Suggested Answers

1 Plant tissues contain the enzyme catalase which catalyses the breakdown of hydrogen peroxide into oxygen gas and water.

Ascorbic acid acts as an **inhibitor** of catalase.

You will investigate the **effect of changing ascorbic acid concentration** on catalase inhibition.

You are provided with the materials shown in Table 1.1.

Table 1.1

labelled	contents	hazard	volume / cm^3
H	hydrogen peroxide solution	harmful irritant	50
W	distilled water	none	50
A	1 mol dm^{-3} ascorbic acid solution	irritant	10

If **H** or **A** comes into contact with your skin, wash off immediately under cold water.

It is recommended that you wear suitable eye protection.

You are also provided with five cylinders of potato tissue, labelled **P**.

(a) You will need to carry out a **serial dilution** of the 1moldm^{-3} ascorbic acid, **A**, to reduce the concentration by a **factor of ten** between each successive dilution.

You will need to prepare four concentrations of ascorbic acid in addition to the 1moldm^{-3} ascorbic acid solution, **A**.

After the serial dilution is completed, you will need to have 9cm^3 of each concentration available to use.

(i) Complete Table. 1.2 to show how you will prepare your **serial dilution**.

Table 1.2 shows the first two beakers you will use to make your serial dilution. You will need to complete **three** additional beakers.

For each beaker, state:

- the concentration of the ascorbic acid
- the concentration of the ascorbic acid transferred
- the volume of ascorbic acid solution transferred
- the volume of distilled water, **W**, added.

Table 1.2

Concentration of ascorbic acid / moldm^{-3}	Concentration of the ascorbic acid transferred / moldm^{-3}	volume of ascorbic acid solution transferred / cm^3	volume of distilled water, **W**, added / cm^3
1.0	1.0	10.0	0.0
0.1	1.0	1.0	9.0
0.01	**0.1**	**1.0**	**9.0**
0.001	**0.01**	**1.0**	**9.0**
0.0001	**0.001**	**1.0**	**9.0**

Mark Scheme:

1 correct concentrations (0.01, 0.001, 0.0001);
accept if student present in index form i.e. 1.0 x 10^{-2};
2 shows transfer of 1.0 (cm^3) to each beaker from the previous beaker;
3 shows 9.0 (cm^3) of water added to each beaker; [3]

Carry out step 1 to step 13.

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

2 Label test-tubes with the ascorbic acid concentrations prepared in step 1.

3 Label another test-tube **0**.

4 On a white tile carefully cut the cylinders of potato tissue into thin discs that are approximately 1–2mm thick.

You will need to cut at least 70 discs.

5 Place 10 potato discs into each labelled test-tube.

6 Add 1cm^3 distilled water, **W**, to the test-tube labelled **0.**

7 Add 1cm^3 of each concentration of ascorbic acid to the appropriately labelled test-tubes.

8 Set up the apparatus as shown in Fig. 1.1 using the test-tube labelled **0**. The syringe barrel should be fully submerged in the beaker of water, **B**.

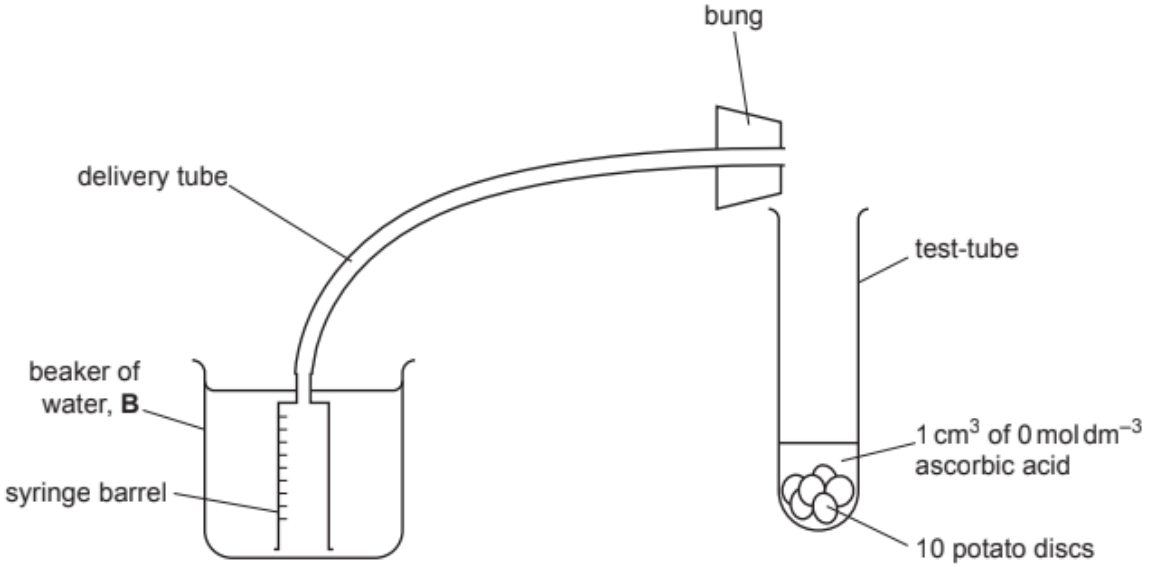


Fig 1.1

9 Add 5cm^3 of hydrogen peroxide solution **H** to the test-tube labelled **0**. Place the bung into the top of the test-tube, making sure that the syringe barrel stays fully submerged.

10 Record in **(a)(ii)** the initial volume of gas in the syringe barrel then start the stop-watch.

11 After 2 minutes record in **(a)(ii)** the **final volume** of gas in the syringe barrel. If the syringe barrel is full of gas, record as 10.

12 Repeat step 9 to step 11 with each of the test-tubes labelled in step 2.

13 Calculate the **total volume** of gas produced at each concentration of ascorbic acid. Record these processed results i

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

Concentration of ascorbic acid / moldm^{-3}	volume of gas in the syringe barrel / cm^3		
	initial	final	total
1.0	0.0	1.3	1.3
0.1	0.0	4.4	4.4
0.01	0.0	5.2	5.2
0.001	0.0	6.0	6.0
0.0001	0.0	7.7	7.7
0	0.0	9.0	9.0

Mark scheme:

1 heading for independent variable: ascorbic acid concentration / moldm^{-3} (before heading for dependent variable) and no units in body of table;

2 heading dependent variable: volume / cm^3 and no units in body of table;

3 results for all concentrations;

4 trend: volume of gas recorded for the lowest concentration of ascorbic acid greater than for the highest concentration of ascorbic acid;

5 results recorded to an appropriate degree of accuracy, i.e. 1 d.p. ;

6 correct calculation of total volume of gas produced; [6]

(iii) Use your results in **(a)(ii)** to identify the **greatest** volume of gas produced in the reaction.

greatest volume of gas produced = ...

Use your answer to calculate the **rate** of gas production.
Show your working.

Mark scheme:

1 selects greatest volume from results in (a)(ii);
2 calculates correct rate of gas production;

rate of gas production = volume in cm^3 / 2 mins

rate of gas production = ... cm^3min^{-1}

[2]

(iv) Describe two improvements to the procedure that would make the measurements more accurate.

1 **Repeat the experiment multiple times to identify any anomalous results and to calculate a more reliable mean value;**

2 **Use a potato slicer / mandolin to cut and standardise the size of the potato discs, ensuring they are all uniform in size to reduce variability in the results;**

3 **Standardise the time interval between adding hydrogen peroxide to the test tube and sealing it with a bung, ensuring consistent reaction conditions across all trials;**

4 **Use a syringe with smaller divisions to ensure more precise measurement of liquids;** [2]

Any 2

Carry out step 14 to step 18.

14 Label a test-tube **T**.

15 Put 5cm3 of H into test-tube **T**.

16 Use a thermometer to measure the temperature of **H** in test-tube **T**. Record this value, to the nearest 0.5°C, in **(b)(i)**.

17 Add 10 discs of potato tissue to test-tube **T** and start timing.

18 After 2 minutes measure the temperature of the mixture in test-tube **T**. Record this value, to the nearest 0.5°C, in **(b)(i)**.

(b) **(i)** State the temperature of **H before** adding potato discs (step 16).

30.0

..... °C

State the temperature of **H** 2 minutes **after** adding potato discs (step 18).

31.0

..... °C

Calculate the **change** in temperature after 2 minutes.

1.0

..... °C

1 temperatures recorded to 0.5 °C ;

2 records the correct rise / fall in temperature ; [2]

(ii) **State** whether temperature is a significant source of error in this investigation.

Explain your answer.

yes, rate of reaction is affected by change in temperature

because for every 10°C increase in temperature, rate of catalase activity doubles;

OR **no, rate of reaction is not affected by change in temperature**

because there is no change in temperature/ small change / quote fig from b(i) after 2 mins suggesting there reaction is neither exothermic or endothermic; [1]

(c) A study was carried out in which volunteers were given different daily doses of ascorbic acid (vitamin C) in addition to their normal diet. The maximum ascorbic acid concentration in the blood plasma of each volunteer was measured.

The results are shown in Table 1.3.

Table 1.3

ascorbic acid daily dose / mg	maximum ascorbic acid concentration in blood plasma / μmol dm^{-3}
0	6
50	25
200	68
500	75
1000	75

(i) Plot a graph of the data in Table 1.3 on the grid in Fig. 1.2.

Use a sharp pencil.

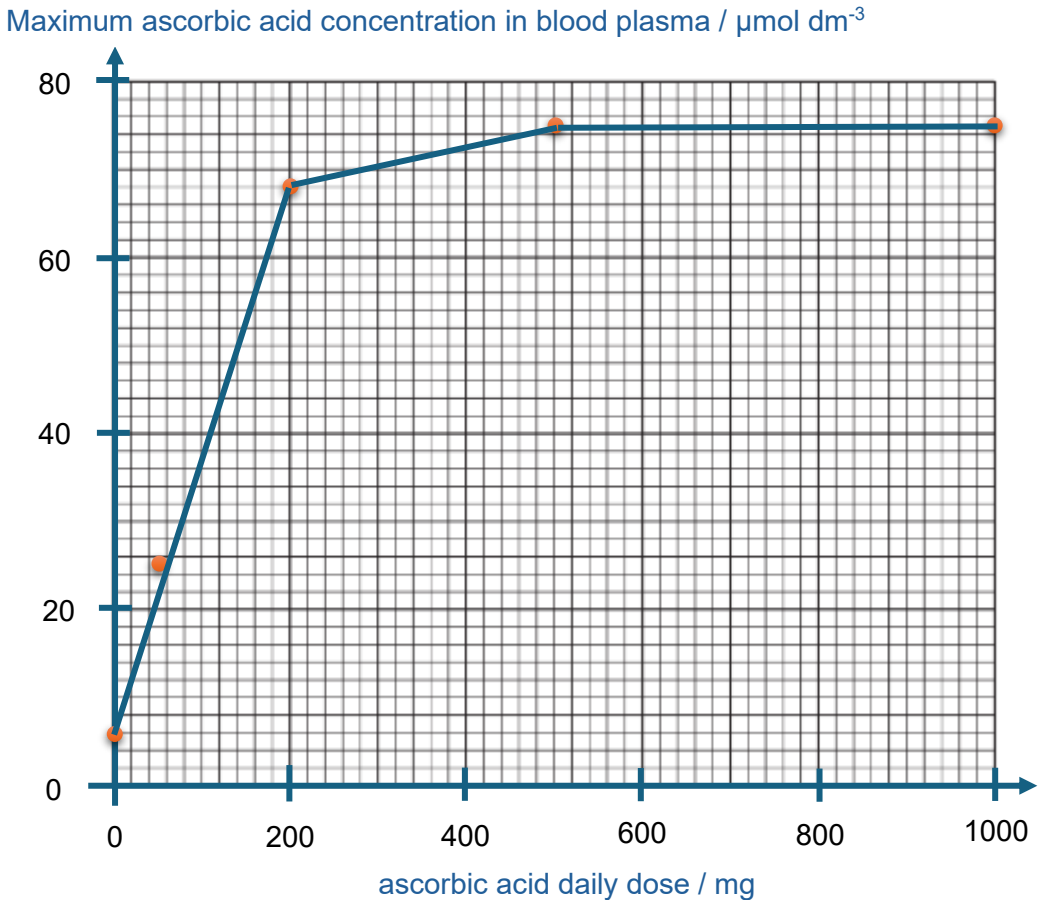


Fig. 1.3

Marking points:

1 **1 x-axis: ascorbic acid daily dose / mg**
and
y-axis: maximum ascorbic acid concentration in blood plasma / µmol dm^{-3};

2 **scale on x-axis: 200 mg to 2 cm and labelled at least every 2 cm**
and
scale on y-axis: 20 µmol dm^{-3} to 2 cm and labelled at least every 2 cm ;

3 **correct plotting of all five points using small crosses or dots in circles ;**

4 **4 five plots joined with thin line passing through all points;** [4]

(ii) Suggest an **explanation** for the results for a **daily dose of 0mg** and the results for daily doses of **between 500–1000mg**.

1 **some ascorbic acid is already present in blood**

as obtained from other foods in the diet / produced by the body ;

2 **maximum rate of absorption (75 umol dm^{-3}) is reached at a dose of 500 mg / day**

so the concentration does not increase with higher doses [2]

[Total: 22]

2 A group of students investigated two habitats: dense woodland and open grassland.

- Trees are the dominant plants in woodland. The trees form a canopy under which flowering herbs, small shrubs and grasses grow.
- Grasses are the dominant plants in grassland. The grasses and small flowering plants form a continuous ground cover with only a few small shrubs present.

Fig. 2.1 shows photographs of the two areas.

Fig. 2.1

The students decided to compare the adaptations for reducing water loss in the plants growing in each area.

The students suggested the following hypothesis:

*The **density of stomata** will be **higher in plants found in the woodland habitat** than in the grassland habitat.*

(a) **(i)** State the independent and dependent variables in this investigation.

Independent variable:
(type of) habitat / woodland versus grassland habitats;

Dependent variable: **density / number of stomata;** [2]

The students collected leaves from a number of different plant species in each area. To study the density of stomata on leaves, impressions of the epidermis can be made using clear varnish.

- One surface of each leaf is painted with a thin layer of varnish.
- The varnish is left to dry.
- Clear sticky tape is applied to the leaf over the varnished area, to make a leaf impression.
- The tape and varnish are removed and stuck to a microscope slide.
- The leaf impression on the slide is viewed using a microscope.

Fig. 2.2 shows the microscope image of one leaf impression prepared in this way.

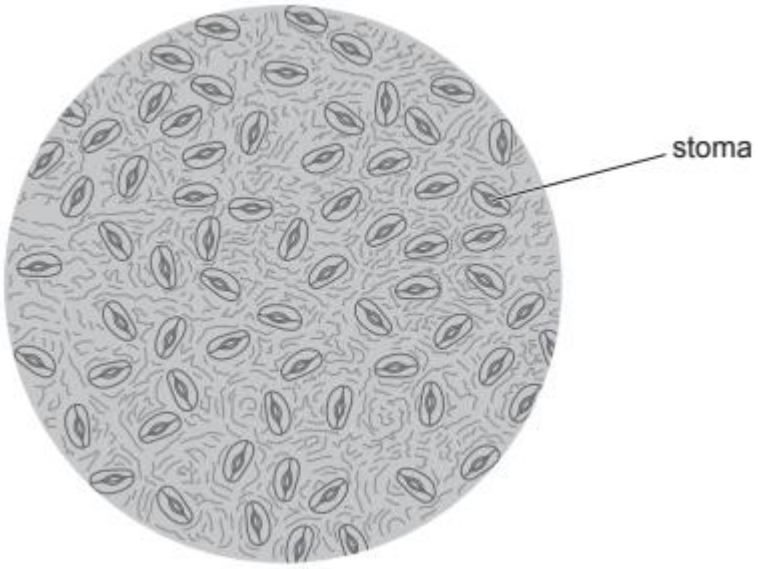


Fig. 2.2

(ii) State the measurements that the students need to make to determine the stomatal density in Fig. 1.2.

1 **Radius / diameter (of field of view / image / circle / Fig 1.2);**

Reject: diameter / radius / area of leaf or leaf impression

2 **number of stomata;** [2]

(iii) Calculate the stomatal density in Fig. 2.2.

Space for working.

2 marks for density range:
0.014–0.019 (calculation of stomatal density must be correct);

if outside this range one mark for:

stomatal number:
61 (full) – 69 (all);

Working:

Stomatal density
= total number of stomata in field of view ÷ area of field of view
= 69 ÷ [3.142 × $(37.5)^2$]
= 69 ÷ 4418.44
= 0.0156 mm^{-2}

stomatal density = ... mm^{-2}

[2]

(iv) Describe how the students could **gather data** to **compare the stomatal density of plants growing in the woodland and the grassland habitat**.

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

You should not repeat details of the method for making the leaf impressions.

---

any six ideas from:

1 ref. to method of, random / systematic sampling of plants ;
2 (take leaves) from same species, that is present in both habitats ;
3 collect a minimum of 5 leaf samples (in both habitats) ;
4 same position / age, of leaf (on plant) ;
5 impressions to be taken from, lower / upper / both / same, surface(s) (of leaves) ;
6 (impressions viewed using) same, magnification / lens / size of field of view ;
7 count stomata (in field of view) ;
8 details of systematic counting / count only whole stomata / take a photograph and mark ;
9 repeat, (same) experiment (both habitats) minimum of twice, and calculate a mean ;
10 safety: hazard and risk and mitigation;

Suggested answers for phrasing:

1. **Use a random or systematic sampling method to select plants from both the woodland and grassland habitats**

   to ensure unbiased data collection.

2. **Select leaves from the same species that is present in both habitats**

   to maintain consistency in the type of plant being studied;

3. **Collect a minimum of five leaf samples from each habitat**

   to ensure a representative sample size.

4. **Ensure the leaves are taken from the same position and of the same age on each plant**

   to minimize variability due to leaf maturity or position.

5. **Take impressions from the same surface (either lower, upper, or both) of each leaf**

   to standardize the area being studied.

6. **View the impressions under a microscope using the same magnification, lens, and size of the field of view**

   to ensure consistent measurement conditions.

7. **Count the stomata in the field of view**

   for each leaf impression.

8. **Use a systematic counting method, such as counting only whole stomata or taking a photograph and marking each stoma,**

   to ensure accuracy in the counts.

9. **Repeat the experiment at least twice for both habitats**

   and calculate the mean stomatal density for each habitat to obtain reliable data.

10. **Address safety by identifying potential hazards, assessing risks, and implementing measures**

    to mitigate them, such as wearing gloves to handle leaves and ensuring proper microscope usage [6]

(b) The students found a published investigation on the effect of light intensity on stomatal density in the species *Lycopersicon esculentum*.

Two plants of *Lycopersicon esculentum* were selected. One was grown in high light intensity and the other was grown in low light intensity.

The results are shown in Table 2.1.

leaf number	high light intensity			low light intensity		
	number of stomata $\times 10^3$		leaf area / cm^2	number of stomata $\times 10^3$		leaf area / cm^2
	upper surface	lower surface		upper surface	lower surface	
1	1634	3131	496	18	1277	160
2	1482	5072	509	10	906	115
3	1865	6365	637	14	1398	171
mean	1660	4856	547	14	1194	149

(i) Calculate the **percentage decrease in mean leaf area** for leaves grown in **low light intensity compared with those grown in high light intensity**.

Your answer should be expressed as a whole number.

percentage decrease in mean leaf area
= (547 – 149) / 547 × 100%
= 73%

..... %

[1]

(ii) The scientists who carried out the published investigation concluded that:

*plants grown in **higher light intensity** have **higher stomatal density** **only** on the **upper surface** of the leaves compared to plants grown in lower light intensity.*

Evaluate whether or not the data in Table 1.1 **supports this conclusion.**

Stomatal density
= total number of stomata in field of view ÷ leaf area

For full credit, candidate should have a balanced evaluation.

support – max 2 marks:

1 **stomatal density on upper surface is higher in plants grown in high light intensity;**

2 **difference in (mean) stomatal density on upper surface (between the two light intensities) is greater than**

the difference between the lower surfaces;

3 **stomatal density on lower surface is similar / very close;**

---

4 stomatal density on lower surface of leaf 1 is less than stomatal density of plants grown in low light intensity;

5 calculate pair of stomatal densities (for 1 to 4);

Do not support – max 2 marks:

1 mean stomatal density, on lower / both, surface(s) is higher in plants grown in high light intensity;

2 for 2 out of 3 leaves / leaves 2 and 3, stomatal density is not higher only on the upper surface / is higher on lower / both surface(s);

3 calculate pair of stomatal densities (for 6 / 7); ecf

4 no statistical analysis done;

5 10 data only, for one species / *L. esculentum*;

[3]

[Total: 16]

3 **K1** is a slide of a stained transverse section through a plant stem.

(a) **(i)** Draw a large plan diagram of the region of the stem on **K1** indicated by the shaded region in Fig. 3.1. Use a sharp pencil.

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

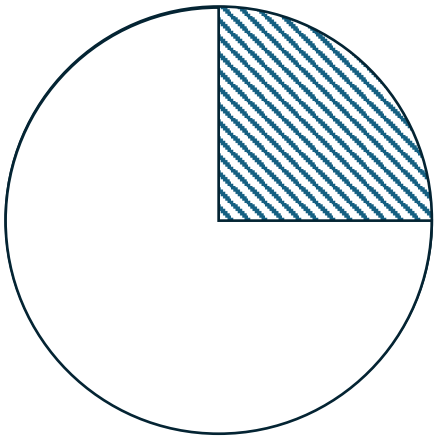
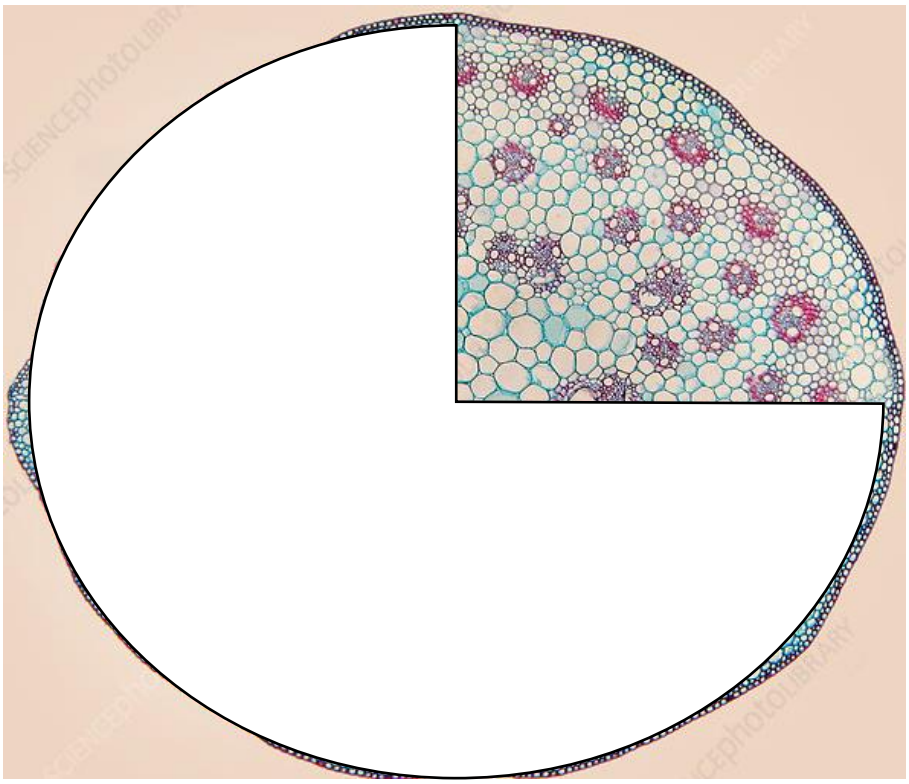


Fig 3.1



1 **minimum size and no shading and correct section of the stem drawn and no cells drawn ;**

2 **draws a layer of vascular bundles under the epidermis ;**

3 **correct position of vascular tissue;**

4 **label line and label to epidermis ;**

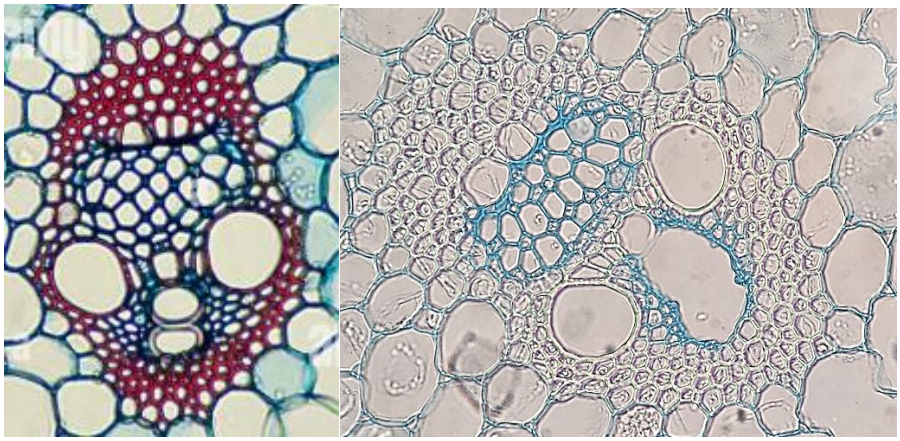
[4]

(ii) Observe one of the larger vascular bundles of the section on **K1**.

Select a group of **four** adjacent xylem vessel elements.

Each xylem vessel element must touch at least **two** other xylem vessel elements.

- Make a large drawing of this group of four xylem vessel elements.
- Use **one** ruled label line and label to identify the wall of **one** xylem vessel element.



1 minimum size and all lines sharp and continuous;

must draw xylem, if whole vascular bundle is drawn, no credit is awarded

2 draws four whole xylem vessel elements and each xylem vessel element touches at least two other xylem vessel elements;

3 two lines around each xylem vessel element and three lines where xylem vessel elements touch;

4 correct shape of xylem vessel elements;

Not just rectangular or square shape, it's slightly elongated and hexagon

***5* label line and label to one xylem vessel element wall;**

[5]

(b) Fig. 3.2 shows a diagram of a stage micrometer scale that is being used to calibrate an eyepiece graticule.

The length of one division on this stage micrometer is 1mm.

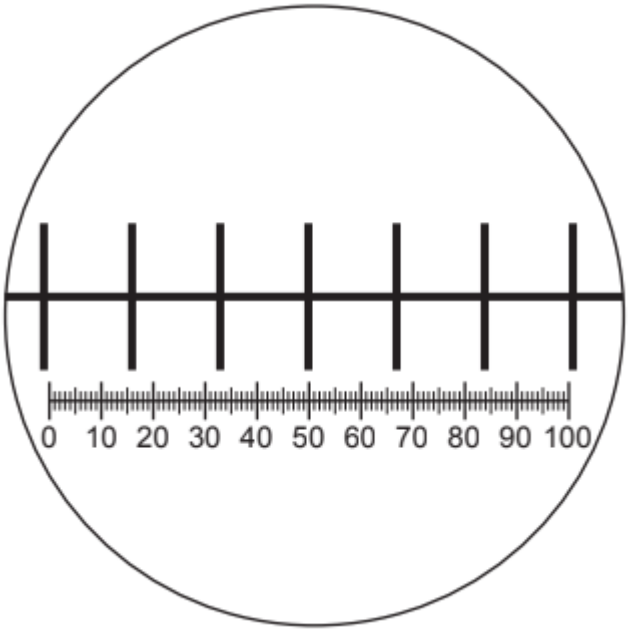


Fig. 3.2

(i) Use Fig. 3.2 to calculate the actual length of one eyepiece graticule unit.

Show your working.

1 shows division of 1 mm by 17 ;
2 answer with 3 significant figures ;
3 appropriate units in µm;

actual length = ...

[3]

Fig. 3.3 shows a photomicrograph of a transverse section through a different stem to **K1**. This was taken with the same microscope and lenses used to take Fig. 3.2. The eyepiece graticule has been placed across the diameter of the section.

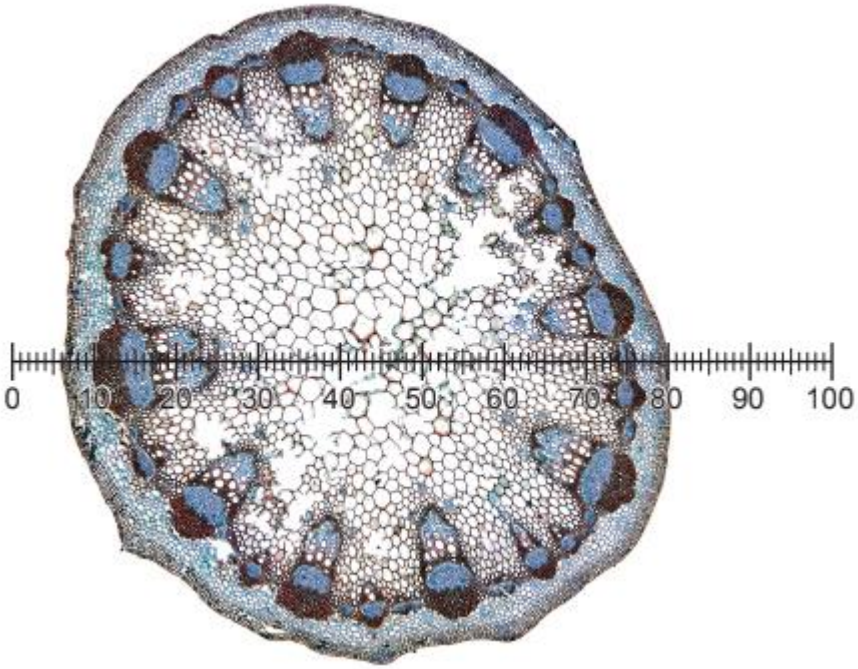


Fig. 2.3

(ii) Use the calibration of the eyepiece graticule from **(b)(i)** to calculate the actual diameter of the section in Fig. 3.3.

Show your working.

1 74 eyepiece graticule units;
2 shows multiplication of answer from 2(b)(i) by eyepiece graticule units;

actual diameter = ...

[2]

(iii) Identify **three** observable differences, other than size and colour, between the stem section on **K1** and the stem section on Fig. 3.3.

Record **three** observable differences in Table 3.1.

Table 3.1

feature	K1	Fig 3.3
Vascular bundle distribution	Scattered and at edge OR disorderly	At edge OR orderly
Vascular bundle shape	circular	oval
Vascular bundle number	more	Fewer
Presence of pith	absent	present

[3]
[Total:17]