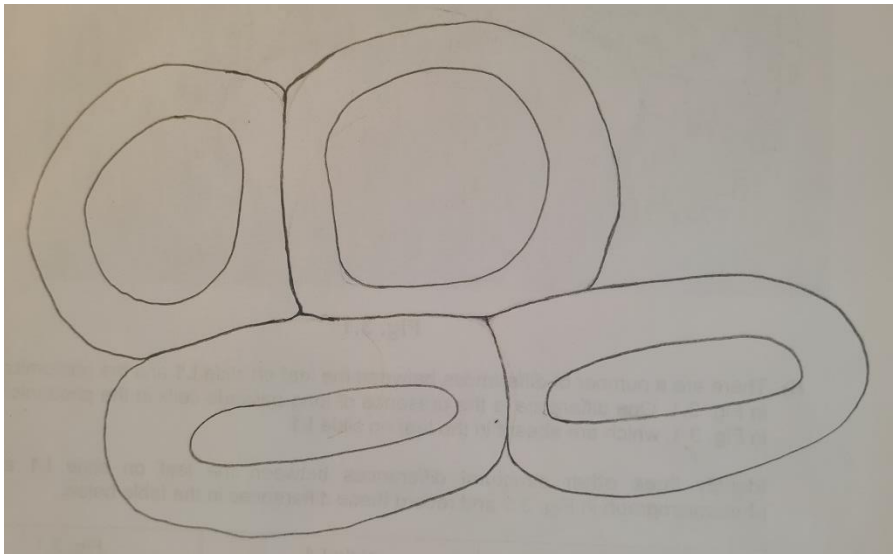
[any 4]

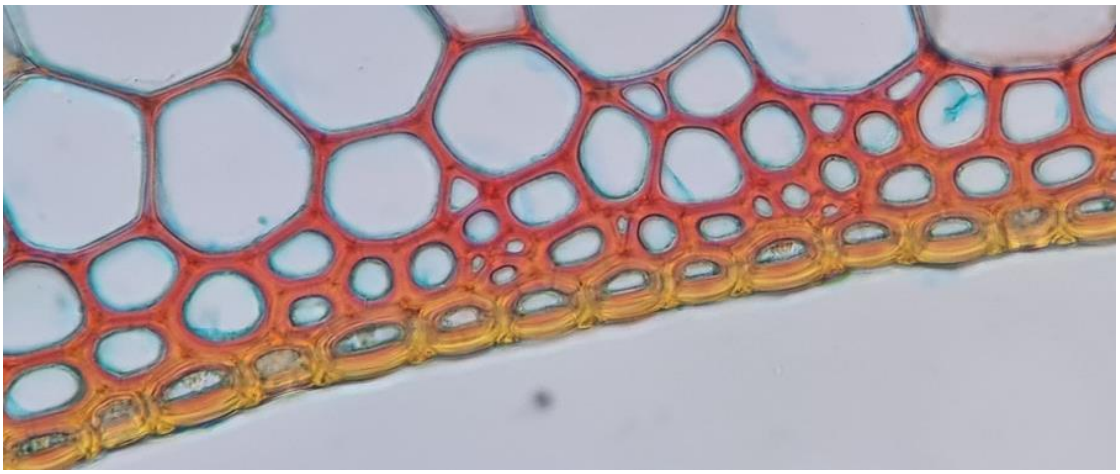
(ii) Observe the outermost layer of cells on the **lower** epidermis of the leaf on slide **L1**. Select a group of four touching cells comprising two cells from the outermost layer and two cells from the layer above the outermost layer.

Each cell must touch at least two other cells in the group.

Make a large drawing of this group of four touching cells.

Labels are **not** required. [3]





1. Large drawing (covers most of the given area) **+** clear, smooth lines
2. Correct shape (elongated) **+** no gap between cells **+** cells not overlapping
3. Correct proportions (Cell wall is as thick as or thicker than the cytoplasm)

(iii) Using high powered lens and the stage micrometer provided, measure the length of one of the cells that you have drawn in **(a)(ii)**. Show your working and express your answer to the nearest μm. [3]

1. Calibration of the eyepiece graticule using the stage micrometer
   100 eyepiece graticule divisions = 25 stage micrometer divisions **[accept: 23-27]**
   = 25 x 0.01mm
   = 0.25 mm
   = 250 μm

   1 eyepiece graticule division = 250 μm / 100
   = **2.5 μm**

2. Correct no. of eyepiece graticule divisions that cover the cell length **[between 5 to 13]**

3. Multiplying no. of divisions by length of 1 eyepiece division **+** to the nearest μm.

   Length of cell = no. of eyepiece divisions x 2.5 μm
   = ___ μm

length of one epidermal cell = …… μm

GENERAL COMMENTS:

- **At this point in time, MANY of you are STILL unable to perform calibration of the eyepiece graticule using the stage micrometer. When will you learn?**
- **When using the term "division", you need to be clear whether you are referring to the eyepiece graticule division or stage micrometer division.**

(b) Fig. 3.1 is a photomicrograph of a stained transverse section through a leaf of another plant.

You are not expected to be familiar with this specimen.

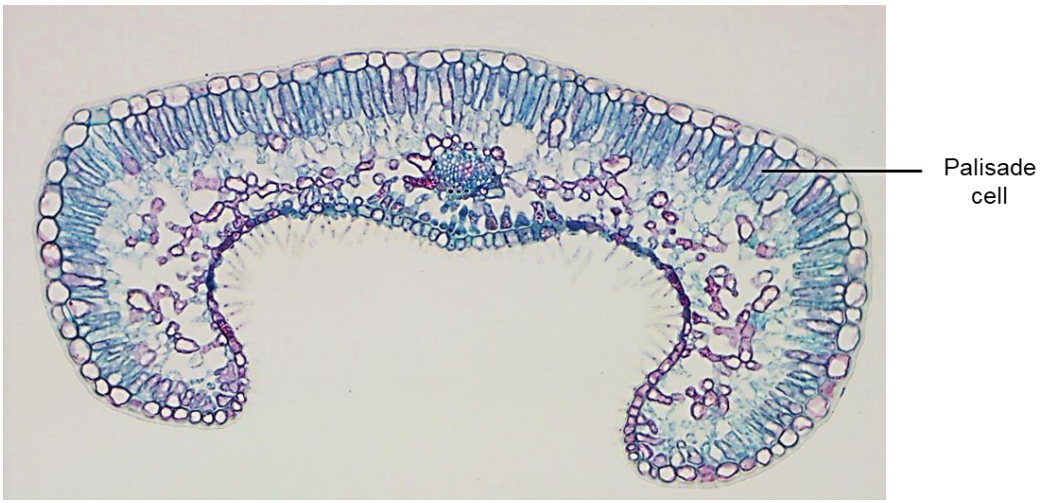


Fig. 3.1

(i) There are a number of differences between the leaf on slide **L1** and the photomicrograph in Fig. 3.1. One difference is the presence of long palisade cells in the photomicrograph in Fig. 3.1, which are absent in the leaf on slide **L1**.

Identify three **other** structural differences between the leaf on slide **L1** and the photomicrograph in Fig. 3.1 and record these differences in the table below. [3]

structural feature	slide **L1**	Fig. 3.1
Leaf shape	Leaf ends spread out	Leaf ends are rolled in
Number of vascular bundles	Many	One
Position of vascular bundles	Along / near the upper epidermis	In the middle of the leaf
Presence of air spaces	Absent	Present
Presence of hair-like structures	Absent	Present
Thickness of cell wall of epidermal cells	Thicker	Thinner
Presence of guard cells / stomata	Present (at the sides)	Absent
Thickness of epidermal layers	Upper and lower epidermis are of about the same thickness	Upper epidermis is thicker than the lower epidermis
Presence of guard cells / stomata	Present	Absent
AVP		

Reject: Shape of cells: Round vs round & long (long palisade cells are already mentioned)

COMMON ERRORS:

✗ *Comparing the size of cells / tissues between the two specimens.*

✓ **The size of slide L1 really depends on the magnification used. There is also no scale bar in Fig. 3.1. Any size comparisons should be made between tissues of the same specimen.**

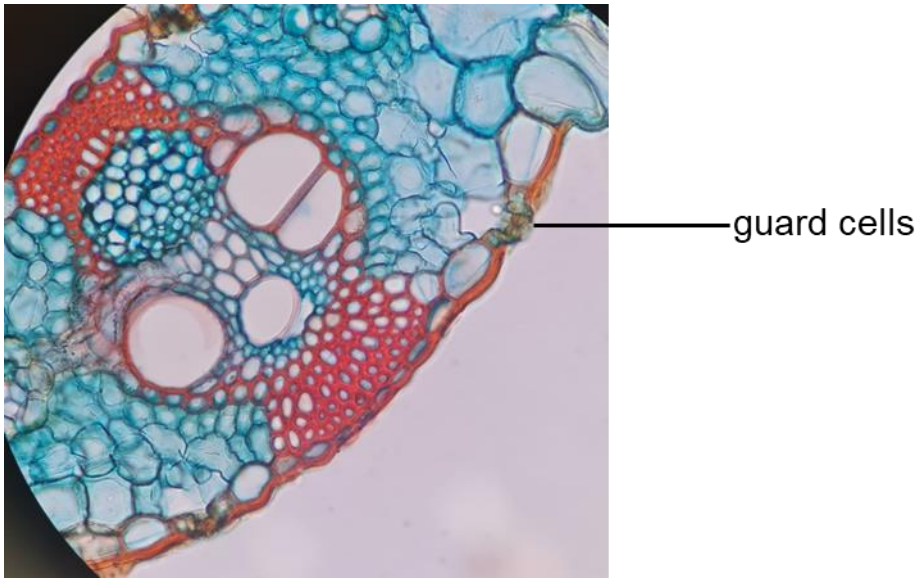


Fig. 3.2 is a photomicrograph of the same leaf section that is in Fig. 3.1.

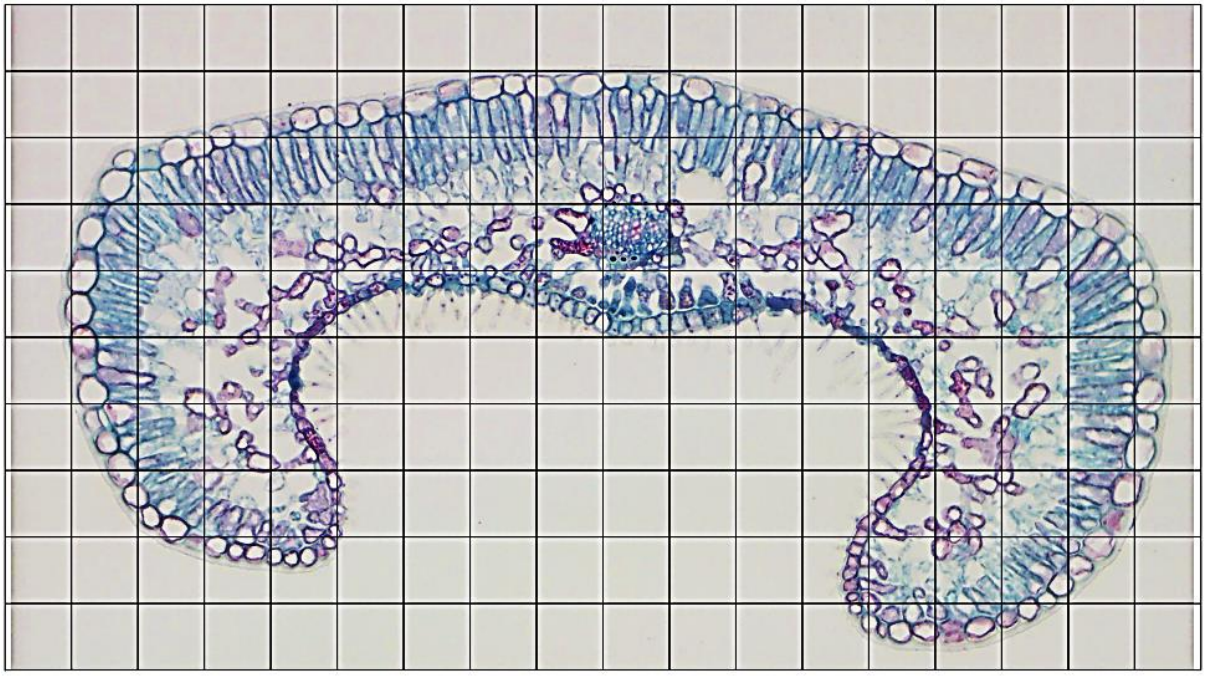


Fig. 3.2

You will need to use the grid to find the area of the palisade layer **and** the total area of the leaf section in Fig. 3.2.

Each square of the grid is 1 cm^2.

In some squares the palisade layer or the leaf section does not fill the whole square.

(ii) State the method you will use to decide which of these squares to include. [1]

- Count squares that are **at least half filled** with palisade cells.

(iii) State the area of the palisade layer and the total area of the leaf section in Fig. 3.2. [2]

area of palisade layer = **26 - 32** cm^2

total area of leaf section = **72 - 78** cm^2

(iv) Calculate the area of the palisade layer as a percentage of the total area of the leaf section. Show your working. [1]

- Area of palisade layer divided by total area of leaf section and multiplied by 100

[Total:17]