Mass Transport in Plants

These practice questions can be used by students and teachers and is

Suitable for AQA A Level 7402 Biology Topic Question

Level: AQA A LEVEL 7402

Subject: Biology

Exam Board: AQA A Level 7402

Topic: Mass Transport in Plants

1 Read the following passage.

Some insect species feed on the leaves of plants. These leaf-chewers bite off pieces of leaves. Other insect species feed on sap from phloem or xylem. These sap-feeders have sharp, piercing mouthparts that they insert directly into either xylem or phloem. Leaf-chewers and insects that feed on xylem sap are active feeders; this means they use their jaw muscles to obtain their food. In contrast, insects that feed on phloem sap are passive feeders; this means they do not use their jaw muscles to take up sap from phloem.

Feeding on phloem sap presents two problems. Firstly, phloem sap has sa high sugar concentration. This could lead to a high pressure of liquid in the insect's gut because of water entering the gut from the insect's body tissues. A phloem-sap-feeder polymerises some of these sugars into polysaccharides which are passed out of its anus as 'honey dew'. The second< >problem is that phloem sap has a low concentration of amino acids. Phloem-sap-feeding insects rely on bacteria in their guts to produce amino acids. Each phloem-sap-feeding insect receives a few of these bacteria from its parent. This has resulted in a reduction in the genetic diversity of the bacteria found within these insects.

A scientist investigated the effect of three different insects on the growth of a plant called the goldenrod. He found that leaf-chewing insects and xylem-sap-feeding insects caused a much greater reduction in total leaf area than did phloem-sap-feeding insects.

Use the information from the passage and your own knowledge to answer the following questions.

(a) Phloem-sap-feeders are passive feeders (lines 6–7).
Phloem-sap-feeders do not use their jaw muscles to take up sap from phloem.

Explain why they can take up sap without using their jaw muscles.

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(3)

(b) A phloem-sap-feeder polymerises some of these sugars into polysaccharides (line 12-13). Suggest the advantage of this.

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(2)

(c) Each phloem-sap-feeding insect receives a few of these bacteria from its parent. (lines 16–17).

Suggest how this has caused a reduction in genetic diversity of the bacteria.

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(2)

(d) A scientist found that leaf-chewers and xylem-sap-feeders had a greater effect on plant growth than phloem-sap-feeders (lines 20–22).

Other than environmental factors, give **two** features the scientist would have controlled in his experiment to ensure this conclusion was valid.

1. ____

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2. ____

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(2)

(e) The scientist used the reduction in total leaf area of the experimental plants as an indicator of plant growth.

Outline a method by which you could find the area of a plant leaf.

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(1)
(Total 10 marks)

2 Organic compounds synthesised in the leaves of a plant can be transported to the plant's roots. This transport is called translocation and occurs in the phloem tissue of the plant.

(a) One theory of translocation states that organic substances are pushed from a high pressure in the leaves to a lower pressure in the roots.

Describe how a high pressure is produced in the leaves.

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(Extra space) ______________________________________

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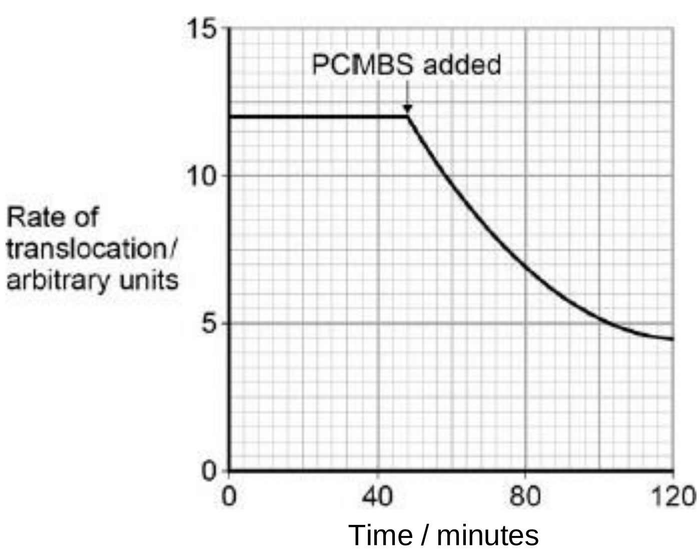
(3)

PCMBS is a substance that inhibits the uptake of sucrose by plant cells.

Scientists investigated the effect of PCMBS on the rate of translocation in sugar beet. The figure below shows their results.



(b) During their experiment, the scientists ensured that the rate of photosynthesis of their plants remained constant.
Explain why this was important.

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(2)

(c) The scientists concluded that some translocation must occur in the spaces in the cell walls.
Explain how the information in the figure above supports this conclusion.

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(2)
(Total 7 marks)

3 (a) Contrast the processes of facilitated diffusion and active transport.

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(Extra space) ___

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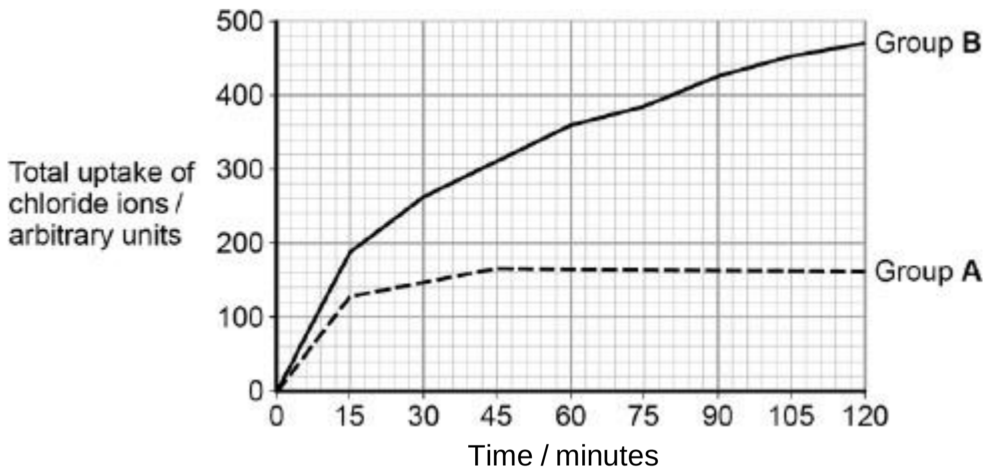
(3)

Students investigated the uptake of chloride ions in barley plants. They divided the plants into two groups and placed their roots in solutions containing radioactive chloride ions.

- Group **A** plants had a substance that inhibited respiration added to the solution.
- Group **B** plants did not have the substance added to the solution.

The students calculated the total amount of chloride ions absorbed by the plants every 15 minutes. Their results are shown in the figure below.



(b) Calculate the ratio of the mean **rate** of uptake of chloride ions in the first hour to the **rate** of uptake of chloride ions in the second hour for group **B** plants.

Ratio =____________________:1

(2)

(c) Explain the results shown in the figure above.

(Extra space)

(4)

(Total 9 marks)

4 A student investigated the distribution of stomata on leaves from two species of plant. She removed small pieces from the lower surface of the leaves of each plant species. She mounted these pieces on separate microscope slides. She then counted the number of stomata in several parts of the epidermis on each piece of leaf tissue using an optical microscope.

(a) Suggest appropriate units the student should use to compare the distribution of stomata on leaves.

(1)

(b) The pieces of leaf tissue examined were very thin.

Explain why this was important.

(2)

(c) Give **two** reasons why it was important that the student counted the number of stomata in several parts of each piece of leaf tissue.

1. ____

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2. ____

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(2)

(d) One of the two plant species used by the student in this investigation was a xerophyte.

Other than the distribution of stomata, suggest and explain **two** xerophytic features the leaves of this plant might have.

1. ____

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2. ____

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(2)

(e) The student then compared the rate of transpiration (evaporation of water) from the two species of plant. She did this by measuring the rate of water uptake by each plant species.

Suggest **two** reasons why the rate of water uptake by a plant might not be the same as the rate of transpiration.

1. ____

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2. ____

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(2)

(Total 9 marks)

5 (a) Describe the mass flow hypothesis for the mechanism of translocation in plants.

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(Extra space) ___

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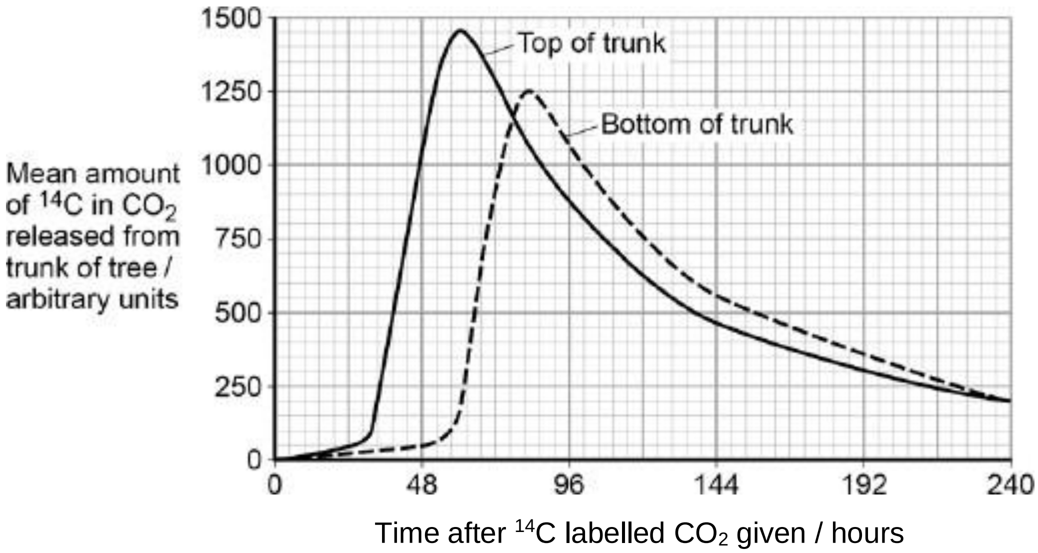
(4)

Scientists measured translocation in the phloem of trees. They used carbon dioxide labelled with radioactive ^{14}C.

They put a large, clear plastic bag over the leaves and branches of each tree and added $^{14}CO_2$. The main trunk of the tree was not in the plastic bag.

At regular intervals after adding the $^{14}CO_2$ to the bag, the scientists measured the amount of $^{14}CO_2$ released from the top and bottom of the main trunk of the tree. On the surface of the trunk of these trees, there are pores for gas exchange.

The following figure shows the scientists' results.



(b) Name the process that produced the $^{14}CO_2$ released from the trunk.

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(1)

(c) How long did it take the ^{14}C label to get from the top of the trunk to the bottom of the trunk? Explain how you reached your answer.

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(2)

(d) What other information is required in order to calculate the mean rate of movement of the ^{14}C down the trunk?

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(1)

(Total 8 marks)

6 (a) Describe how the structures of starch and cellulose molecules are related to their functions.

(5)

(b) Describe the processes involved in the transport of sugars in plant stems.

(5)

(Total 10 marks)

7 (a) (i) Give **two** ways in which the structure of starch is **similar** to cellulose.

1. ____

2. ____

(2)

(ii) Give **two** ways in which the structure of starch is **different** from cellulose.

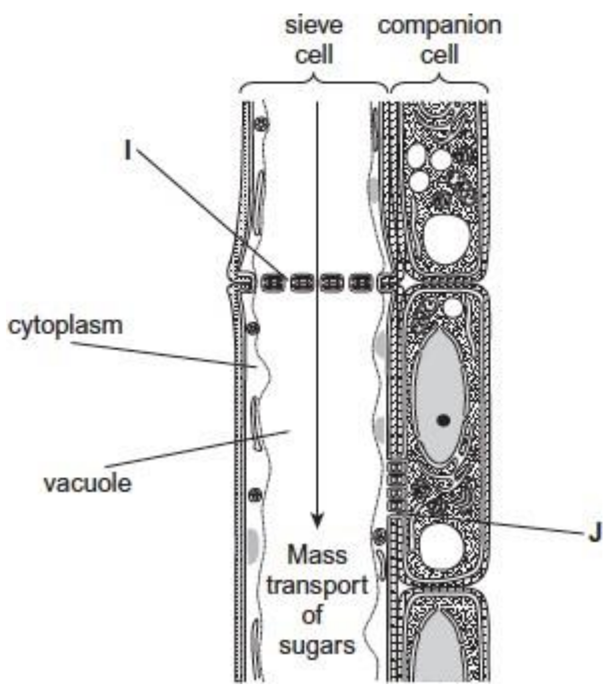
1. ____

2. ____

(2)

(b) In plants, mass transport of sugars takes place through columns of sieve cells in the phloem. Other cells, called companion cells, transport sugars into, and out of, the sieve cells.

The diagram shows the structure of phloem.



Structures **I** and **J** allow the transport of sugars between cells.

(i) Using the diagram, suggest and explain **one** other way in which sieve cells are adapted for mass transport.

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(2)

(ii) Using the diagram, suggest and explain **one** other way in which companion cells are adapted for the transport of sugars between cells.

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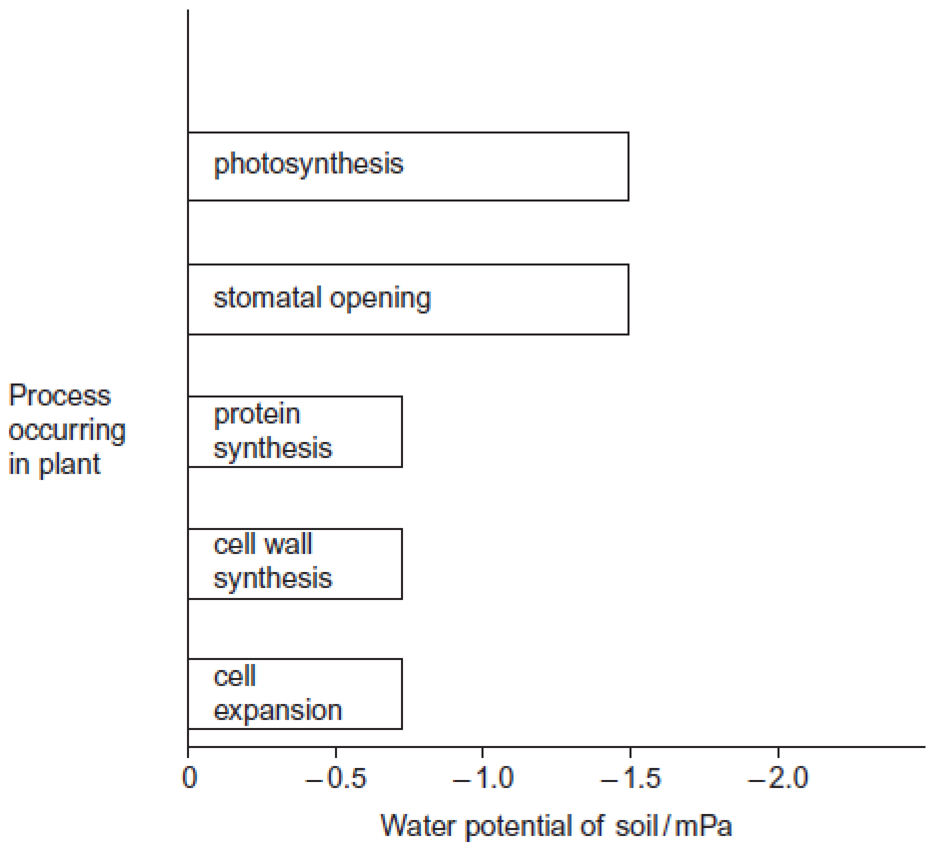
(2)

(Total 8 marks)

8 Scientists investigated the effect of the water potential of soil water on plant growth. They investigated the effect of this water potential on several plant processes.

The figure below shows their results in the form they were presented. The bars show whether or not each process was occurring.

The plants stopped growing when the water potential of the soil water was below –0.7 mPa. All of the changes in the plants were related to the ability of the roots to take up water from the soil.



(a) Describe the results in the figure.

(2)

(b) Explain the relationship between stomatal opening and photosynthesis.

(2)

(c) Although photosynthesis is still occurring, plants stop growing when the soil water potential falls below –0.7 mPa.

Use information from the figure above to suggest two reasons why.

(3)

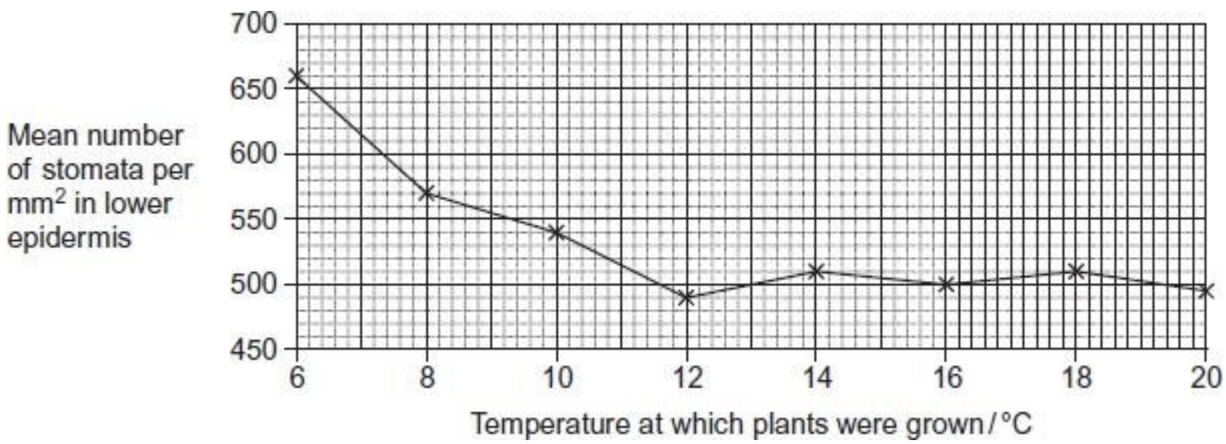
(Total 7 marks)

9 Environmental factors can affect the density of stomata in the lower epidermis of leaves of plants of the same species.

Scientists investigated how growing plants at different temperatures affected the density of stomata in the lower epidermis of leaves. They grew plants of the same species from seeds. Their method is outlined below.

- They took 8 trays containing soil and planted 50 seeds in each tray.
- They put each tray in a controlled environment at a different temperature.
- When the plants had grown from the seeds, they selected 20 fully grown leaves from the plants in each tray.
- They determined the mean number of stomata per mm^2 in the lower epidermis for each group of leaves.

Their results are shown in the graph.



(a) Give **three** environmental variables, other than temperature, that the scientists would have controlled when growing the plants.

1. ____

2. ____

3. ____

(3)

(b) The scientists used a range of temperatures from 6 to 20 °C.
Using their data, explain why they did not use temperatures above 20 °C.

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(1)

(c) The scientists only selected fully grown leaves from the plants.

Suggest why.

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(1)

(d) The plants grown at higher temperatures had a lower number of stomata per mm^2.
This would be an advantage to the plant because the transpiration rate increases as the temperature increases.

Explain why the transpiration rate increases when the temperature increases.

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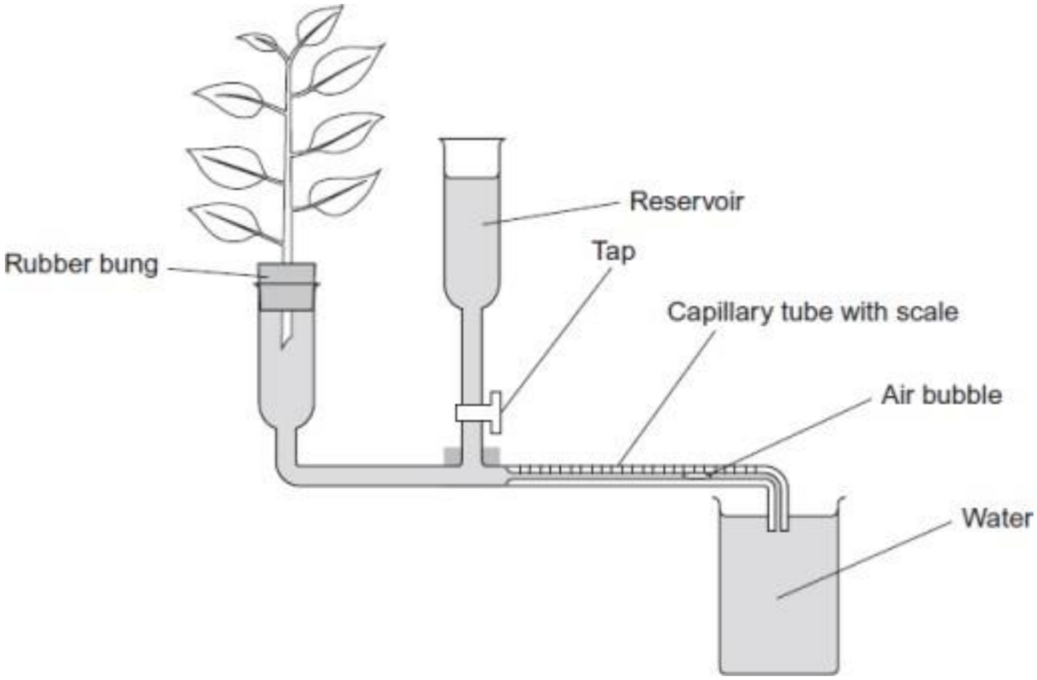
(2)
(Total 7 marks)

10 Students investigated the effect of removing leaves from a plant shoot on the rate of water uptake. Each student set up a potometer with a shoot that had eight leaves. All the shoots came from the same plant. The potometer they used is shown in the diagram.



(a) Describe how the students would have returned the air bubble to the start of the capillary tube in this investigation.

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(1)

(b) Give **two** precautions the students should have taken when setting up the potometer to obtain reliable measurements of water uptake by the plant shoot.

1. ____

2. ____

(2)

(c) A potometer measures the rate of water uptake rather than the rate of transpiration. Give **two** reasons why the potometer does **not** truly measure the rate of transpiration.

1. ____

2. ____

(2)

(d) The students' results are shown in the table.

Number of leaves removed from the plant shoot	Mean rate of water uptake / cm^3 per minute
0	0.10
2	0.08
4	0.04
6	0.02
8	0.01

Explain the relationship between the number of leaves removed from the plant shoot and the mean rate of water uptake.

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*(Extra space)*____

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(3)

(Total 8 marks)

11 Scientists used fossil leaves from one species of pine tree to investigate whether changes in the concentration of carbon dioxide in the air over long periods of time had led to changes in the number of stomata in the leaves.

Their method is outlined below.

- They selected sites of different ages.
- They collected between 11 and 24 fossil leaves from each site.
- They found the mean number of stomata per mm^2 on the leaves from each site.
- They estimated the age of each sample by dating organic remains around the leaves at each site.

They compared results from the fossil leaves with leaves from the same species of pine tree growing today.

They knew the concentration of carbon dioxide in the air at different times in the past.

Their results are shown in the table.

Age of sample / years	Concentration of carbon dioxide in the air / %	Mean number of stomata per mm^2 (± standard deviation)
present day	0.0350	92 (±2)
5000	0.0270	87 (±4)
10 000	0.0250	95 (±2)
15 000	0.0205	108 (±6)
20 000	0.0195	115 (±4)
25 000	0.0188	118 (±6)
30 000	0.0190	130 (±6)

(a) The concentration of carbon dioxide in the air has changed with time. Use the data to describe how.

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(2)

(b) The scientists calculated the mean number of stomata per mm^2 and the standard deviation.

What does the standard deviation show?

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(2)

(c) The scientists found the age of the fossil leaves by dating the organic remains around them.
Would this have affected the accuracy of their data? Explain your answer.

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(1)

(d) 30 000 years ago the mean number of stomata per mm^2 on the lower epidermis of pine tree leaves was much higher than it is today. This would have enabled the plant to grow faster when the carbon dioxide concentration of the air was low.

Explain why.

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(1)

(e) A student who saw these results concluded that as the carbon dioxide concentration of the air had increased the number of stomata per mm^2 in leaves had decreased.
Do the results support this conclusion?

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(Extra space)___

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(3)

(f) The leaves of plants that grow in dry areas usually have a low number of stomata per mm^2. Use your knowledge of leaf structure to suggest **three** other adaptations that the leaves might have that enable the plants to grow well in dry conditions.

1. ____

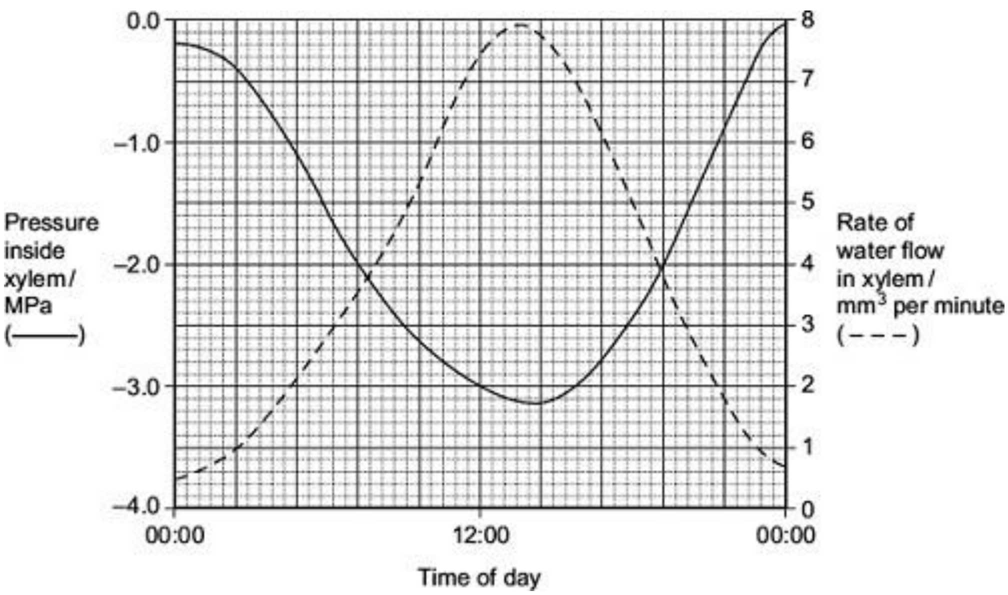
2. ____

3. ____

(3)

(Total 12 marks)

12 (a) Scientists measured the rate of water flow and the pressure in the xylem in a small branch. Their results are shown in the graph.



(i) Use your knowledge of transpiration to explain the changes in the rate of flow in the xylem shown in the graph.

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(Extra space) ____

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(3)

(Extra space)

(3)

(ii) Explain why the values for the pressure in the xylem are negative.

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(1)

(b) Doctors measured the thickness of the walls of three blood vessels in a large group of people. Their results are given in the table.

Name of vessel	Mean wall thickness /mm (± standard deviation)
Aorta	5.7 ± 1.2
Pulmonary artery	1.0 ± 0.2
Pulmonary vein	0.5 ± 0.2

(i) Explain the difference in thickness between the pulmonary artery and the pulmonary vein.

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(1)

(ii) The thickness of the aorta wall changes all the time during each cardiac cycle. Explain why

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*(Extra space)*____

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(3)

(iii) Which of the three blood vessels shows the greatest variation in wall thickness? Explain your answer.

(1)

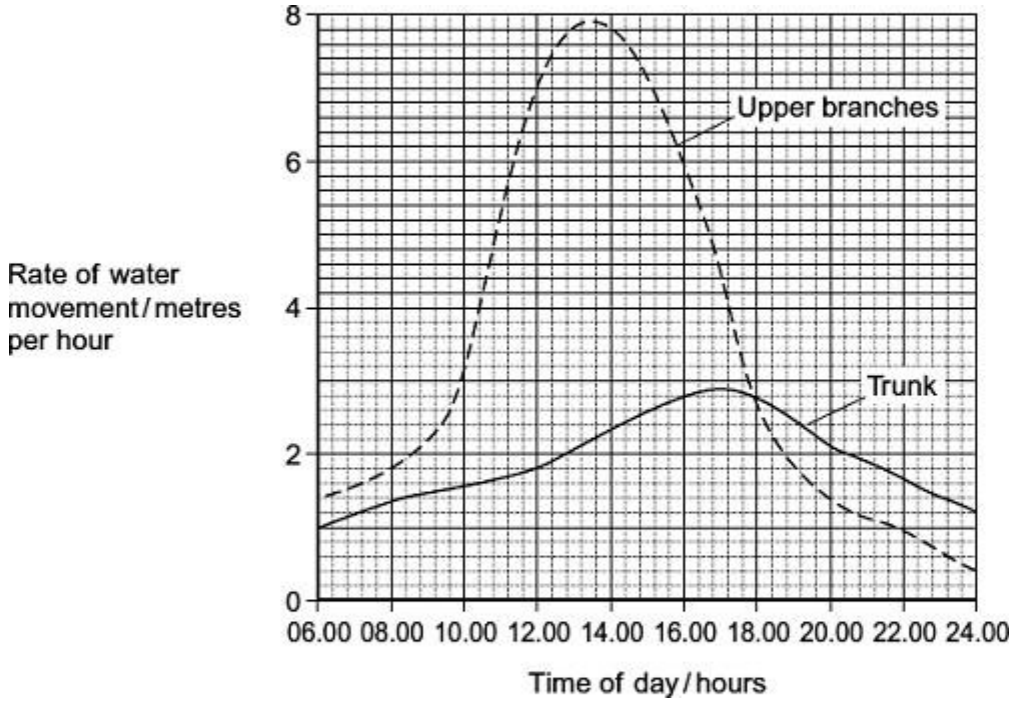
(c) Describe how tissue fluid is formed **and** how it is returned to the circulatory system.

*(Extra space)*____

(6)

(Total 15 marks)

13 A biologist investigated the rate of water movement during the day in different parts of a tree. The results are shown in the graph.



(i) Describe how the rate of water movement in the upper branches changed over the period shown in the graph.

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(2)

(ii) The rate of water movement in the upper branches was different from the rate of water movement in the trunk. Describe how.

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(2)

(iii) The results of this investigation support the cohesion tension theory. Explain how.

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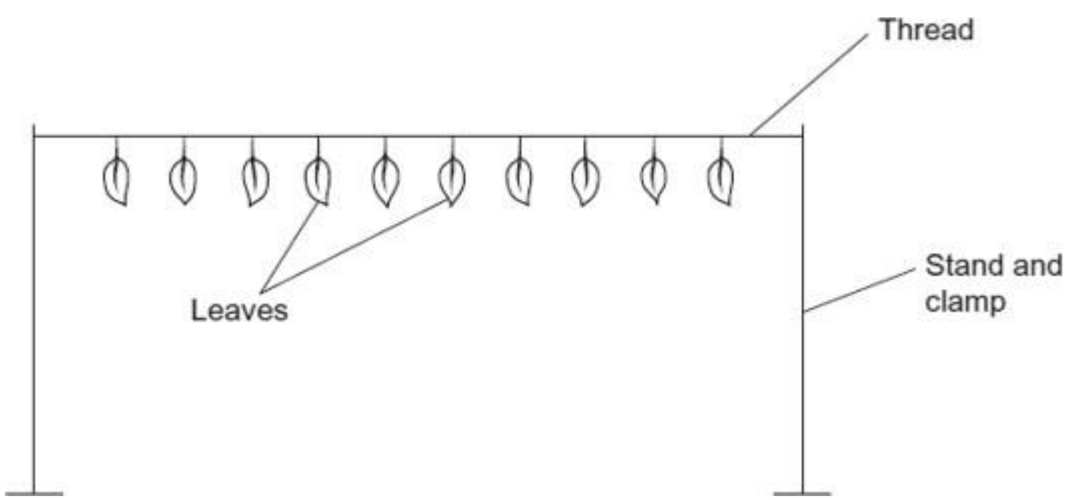
(2)

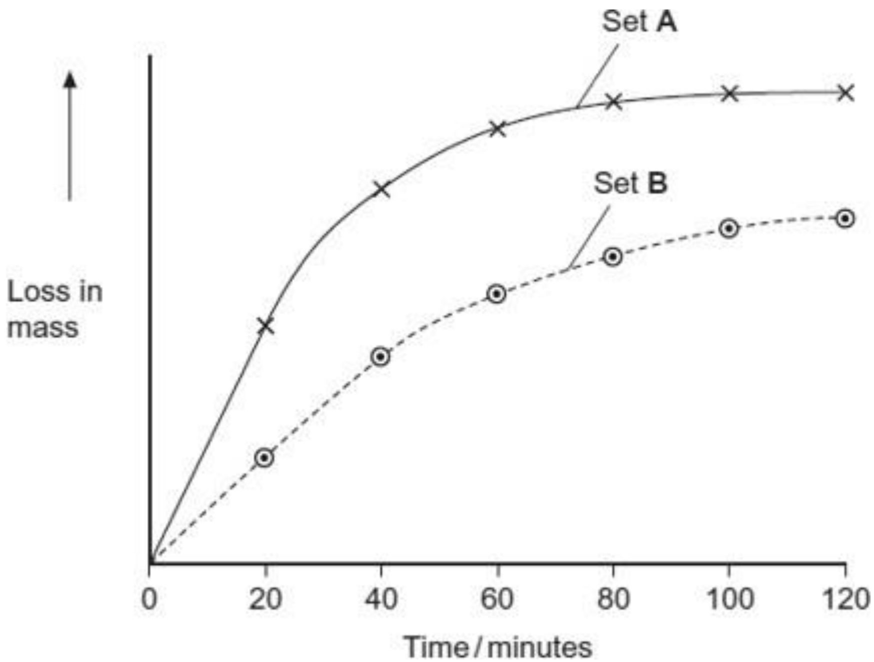
(Total 6 marks)

14 A student investigated the rate of transpiration from privet leaves.

- She obtained two sets of ten privet leaves.
- She left the ten leaves in set **A** untreated. She covered the upper surfaces of the ten leaves in set **B** with grease.
- She weighed each set of leaves and then tied all the leaves in each set to a separate length of thread. This is shown in the diagram.



•	She then weighed each set of leaves every 20 minutes over a period of 2 hours and plotted a graph of her results.



(a)	Give **two** environmental conditions that the student should have kept constant during this investigation.

1. ____

2. ____

(2)

(b)	The student measured the water loss in milligrams. Explain the advantage of using ten leaves when taking measurements in milligrams.

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(1)

(c) Explain the change in mass of untreated leaves in set **A** shown in the graph.

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*(Extra space)*___

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(3)

(d) The results that the student obtained for the leaves in set **B** were different from those for set **A**. Suggest an explanation for this difference.

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(2)

(Total 8 marks)

15 (a) Students measured the rate of transpiration of a plant growing in a pot under different environmental conditions. Their results are shown in the table.

Conditions	Transpiration rate / g h^{-1}
A Still air 15°	1.2
B Moving air 15°	1.7
C Still air 25°	2.3

During transpiration, water diffuses from cells to the air surrounding a leaf.

(i) Suggest an explanation for the difference in transpiration rate between conditions **A** and **B**.

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(2)

(ii) Suggest an explanation for the difference in transpiration rate between conditions **A** and **C**.

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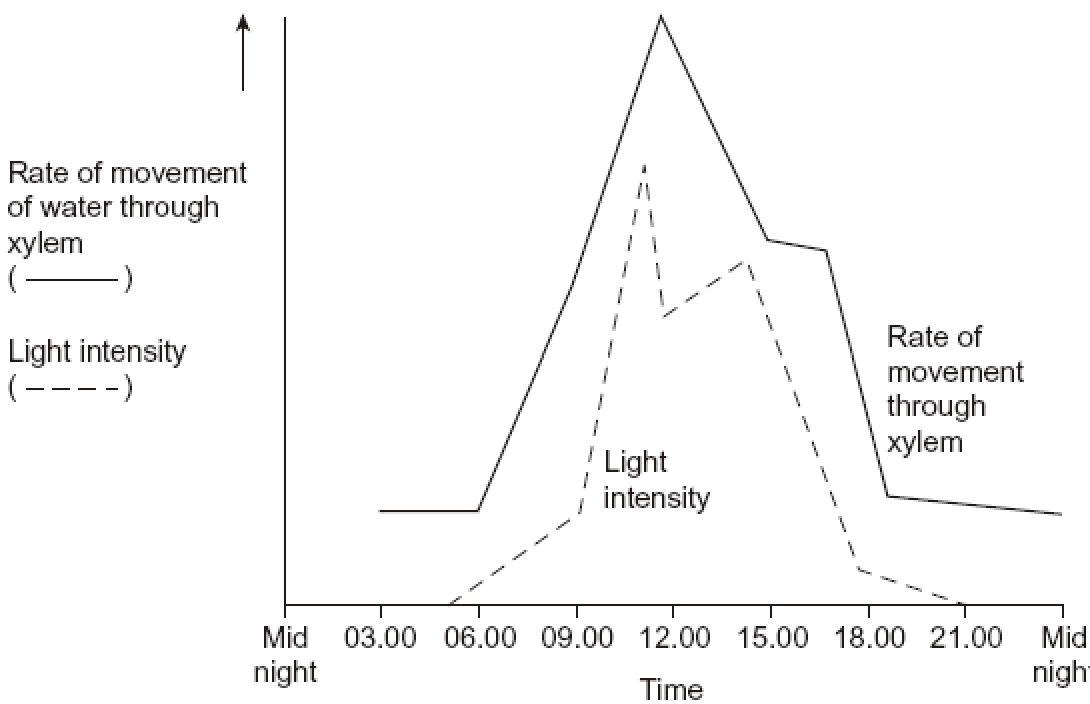
(2)

(b) Scientists investigated the rate of water movement through the xylem of a twig from a tree over 24 hours. The graph shows their results. It also shows the light intensity for the same period of time.



(i) Describe the relationship between the rate of water movement through the xylem and the light intensity.

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(1)

(ii) Explain the change in the rate of water movement through the xylem between 06.00 and 12.00 hours.

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(2)

(iii) The scientists also measured the diameter of the trunk of the tree on which the twig had been growing. The diameter was less at 12.00 than it was at 03.00 hours.

Explain why the diameter was less at 12.00 hours.

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(2)

(c) Arteries and arterioles take blood away from the heart.

Explain how the structures of the walls of arteries and arterioles are related to their functions.

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(6)

(Total 15 marks)

16 A student found the number of stomata per cm^2 on the lower surface of a daffodil leaf. He removed a small, thin piece of lower epidermis and mounted it on a microscope slide.

He examined the slide using an optical microscope.

(a) Explain why it was important that the piece of the epidermis that the student removed was thin.

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(2)

(b) Suggest how the student could have used his slide to find the number of stomata per cm^2.

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(3)

(c) The stomata on the leaves of pine trees are found in pits below the leaf surface. Explain how this helps to reduce water loss.

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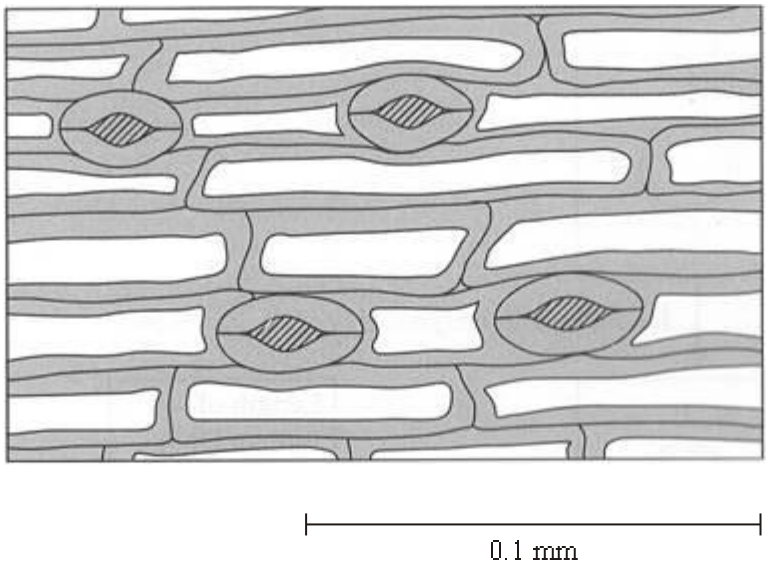
(2)
(Total 7 marks)

17 The drawing shows part of the lower leaf epidermis of sorghum.



(a) Calculate the number of stomata per mm^2 of the leaf surface. Show your working.

Answer____________________stomata per mm^2

(2)

(b) Sorghum has few stomata per mm^2 of leaf surface area. Explain how this is an adaptation to the conditions in which sorghum grows.

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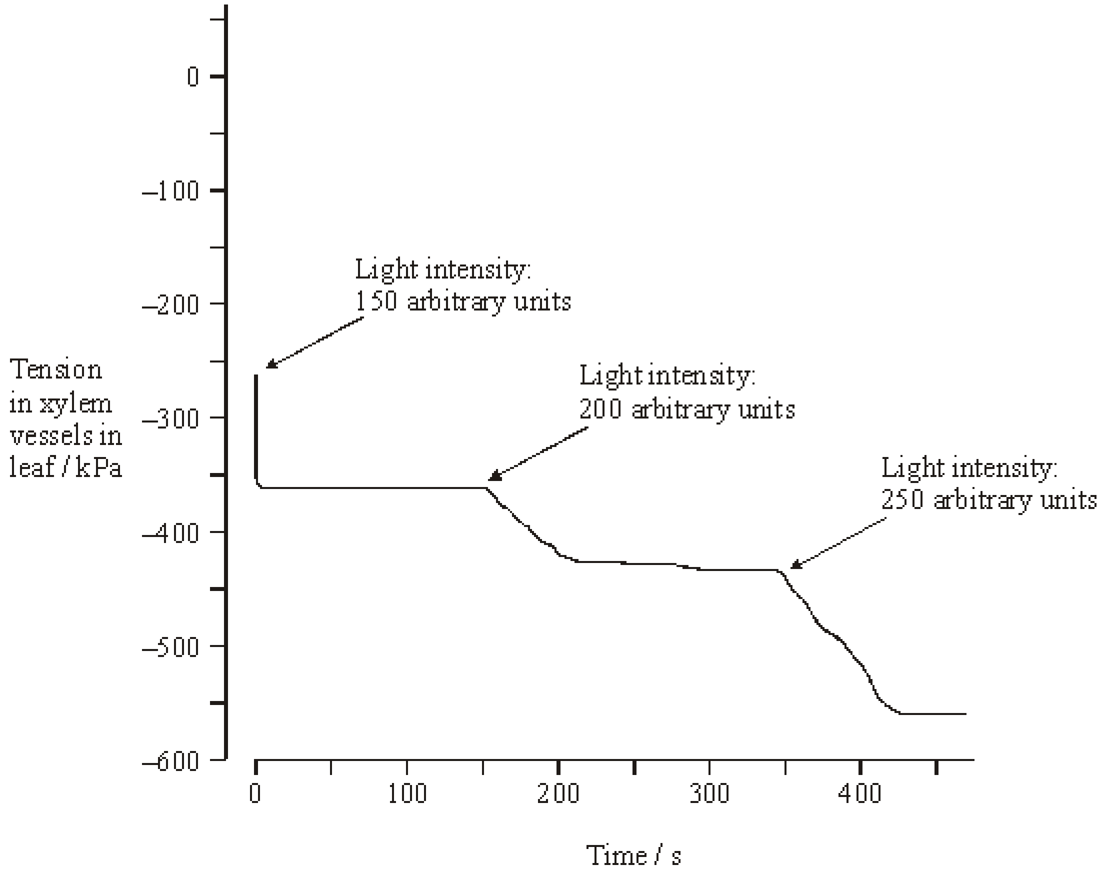
(3)

(Total 5 marks)

18 The chart shows the results obtained from an investigation to determine the effect of light intensity on the tension in xylem vessels in the leaves of a plant.



(a) Describe and explain the effects of increasing light intensity on the tension in the xylem vessels in the leaves.

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(5)

(b) Explain why it was important to keep the humidity constant during the investigation.

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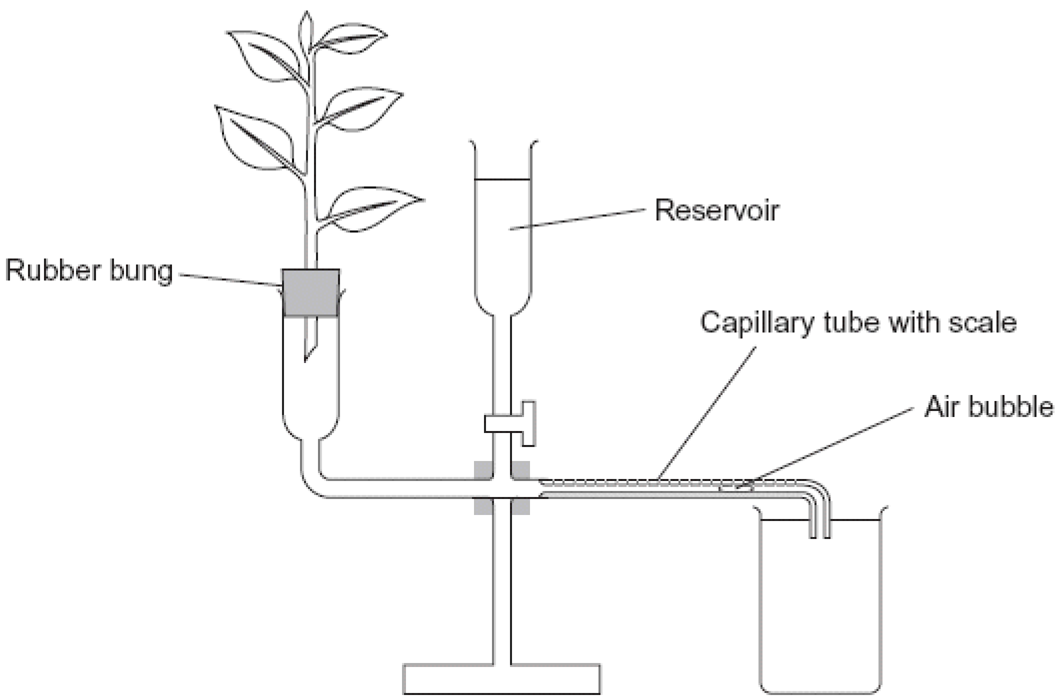
(2)
(Total 7 marks)

19 A student investigated the rate of transpiration from a leafy shoot. She used a potometer to measure the rate of water uptake by the shoot. The diagram shows the potometer used by the student.



(a) Give **one** environmental factor that the student should have kept constant during this investigation.

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(1)

(b) The student cut the shoot and put it into the potometer under water. Explain why.

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(1)

(c) The student wanted to calculate the rate of water uptake by the shoot in cm^3 per minute. What measurements did she need to make?

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(2)

(d) The student assumed that water uptake was equivalent to the rate of transpiration.

Give **two** reasons why this might **not** be a valid assumption.

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2. ___

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(2)

(e) The student measured the rate of water uptake three times.

(i) Suggest how the reservoir allows repeat measurements to be made.

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(1)

(ii) Suggest why she made repeat measurements.

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(1)

(Total 8 marks)

20 (a) The table shows the transpiration rate of a group of plants exposed to different humidities at a temperature of 25°C.

Humidity / %	**Transpiration rate / arbitrary units**
20	26.0
40	21.0
50	16.5
60	11.0
70	9.5

Describe and explain the relationship between humidity and transpiration rate.

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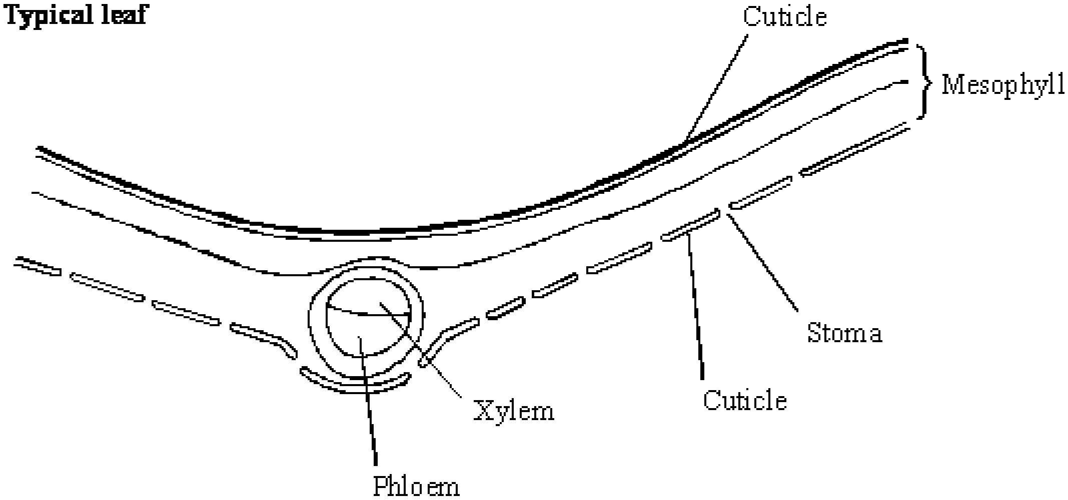
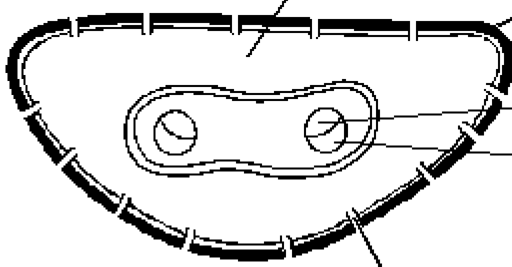
(3)

(b) The diagrams show a section through a typical leaf and a section through a leaf from a xerophytic plant. The xerophytic leaf has a lower transpiration rate than the typical leaf.

Typical leaf



Xerophytic leaf



Describe **two** features shown in the diagram of the xerophytic leaf which reduce transpiration rate. Explain how each of these features contributes to a lower transpiration rate.

Feature 1 ______________________________

Explanation ______________________________

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Feature 2 ______________________________

Explanation ______________________________

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(4)
(Total 7 marks)

21 (a) Describe how water is moved through a plant according to the *cohesion-tension* hypothesis.

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____

(4)

(b) The mass of water lost from a plant was investigated. The same plant was used in every treatment and the plant was subjected to identical environmental conditions. In some treatments, the leaves were coated with a type of grease. This grease provides a waterproof barrier. The results of the investigation are given in the table.

Treatment	**Mass lost in 5 days / g**
No grease applied	10.0
Grease applied only to the upper surface of every leaf	8.7
Grease applied to both surfaces of every leaf	0.1

(i) What is the advantage of using the same plant in every treatment?

____

____

(1)

(ii) Why was it important to keep the environmental conditions constant?

____

____

(1)

(iii) What is the evidence that the grease provides a waterproof barrier?

____

____

(1)

(c) (i) Calculate the mass of water lost in 5 days through the upper surface of the leaves.

Answer ______________________________

(1)

(ii) Use your knowledge of leaf structure to explain why less water is lost through the upper surface of leaves than is lost through the lower surface.

____

____

____

____

(2)

(Total 10 marks)

22 (a) Explain how each of the following is related to the function of xylem tissue.

(i) Xylem tissue contains hollow tubes.

____

____

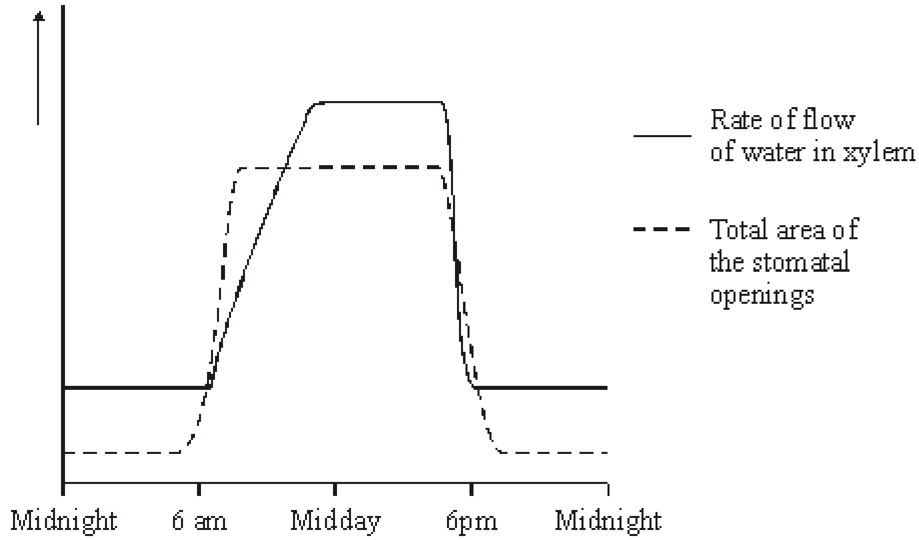
(ii) Lignin is present in xylem cell walls.

____

____

(2)

(b) In an investigation the total area of the stomatal openings and the rate of flow of water through xylem were measured in a plant over a period of 24 hours. The results are shown in the graph.



(i) Describe the relationship between the rate of flow of water and the total area of the stomatal openings for the period of time between midday and midnight.

___

___

(1)

(ii) Between 8 am and midday the rate of flow of water continues to rise although the total area of the stomatal openings remains constant. Explain why the rate of flow of water rises.

___

(1)

(iii) How would the curve showing the total area of the stomatal openings differ if the investigation was repeated on a dull day?

___

___

(1)

(c) Some xerophytic plants have sunken stomata. Explain the advantage of this adaptation.

___

___

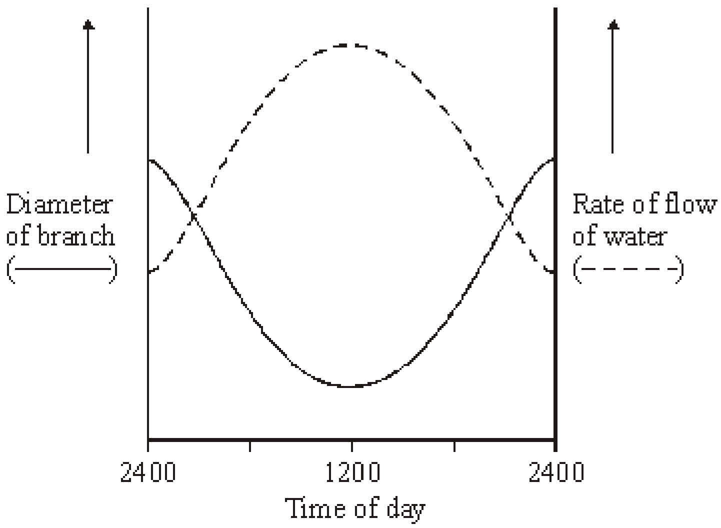
___

___

(2)

(Total 7 marks)

23 (a) The diameter of a branch of a tree and the rate of flow of water through the branch were measured over a 24-hour period. The results are shown in the graph.



Using your knowledge of cohesion-tension theory

(i) describe and explain the changes in rate of flow of water in the branch over the 24 hour period;

____

____

____

____

____

____

(3)

(ii) explain why the diameter of the branch decreased during the first 12 hours.

____

____

(1)

(b) A stem was cut from a transpiring plant. The cut end of the stem was put into a solution of picric acid, which kills plant cells. The transpiration stream continued. Suggest an explanation for this observation.

____

____

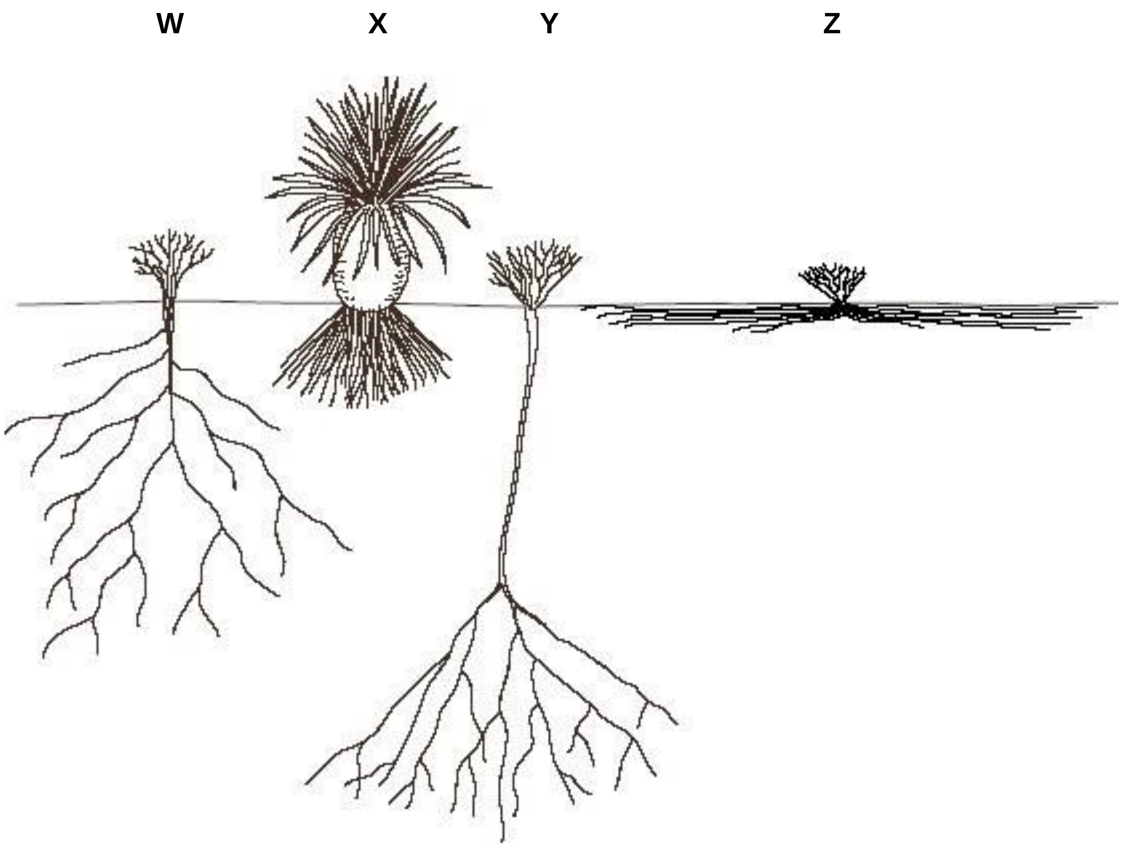
____

____

(2)

(Total 6 marks)

24 The drawing shows four common plants found in the Mojave Desert.



(a) Explain how **three** features of the plants shown in the drawing are adaptations to desert conditions.

1. ____

____

2. ____

____

3. ____

____

(3)

(b) Resurrection plants can lose up to 95% of their water content without dying. They can survive for many years in this desiccated state and will revive within hours of rainfall. Suggest which of the plants **W** to **Z** is most likely to be a resurrection plant. Give a reason for your choice.

____

____

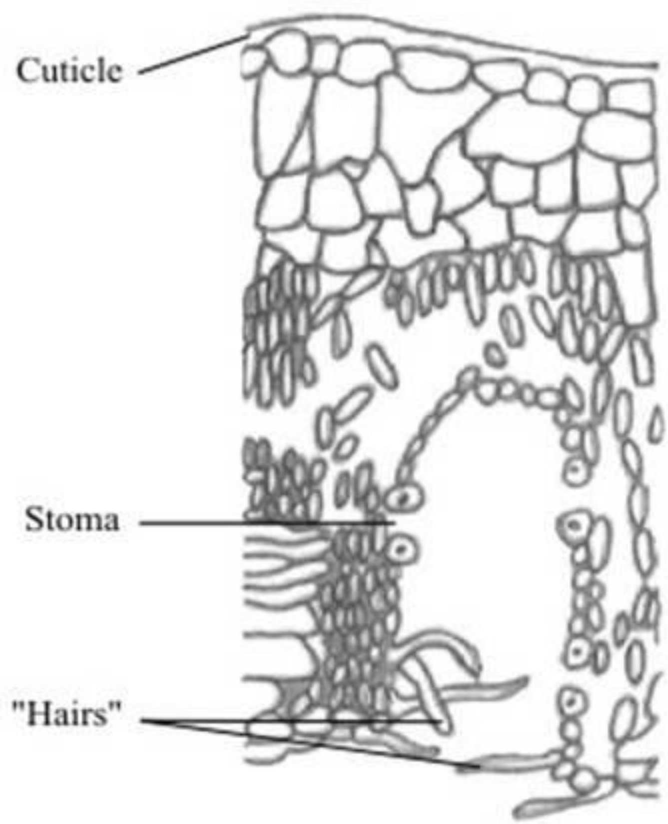
____

____

(2)
(Total 5 marks)

25 **Figure 2** shows a single stoma and surrounding cells from the leaf of a xerophytic plant.

Figure 2



(i) Explain how the cuticle reduces water loss.

___

___

(1)

(ii) Explain how **one** of the other labelled parts reduces water loss.

___

___

___

___

(2)
(Total 3 marks)

26 (a) Explain how xylem tissue is adapted for its function.

___

___

___

___

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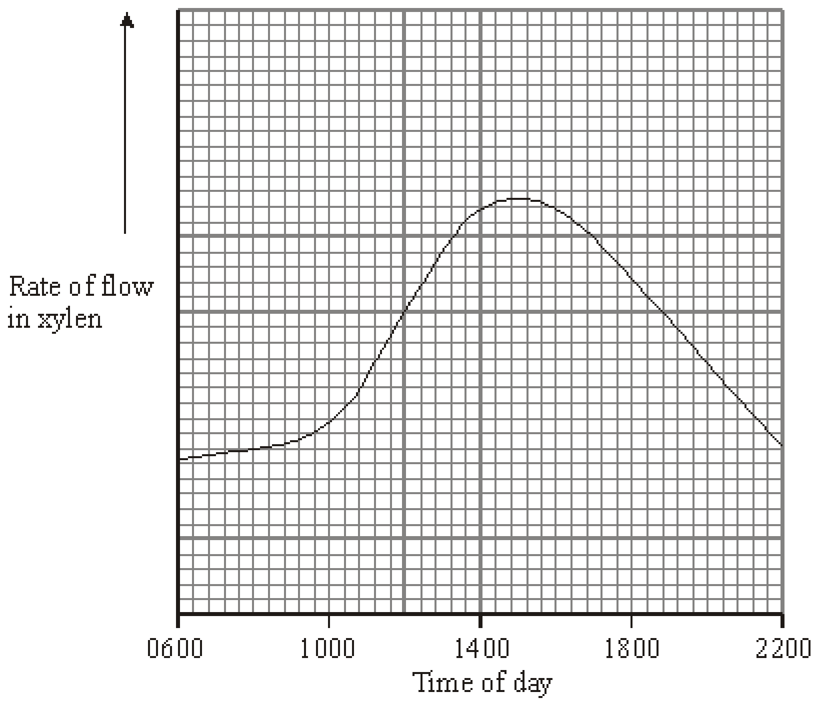
___

___

___

(4)

(b) The graph shows the flow rate in the xylem in the trunk of a tree.



(i) Explain the increase in the flow rate between 1000 and 1400 hours.

___

___

___

___

(2)

(ii) The diameter of the trunk decreased during the same period, reaching its minimum when the flow rate was highest. Use your knowledge of the cohesion-tension theory to suggest an explanation for this decrease.

___

___

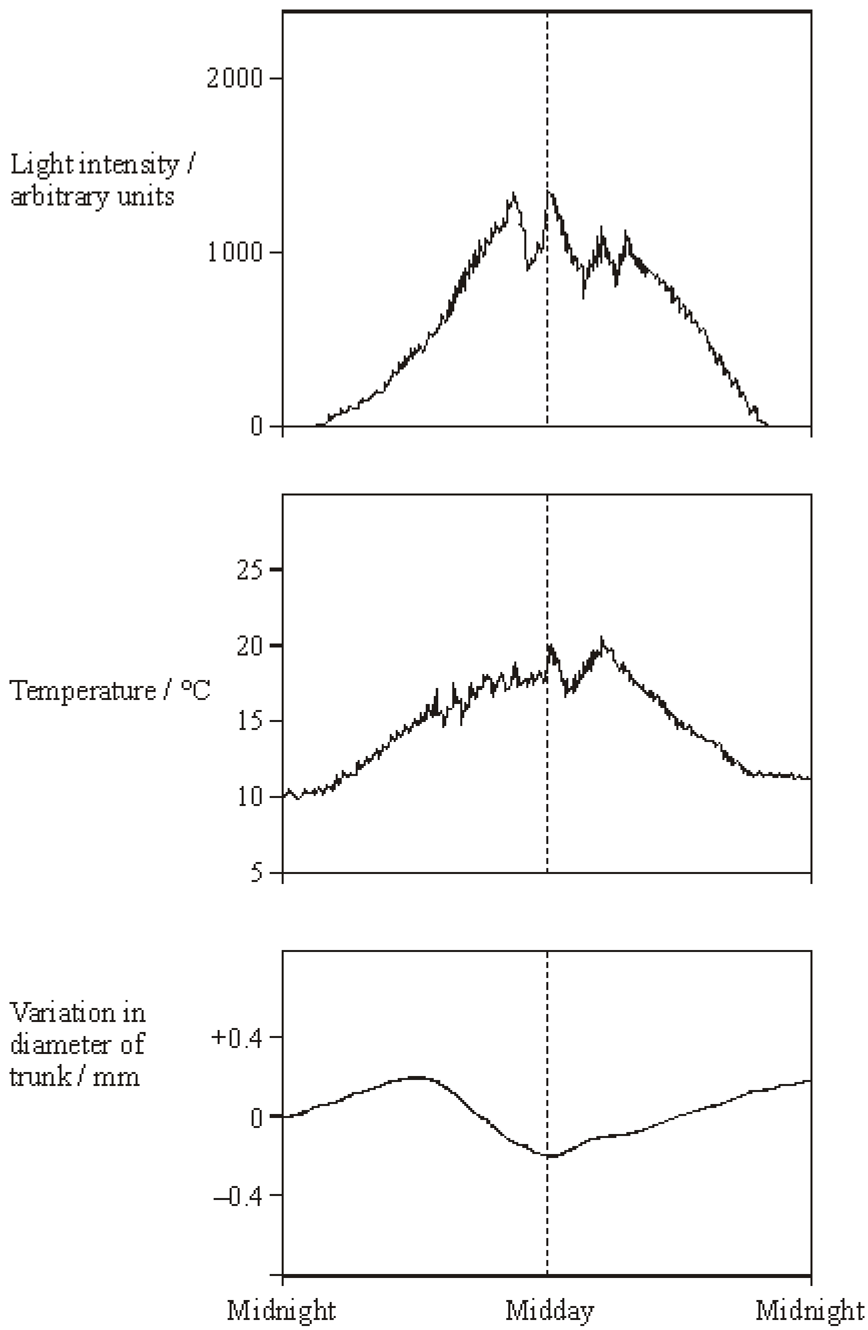
___

___

(2)

(Total 8 marks)

27 (a) The graphs show the daily changes in environmental temperature and light intensity, and changes in the diameter of the trunk of a pine tree.



Use information from the graphs, and your knowledge of the cohesion-tension theory of water movement through a plant, to explain why the diameter of the trunk is smallest at midday.

____

____

____

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____

(6)

(b) Describe and explain **three** ways in which the leaves of xerophytic plants may be adapted to reduce water loss.

____

____

____

____

____

____

(3)

(Total 9 marks)

Mark schemes

1 (a) 1. Contents of phloem vessel pushed into insect's mouth by high pressure;

2. (High pressure in phloem vessel) caused by loading of sugars into phloem in leaf;

3. And (resulting) entry of water by osmosis.

3

(b) 1. Polysaccharides are insoluble;

2. So do not affect water potential of gut.

2

(c) 1. (Only few bacteria passed from parent, so) only a few (copies of) genes passed on (in bacteria);

2. May not / does not include all alleles (of genes, so diversity reduced)
OR
Small number of bacteria transmitted means unrepresentative sample.

2

(d) 1. Number / mass / density of insects per plant;

2. Stage of development / size of plants / insects;

Ignore any abiotic factor

2

(e) Draw around leaf on graph paper **and** count squares;

1

[10]

2 (a) 1. Water potential becomes lower / becomes more negative (as sugar enters phloem);
2. Water enters phloem by osmosis;
3. Increased volume (of water) causes increased pressure.

3

(b) 1. Rate of photosynthesis related to rate of sucrose production;
2. Rate of translocation higher when sucrose concentration is higher.

2

(c) 1. Rate of translocation does not fall to zero / translocation still occurs after 120 minutes;
2. But sucrose no longer able to enter cytoplasm of phloem cells.

2

[7]

3 (a) 1. Facilitated diffusion involves channel or carrier proteins whereas active transport only involves carrier proteins;
2. Facilitated diffusion does not use ATP / is passive whereas active transport uses ATP;
3. Facilitated diffusion takes place down a concentration gradient whereas active transport can occur against a concentration gradient.

Since ‘contrast’, both sides of the differences needed

3

(b) 3.3:1.

Correct answer = 2 marks

If incorrect, allow 1 mark for 470–360 / 60 for rate in second hour

2

(c) 1. Group **A** – initial uptake slower because by diffusion (only);
2. Group **A** – levels off because same concentrations inside cells and outside cells / reached equilibrium;
3. Group **B** – uptake faster because by diffusion plus active transport;
4. Group **B** fails to level off because uptake against gradient / no equilibrium to be reached;
5. Group **B** – rate slows because few / fewer chloride ions in external solution / respiratory substrate used up.

4 max

[9]

4 (a) Stomata per mm^2 or cm^2
OR
Number per mm^2 or cm^2;

Accept: mm^{-2} or cm^{-2}.

Reject: per μm^2 or μm^{-2}.

Reject: the use of a solidus / as being equivalent to per.

Ignore: 'amount'.

1

(b) 1. Single/few layer(s) of cells;

Accept: more/too many/overlapping.

*'Single layer' without reference to cells/tissue should **not** be credited.*

2. So light can pass through;

2

(c) 1. Distribution may not be uniform
OR
So it is a representative sample;

Accept: more/fewer stomata in different areas.

Ignore: anomalies/random/bias.

2. To obtain a (reliable) mean;

Accept: 'average'.

2

(d) 1. Hairs **so** 'trap' water vapour and water potential gradient decreased;
2. Stomata in pits/grooves **so** 'trap' water vapour and water potential gradient decreased;
3. Thick (cuticle/waxy) layer **so** increases diffusion distance;
4. Waxy layer/cuticle **so** reduces evaporation/transpiration.
5. Rolled/folded/curled leaves **so** 'trap' water vapour and water potential gradient decreased;
6. Spines/needles **so** reduces surface area to volume ratio;

*1, 2 and 5. Accept: humid/moist air as 'water vapour' but **not** water/moisture on its own.*

1, 2 and 5. Accept: diffusion gradient as equivalent to water potential gradient.

1, 2 and 5. Accept: less exposed to air as an alternative to water potential gradient.

*6. Accept: spines/needles **so** 'reduce area'.*

2 max

(e) 1. Water used for support/turgidity;
2. Water used in photosynthesis;
3. Water used in hydrolysis;
4. Water produced during respiration;

2 max

[9]

5

(a) 1. In source / leaf sugars actively transported into phloem;
2. By companion cells;
3. Lowers water potential of sieve cell / tube and water enters by osmosis;
4. Increase in pressure causes mass movement (towards sink / root);
5. Sugars used / converted in root for respiration for storage.

Accept starch

4 max

(b) Respiration.

1

(c) 1. (About) 30 hours;
2. Time between peak ^{14}C at top of trunk and bottom.

2

(d) Length of trunk (between top and bottom).

1

[8]

6 (a) Starch (max 3)

1. Helical/ spiral shape **so** compact;
2. Large (molecule)/insoluble **so** osmotically inactive;

   Accept: does not affect water potential/ψ.
3. Branched **so** glucose is (easily) released for respiration;

   Ignore: unbranched.
4. Large (molecule) **so** cannot leave cell/cross cell-surface membrane;

Cellulose (max 3)

5. Long, straight/unbranched chains of β glucose;
6. Joined by hydrogen bonding;

   Note: references to 'strong hydrogen bonds' disqualifies this mark point.
7. To form (micro/macro)fibrils;
8. Provides rigidity/strength;

5 max

(b)

1. (At source) sucrose is actively (transported) into the phloem/sieve element/tube;

   Accept: 'sugar/s' for sucrose but reject other named sugars e.g. glucose.

   Accept: co-transport (with H^+ ions).
2. By companion/transfer cells;
3. Lowers water potential in phloem/sieve element/tube **and** water enters by osmosis;
4. (Produces) high (hydrostatic) pressure;

   Accept: pressure gradient.
5. Mass flow/transport towards sink/roots/storage tissue;

   Accept: sieve element/tube.
6. At sink/roots sugars are removed/unloaded;

   Accept: at sink/roots sugars are used in respiration/stored.

5 max

[10]

7 ***(a)*** (i) ***(Both)***

1. Are polymers / polysaccharides / are made of monomers / of monosaccharides;
2. Contain glucose / carbon, hydrogen and oxygen;
3. Contain glycosidic bonds;
4. Have 1−4 links;

   Neutral: references to 'unbranched', insoluble, formed by condensation, flexible and rigid

   Are made of the monomer glucose = MP 1 and 2 = 2 marks
5. Hydrogen bonding (within structure).

   Ignore reference to H bonds between cellulose molecules

2 max

(ii) (Starch)

1. Contains <u>α / alpha</u> glucose;

   Assume 'it' refers to starch

   Accept: converse arguments only if linked directly to cellulose

   Accept: forms α glycosidic bonds
2. Helical / coiled / compact / branched / not straight;
3. 1,6 bonds / 1,6 branching;
4. Glucoses / monomers same way up;
5. No H-bonds <u>between</u> molecules;
6. No (micro / macro) fibres / fibrils.

2 max

(b) (i)

1. No / few organelles / very little cytoplasm / cytoplasm at edge / more room / hollow / large vacuole / large space / thick walls;

   Accept strong walls for thick walls

2. (So) easier / more flow / (thick / strong walls) resist pressure.

   Easier flow may be expressed in other ways e.g. lower resistance to flow

2

(ii)

1. Mitochondria release energy / ATP / site of respiration;

   ***Q** Reject: 'produce energy'*

   but accept produce energy in form of ATP

2. For <u>active</u> transport / uptake against concentration gradient.

   Note: no mark is awarded for simply naming an organelle

OR:

3. Ribosomes / rough endoplasmic reticulum produce(s) proteins;

   Concept of making proteins needed

4. (Proteins) linked to transport e.g. carrier proteins / enzymes.

2

[8]

8

(a) 1. Protein synthesis **and** cell wall synthesis **and** cell expansion stop at −0.7 / at a *higher* water potential than other two;

   If all 3 are correctly identified in marking point 1, accept 'the others / the other two' in marking point 2, and vice versa

2. Photosynthesis **and** stomatal opening stop at -1.5 / at a *lower* water potential than other three;

   Correct processes must be named in at least one of marking point 1 or marking point 2

   Where reference to water potential differences are made, they must be comparative, eg 'higher'

2

(b) 1. Stomata allow uptake of carbon dioxide;

2. Carbon dioxide used in / required for photosynthesis;

2

(c) 1. Growth involves cell division / cell expansion / increase in mass;

Marking point 1 is for the principle

2. Protein synthesis stops **so** no enzymes / no membrane proteins / no <u>named</u> protein (for growth / division);

Marking points 2, 3 and 4 require appreciation of 'why' before credit can be awarded

'named' protein must relate to proteins involved in growth or cell division

3. Cell wall synthesis stops **so** no new cells can be made;

Full credit is possible without a statement of the principle (marking point 1)

4. No cell expansion / increase in mass **because** (cells) stop taking up water;

3 max

[7]

9 (a) Any **three** from:

1. Light;

2. Carbon dioxide;

3. Type of soil;

4. Minerals / nutrients;

Accept named example

5. Water (in soil);

6. Humidity (of air);

7. pH (of soil)

8. Planting density;

Idea of equally spaced

3 max

(b) Already levelled out (before 20 °C);

1

(c) Young leaves (may) have different number of stomata (per mm^2) / number of stomata (per mm^2) changes during development (of leaf);

Accept reference to density of stomata

1

(d) Any **two** from:

Points 1 and 2 need context of ‘more’

1. Molecules have more <u>kinetic</u> energy;

   Accept <u>K</u>E

2. Faster diffusion of water / more evaporation of water (as temperature increases in leaf);

   For this point, diffusion must relate to movement of water

3. For this point, diffusion must relate to movement of water

2 max

[7]

10 (a) Open / use tap / add water from reservoir;

1

(b) 1. Seal joints / ensure airtight / ensure watertight;

Answer must refer to precautions when setting up the apparatus

Ignore: references to keeping other factors constant

2. Cut shoot under water;

3. Cut shoot at a slant;

4. Dry off leaves;

5. Insert into apparatus under water;

6. Ensure no air bubbles are present;

7. Shut tap;

8. Note where bubble is at start / move bubble to the start position;

2 max

(c) 1. Water used for support / turgidity;

Accept: water used in (the cell’s) hydrolysis or condensation (reactions) for one mark. Allow a named example of these reactions

2. Water used in photosynthesis;

3. Water produced in respiration;

4. Apparatus not sealed / ‘leaks’;

2 max

(d) As number of leaves are reduced (no mark),

Accept: converse arguments

1. Less surface area / fewer stomata;

3. Less evaporation / transpiration;

4. Less cohesion / tension / pulling (force);

3

[8]

11 (a) 1. The more recent the sample the greater the concentration;

Accept converse

This could be expressed by reference to time e.g. 'concentration has increased since 25 000 years ago

2. Increases most in last 5000 years / more or less constant / slight increase between 30 000 and 15 000 years ago;

2

(b) 1. Variation in data / spread of data;

Reject references to range e.g. 'range of data'

2. Around the mean;

Both marks are possible in the context of using the data

2

(c) 1. Yes as pine leaves not in organic matter of the same age;

2. No as organic matter would be the same age as the pine leaves;

Accept either approach

1 max

(d) Can get more CO_2 for <u>photosynthesis</u>;

More CO_2 enters leaf is insufficient.
Accept light-independent (reaction) as equivalent

1

(e) Any **three** from:

1. (Overall data show) negative correlation;
   Do not allow description of correlation because in question stem

2. Little change in number of stomata in last 10 000 years;

3. Small sample size;

4. Only one species studied;

5. Other factors / named factor may have affected number of stomata;

6. Evidence does not support the conclusion between 30 000 and 25 000 years ago / between 5000 years ago and present day;
   Accept reference to either one of these age ranges

7. Appropriate reference to standard deviations (in comparing means);
   E.g. no overlap between 15 000 and 10 000 years ago

3 max

(f) Any **three** from :

1. Thick cuticle;

2. Small leaves / low surface area;
   Accept other ways of describing 'small', e.g. 'needle-like'

3. Hairy leaves;

4. Sunken stomata;

5. Rolled leaves;

3 max

[12]

12 (a) (i) 1. Stomata open;
Allow converse

2. Transpiration highest around mid-day as middle of day warm<u>er</u> / light<u>er</u>;
2. Allow 'Sun is at its hottest'

3. (Increased) tension / water potential gradient;
Ignore 'pull, suck'

3

(ii) (Inside xylem) lower than atmospheric pressure / (water is under) tension;
Accept cohesion tension. Ignore vacuum

1

(b) (i) High pressure / smoothes out blood flow / artery wall contains more collagen / muscle / elastic (fibres) / connective tissue;

Accept converse for pulmonary vein

Incorrect function of artery disqualifies mark

1

(ii) 1. (Aorta wall) stretches because ventricle / heart contracts / systole / pressure increases;

1. Allow expand

2. (Aorta wall) recoils because ventricle relaxes / heart relaxes / diastole / pressure falls;

2. Allow spring back

Reject any reference to contract / relax in MP1 and 2

3. Maintain smooth flow / pressure;

3

(iii) Aorta 1.2 / largest SD;

Allow pulmonary vein provided candidate relates standard deviation to mean

1

(c) Formation

1. High blood / hydrostatic pressure / pressure filtration;

2. Forces water / fluid out;

2. Reject plasma, ignore tissue

3. Large proteins remain in capillary;

Return

4. Low water potential in capillary / blood;

5. Due to (plasma) proteins;

6. <u>Water</u> enters capillary / blood;

7. (By) <u>osmosis</u>;

7. Osmosis must be in correct context

8. Correct reference to lymph;

6 max

13 (i) 1. Increases then decreases;

Allow peak / maximum at any time between 13.00 - 14.00 or 7.8 - 8.0;

2. Peak / maximum at 13.00 / 14.00 (hours) / 7.8 - 8.0;

2

[15]

(ii) 1. Maximum / overall rate is higher (in branches);

Allow converse for all marking points.

2. Reaches maximum / peak earlier (in the day) (in branches);

3. Starts higher / ends lower (in branches)

2

(iii) 1. Movement starts / peaks earlier in branches / higher up;

2. Creates tension / 'negative pressure' / 'pull'

2

[6]

14 (a) Light;

Humidity / moisture in air;

Air movement / wind;

Temperature;

2 max

(b) Decreases chance of error / larger difference in mass / improves accuracy / precision;

Neutral: Reliability, references to anomalies.

1

(c) 1. Stomata open, (water) transpired / evaporates / diffuses out (via) water potential gradient / leaf has higher water potential;

2. Water potential / diffusion gradient reduces (during investigation) as water not being replaced / no water supply;

3. Stomata close / closing;

Must clearly indicate that stomata are open for third marking point. However, allow correct descriptions of guard cells being turgid or flaccid as being equivalent to stomata being open or closed. ‘Loss through stomata’ on its own is not sufficient.

Neutral: Any reference to ‘loss by osmosis’.

3

(d) Stomata (on upper surface) covered / stomata close due to lack of light / (grease provides) longer diffusion pathway;

Less evaporation / transpiration / diffusion out;

Accept: Evaporation / transpiration / diffusion ‘stops’ for second point as this could be referring to upper surface.

2

[8]

15 (a) (i) 1. Removes water vapour / moisture / saturated air;

2. Increases water potential gradient / more diffusion / more evaporation;

2

(ii) 1. Increases kinetic energy so water molecules move faster;

2. Increases diffusion / evaporation;

2

(b) (i) Positive correlation / as light intensity increases so does rate of water movement / follows same pattern / directly proportional;

1

(ii) 1. Stomata open and photosynthesis increases / transpiration increases;

2. More water pulled up due to cohesion between water molecules / by cohesion tension;

2

(iii) 1. Water pulled up trunk / moves up at fast rate under tension;

2. Sticking / adhesion (between water and) cells / walls / pulls xylem in;

Adhesion is not a specification requirement.

Accept cohesion in this context

2

(c) Elastic tissue

1. Elastic tissue stretches under pressure / when heart beats then recoils / springs back;

2. Evens out pressure / flow;

Do not allow credit for expands / contracts / relaxes in this context.

From a marking viewpoint ignore all specific references to arteries and arterioles. Consider all points as applying to both.

2 Do accept controls

Muscle

3. Muscle contracts to reduce diameter of lumen / vasoconstriction / constricts vessel;

4. Changes flow / pressure;

Epithelium

5. Epithelium smooth;

6. Reduces friction / blood clots / less resistance;

6

[15]

16 (a) Single layer of cells / few layers of cells;

So that light that can pass through / cells absorb light;

2

(b) Method of determining area of field of view / area seen using microscope;

Count number of stomata in field of view;

Repeats and calculation of mean;

3

(c) Water <u>vapour</u> accumulates / increased humidity / reduced air movement (around stomata);

Water potential / diffusion gradient reduced;

2

[7]

17 (a) 235–240;;

(one mark for an answer between 200-300

based on 2 - 3 stomata in 0.01mm^2

Alternatively, one mark for calculating the area of the

rectangle correctly as 0.016 – 0.017mm^2)

2

(b) grows in arid / dry conditions;

less surface area;

(rate of) transpiration / water loss would be reduced;

3

[5]

18 (a)

1. (when light intensity is increased) tension in the xylem becomes greater / more negative / stronger;
2. (this increase) takes place over ≈100 second;
3. then levels out;
4. stomata open (more);
5. increased evaporation / transpiration;
6. therefore the water potential of leaf cells becomes more negative / lower;
7. therefore more water moves from xylem to surrounding cells;
8. down a water potential gradient;
9. correct ref. to hydrogen bonds / cohesion;

5 max

(b) humidity will affect (the rate of) evaporation / transpiration;

increased humidity / humid conditions decreases rate of water loss;

2

[7]

19 (a) Light (intensity) / temperature / air movement / humidity;

1

(b) Prevent air entering / continuous water column;

Allow answer in context of shoot, xylem or potometer.

1

(c) Distance and time;

Reject 'amount bubble moves'

1

Radius / diameter / area (of capillary tube);

1

(d) (used to provide) turgidity / support / description of;

(used in) photosynthesis / (produced in) respiration;

Apparatus not sealed / 'leaks';

2 max

(e) (i) Returns bubble (to start);

1

(ii) Increases reliability (of results) / anomalous result can be identified;

Q *Ignore references to validity / precision / accuracy etc.*

1

[8]

20 (a) increased humidity leads to decreased transpiration;
high humidity means more water in the air / increased saturation / increased water potential;
reduced diffusion gradient / water potential gradient;
slower rate of water loss / less evaporation;

3 max

(b) thick cuticle;
impermeable to water / waterproof;

sunken stomata;
reduces water diffusion gradient;

shape of leaf / rounded / small surface area;
small surface area : volume ratio;

(explanation must be linked to feature)

4 max

[7]

21 (a) 1. water <u>evaporates / transpires</u> from leaves;
2. reduces water potential in cell / water potential / osmotic gradient across cells *(ignore reference to air space)*;
3. water is drawn out of xylem;
4. creates tension *(accept negative pressure, not reduced pressure)*;
5. cohesive forces between water molecules;
6. water pulled up as a column;

4 max

(b) (i) same surface area of leaf / number of leaves / age / thickness of cuticle;

1

(ii) (environmental conditions) affect rate of transpiration / evaporation;

1

(iii) presence of grease reduces water loss;

1

(c) (i) 1.2 / 1.3g;

1

(ii) more stomata on the lower surface;
(thicker) waxy cuticle on the upper surface;

2

[10]

22 (a) (i) unrestricted / free / quick / easy water flow / continuous column / maintains transpiration stream;

1

(ii) resists tension in water (column) / provides support / strength / maintains column of water / adhesion / prevents water loss
(allow waterproofing in correct context i.e. not absorbing);

1

(b) (i) as total area of stomata decreases the rate of water flow decreases / <u>decrease</u> is proportional;
(reject proportional, 'as one goes up the other goes up' and 'same shape')

1

(ii) <u>increasing / higher</u> temperature causes <u>increasing / higher</u> rate of evaporation / transpiration;
(*not water loss*)

1

(iii) lower plateau (start and finish at same point);
(allow *if curve sketched on original graph, reject 'curve is lower'*)

1

(c) conserves water / reduces water loss / reduces transpiration / reduces evaporation;
high humidity (in pit) / reduced water potential gradient / less water blown away / increased diffusion pathway;

2

[7]

23 (a) (i) rate of flow increases to max at 1200 and then decreases;
increasing transpiration / evaporation from leaves;
transpiration creates tension / increases transpirational pull;
water molecules are cohesive / stick together;
produces a water column;

3 max

(ii) (increase transpiration) produce a higher tension / reduces the pressure in the xylem reducing the diameter / adhesive forces between xylem and water;

1

(b) water moves in dead cells / xylem is non-living tissue;
the process is passive / no energy is needed;

2

[6]

24 (a) shallow roots enable rapid uptake of rainfall (in **X** and / or **Z**);
widespread / shallow roots allow collection of larger volume water / over a larger area / rapid uptake of water (in **Z**);
swollen stem for water storage (in **X**);
deep roots for accessing deep groundwater (in **Y**);
small / no leaves so little transpiration;

3

(b) **Z**;
wide spread of roots for rapid water absorption;
(accept **X**; if linked to leaves channelling water to roots)
(ignore references to water storage abilities)
(accept other responses if justified)

2

[5]

25 (i) (waxy so) impermeable to water / waterproof / stops water passing through;

1

(ii) reference to hairs / position of stomata (sunken stomata / stomata in pits)
LINKED to reduced air movement / trap layer of air / trap water vapour (*reject water) /* maintains humidity;

reduces diffusion gradient / concentration gradient of water / water potential gradient;

OR

stoma can close;
reduces area for evaporation or transpiration;

2

[3]

26 (a) long cells / tubes with no end walls;
continuous water columns;
no cytoplasm / no organelles / named organelle;
to impede / obstruct flow / allows easier water flow;
thickening / lignin;
support / withstand tension / waterproof / keeps water in cells;
pits in walls;
allow lateral movement / get round blocked vessels;

4 max

(b) (i) increase in transpiration rate / evaporation due to increase in temperature ;
increased (kinetic) energy of water molecules;

OR

increase in light (intensity) increases transpiration rate / evaporation;

greater stomatal aperture / more stomata open so increase in flow rate due to cohesion / attraction of water molecules;

2 max

(ii) adhesion / attraction of water molecules to walls of xylem;
results in tension as water pulled up stem;
pulling in walls;

2

[8]

27

(a) 1. Diameter of trunk minimal at warmest / brightest time of day / midday = warmest / brightest;
2. Stomata open in light → more water loss;
3. Water evaporates more when warm / more heat energy for water evaporation;
4. Hydrogen-bonding between water molecules / cohesion (/ described) between water molecules;
5. Adhesion (described) between water molecules and walls of xylem vessels;
6. (Xylem) pulled inwards by faster flow of water / pulled in by tension;

6

(b)

Feature	Explanation
Think cuticle / wax layer	waterproof / impermeable;
Sunken stomata	saturated layer of still air outside;
Hairy	saturated layer of still air outside;
Leaves small / reduced to spines / needles	reduced S.A. for water loss;
Leaves roll up in dry weather	less S.A. for water loss / stomata covered / saturated region of still air;
Reduced number of stomata	reduced S.A. for water loss;
CAM (/ Crassulacean Acid Metabolism)	stomata closed in light / in warm / only open in dark / when cool;

3 features but no explanations – max 1 mark

max 3

[9]