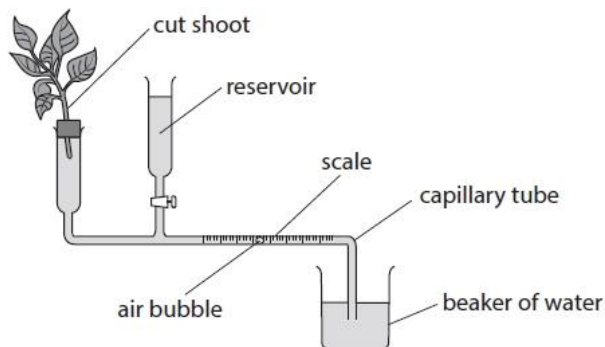


Questions

Q1.

Water moves through xylem vessels in a plant during transpiration.

A student used the potometer shown in the diagram to investigate the rate of water uptake in a leafy shoot.



The student investigated the effect of a combination of environmental conditions on the rate of water uptake.

The table shows the results of this investigation.

Conditions	Distance moved by the bubble in 5 minutes / cm					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
Still air, in light	2.4	2.2	2.2	2.2	2.1	2.2
Moving air, in light	6.5	6.7	6.4	6.2	6.3	6.4
Still air, in dark	0.9	0.4	0.0	0.0	0.0	0.3
Moving air, in dark	1.7	0.8	0.0	0.0	0.0	0.5

(i) The internal diameter of the capillary tubing is 0.3 mm.

The volume of a cylinder is calculated using the formula

$$\pi r^2 h$$

Calculate the mean rate of water uptake for the shoot in moving air, in the light.
Give your answer in $\text{mm}^3 \text{min}^{-1}$ to two significant figures.

(3)

Answer $\text{mm}^3 \text{min}^{-1}$

(ii) Analyse the data to explain the results of this investigation.

(3)

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(iii) Describe how this investigation could be modified to make a valid comparison of water loss from the upper and lower surfaces of the leaves.

(4)

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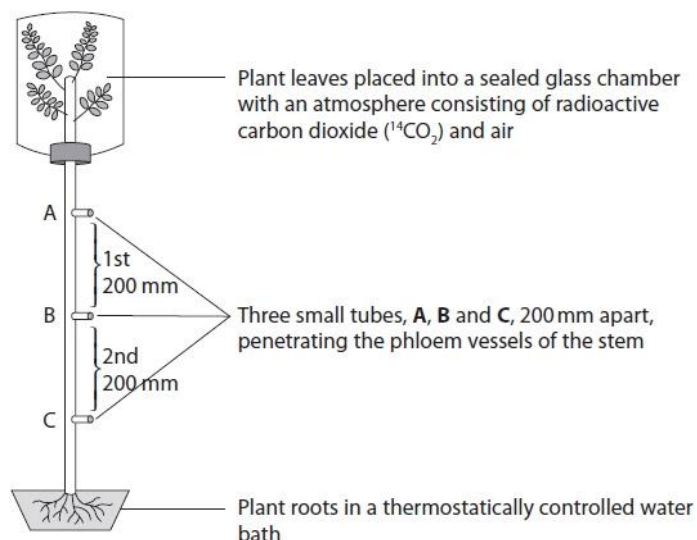
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(Total for question = 10 marks)

Q2.

The effect of root temperature and oxygen on the movement of sucrose through a plant was investigated using the apparatus shown in the diagram.



The water bath was set at 10°C and a solution from each of the small tubes was collected. The time taken for radioactive sucrose to travel the first 200 mm and the second 200 mm was recorded.

The experiment was repeated at 20°C and 30°C .

The whole experiment was then repeated replacing the air with nitrogen gas (N_2).

The results are shown in the table.

Glass chamber containing	Temperature of roots / $^\circ\text{C}$	Time taken for sucrose to travel 200 mm / hr			Mean rate of sucrose transport / mm hr^{-1}
		From A to B	From B to C	Mean	
$^{14}\text{CO}_2 + \text{air}$	10	3.25	3.50	3.38	59.17
$^{14}\text{CO}_2 + \text{air}$	20	2.35	2.45	2.40	83.33
$^{14}\text{CO}_2 + \text{air}$	30	1.75	1.83		
$^{14}\text{CO}_2 + \text{N}_2$	10	6.50	6.25	6.38	31.35
$^{14}\text{CO}_2 + \text{N}_2$	20	6.25	6.10	6.18	32.36
$^{14}\text{CO}_2 + \text{N}_2$	30	6.45	6.11	6.28	31.85

(i) Calculate the mean rate of sucrose transport when the plant is kept in $^{14}\text{CO}_2 + \text{air}$ whilst at 30°C .

Show your working.

(1)

Answer mm hr^{-1}

(ii) Analyse the data in the table to explain the effect of temperature and oxygen on sucrose transport.

(4)

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(Total for question = 5 marks)

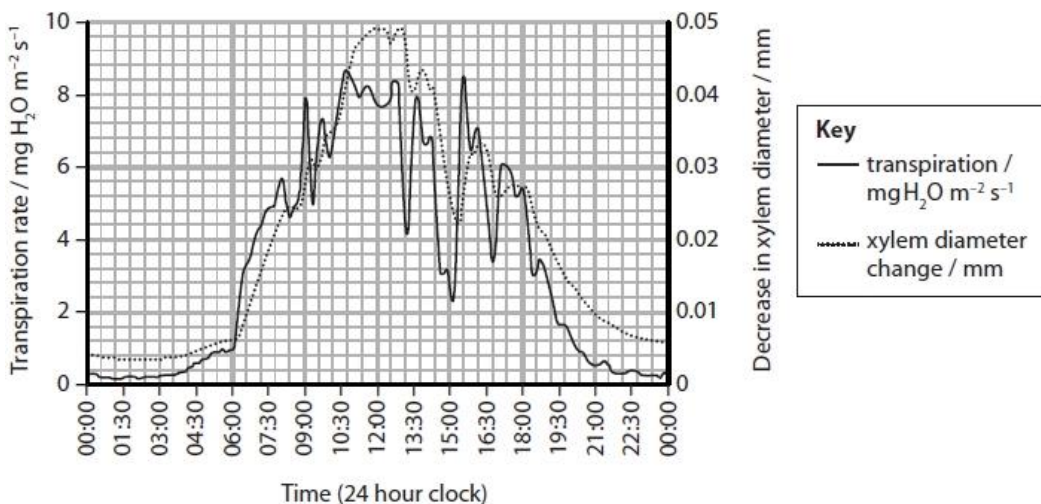
Q3.

* Scientists investigated the transpiration of pine trees over a 24-hour period.

The mass of water lost per second and the total area of the leaves were measured.

The decrease in diameter of xylem vessels was also measured over the same 24 hours.

The results are shown in the graph.



Using your knowledge of cohesion-tension theory, explain the changes in xylem diameter and transpiration rate over the 24-hour period.

(6)

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(Total for question = 6 marks)

Q4.

Water enters a plant through root hair cells and then travels by the apoplastic and by the symplastic pathways.

Describe the differences between the apoplastic and the symplastic pathways.

(3)

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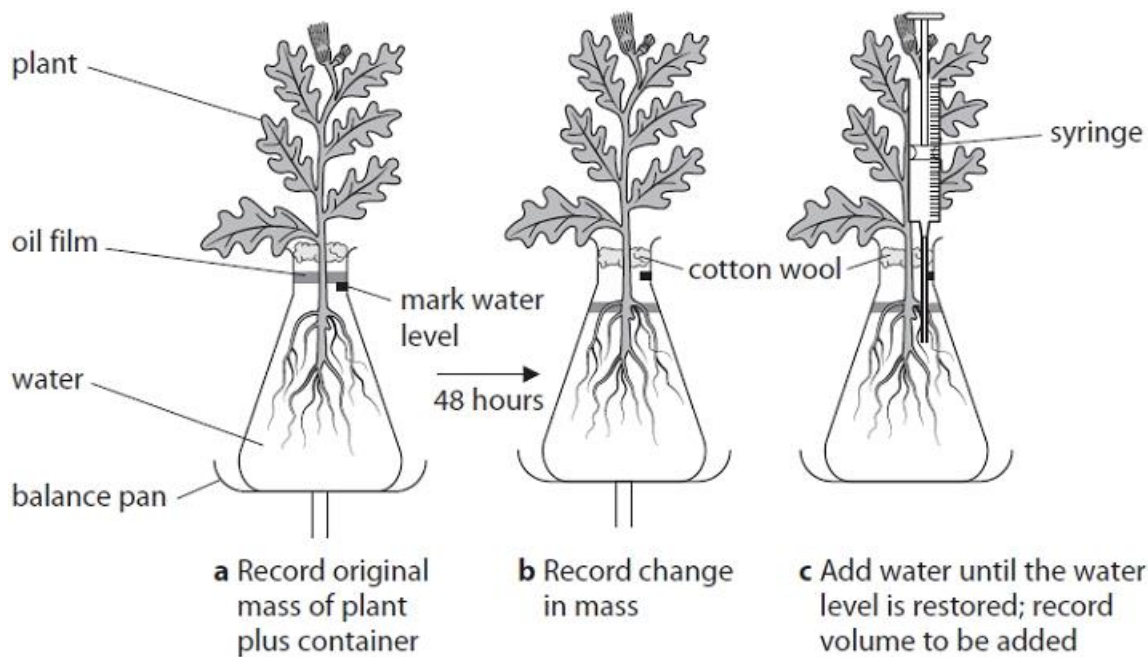
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(Total for question = 3 marks)

Q5.

An experiment was carried out to measure the rate of uptake and loss of water in a plant, using a mass potometer.

A plant with roots was set up in a flask on a balance and the mass of the plant and apparatus was recorded as shown in the diagram.



The plant was left for 48 hours and the change in mass and volume of water that the plant had absorbed were measured.

The results showed that the plant had lost 3.1 g in 48 hours.

A volume of 3.2 cm³ of water was added to restore the original water level in the flask.

In which of these conditions would water uptake be slowest?

- A** cold, dry and bright conditions
- B** cold, humid and dark conditions
- C** warm, dry and bright conditions
- D** warm, humid and bright conditions

(1)

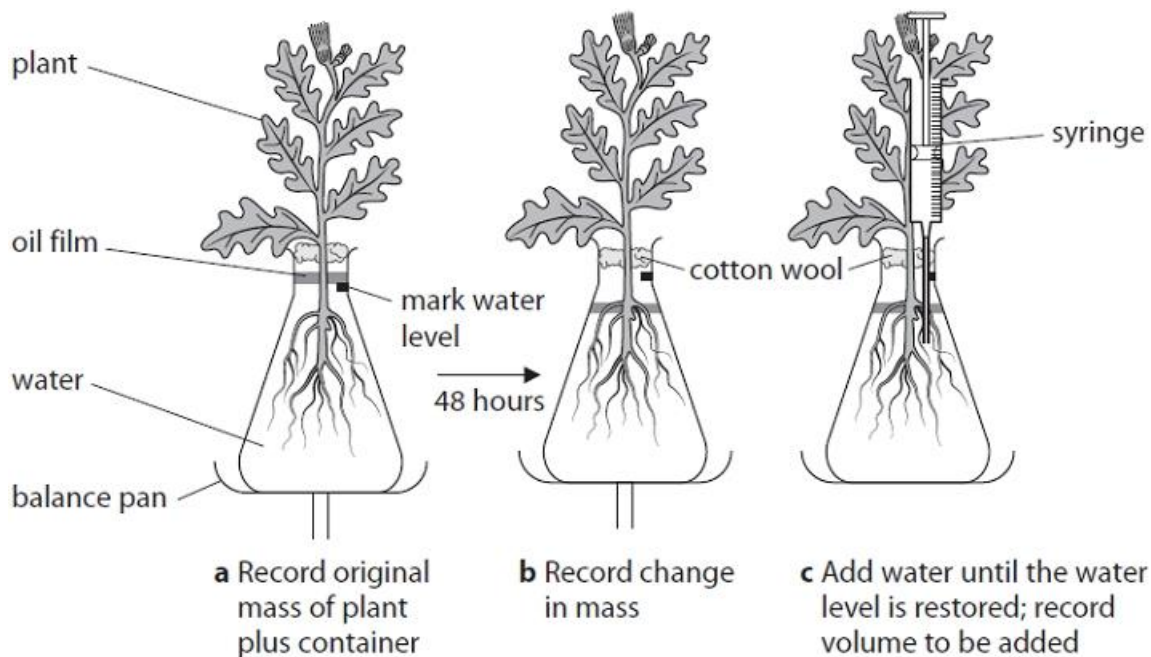
(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

An experiment was carried out to measure the rate of uptake and loss of water in a plant, using a mass potometer.

A plant with roots was set up in a flask on a balance and the mass of the plant and apparatus was recorded as shown in the diagram.



The plant was left for 48 hours and the change in mass and volume of water that the plant had absorbed were measured.

The results showed that the plant had lost 3.1 g in 48 hours.

A volume of 3.2 cm³ of water was added to restore the original water level in the flask.

The correct conclusion from these results is

- A** the plant absorbed more water than it lost
 B the plant lost more water than it absorbed
 C the rate of respiration and photosynthesis are the same
 D the rate of transpiration and absorption are the same

(1)

(Total for question = 1 mark)

Q7.

The photograph shows a wombat, an animal that lives in dry parts of Australia.



Source: © Blue Gum Pictures/Alamy Stock Photo

Wombats are herbivores, feeding on grasses, leaves and bark. Wombats also dig in the soil for roots.

They have behavioural and physiological adaptations to survive periods of severe drought.

The effect of drought on the health of wild wombats was investigated.

Changes in body mass, body condition and the chemical constituents of stomach contents and faeces were recorded.

These changes were related to the changes in the quality and quantity of the food of wombats.

Explain why drought affects the quality and quantity of the food of wombats.

(5)

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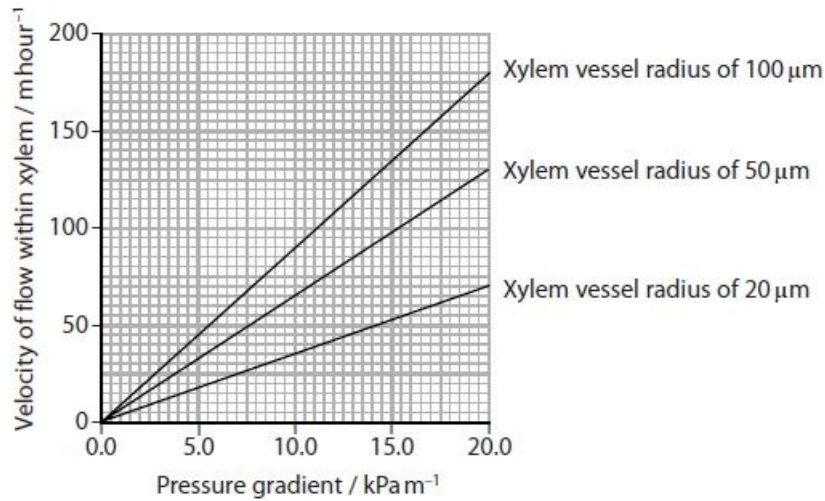
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(Total for question = 5 marks)

Q8.

Xylem and phloem are involved in transport in plants.

The graph shows the effect of pressure gradient on the velocity of flow within three xylem vessels.



(i) Describe the effect of pressure gradient and radius on the velocity of flow within the xylem vessels.

(2)

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(ii) Calculate the percentage increase in the velocity of water flowing through a xylem vessel of radius 20 μm and a xylem vessel of radius 100 μm, at a pressure gradient of 17.5 kPa m⁻¹.

(2)

Answer

(Total for question = 4 marks)

Q9.

Water enters a plant through root hair cells and then travels by the apoplastic and by the symplastic pathways.

To grow plants successfully in a glasshouse, the humidity needs to be controlled because the humidity would be higher in the summer than in the spring.

Explain why the humidity in a glasshouse would be higher in the summer than in the spring.

(5)

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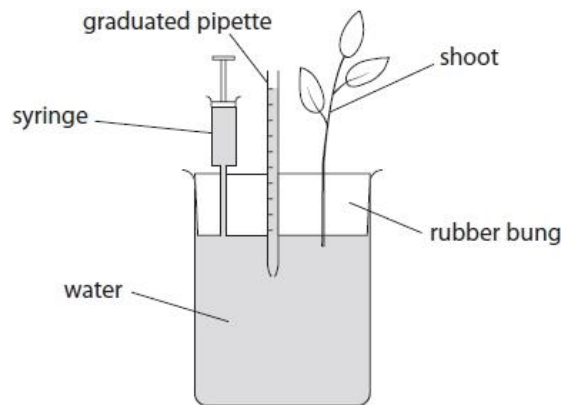
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(Total for question = 5 marks)

Q10.

The diagram shows a type of potometer.



(Source from: Science and Plants for Schools: www.saps.org.uk)

The leaves of the shoot must be kept dry when assembling the potometer under water in a sink.

The syringe plunger is pushed down until the water level is raised to zero in the graduated pipette.

The water level in the graduated pipette is used to measure water uptake by the shoot.

(i) Explain why the apparatus should be assembled under water.

(2)

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(ii) Explain why the leaves must be kept dry whilst assembling the apparatus.

(2)

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(Total for question = 4 marks)

(ii) Describe how the bubble potometer can be used to investigate the effect of wind speed on the rate of water uptake.

(4)

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(Total for question = 8 marks)

Q12.

The primary productivity of plants depends on their ability to synthesise carbohydrates and transport solutes to cells.

Explain how the mass-flow hypothesis accounts for the movement of sugars from leaves to roots.

(4)

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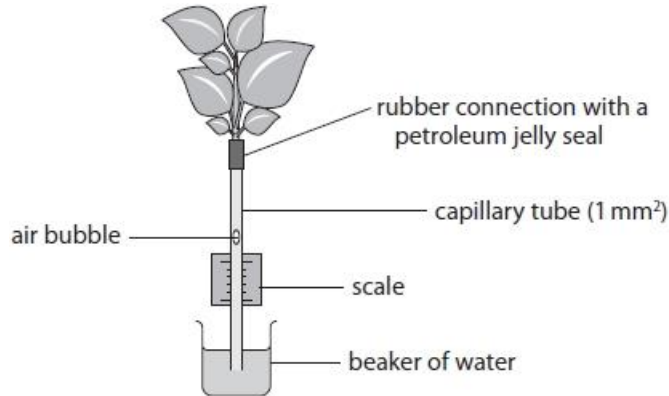
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(Total for question = 4 marks)

Q13.

A student investigated the effect of moving air on transpiration in a leafy shoot.

The diagram shows the potometer used by the student.



During the investigation, the air bubble moved off the scale very quickly.

Explain how this potometer could be modified to obtain repeat readings.

(2)

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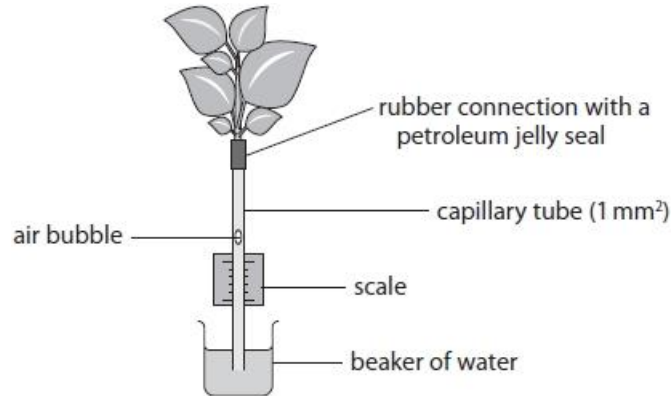
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(Total for question = 2 marks)

Q14.

A student investigated the effect of moving air on transpiration in a leafy shoot.

The diagram shows the potometer used by the student.



In this investigation, a leafy shoot was cut from a plant.

The leafy shoot was then put under water and the stem inserted into the rubber connection.

Explain how this procedure should be modified to produce accurate readings.

(2)

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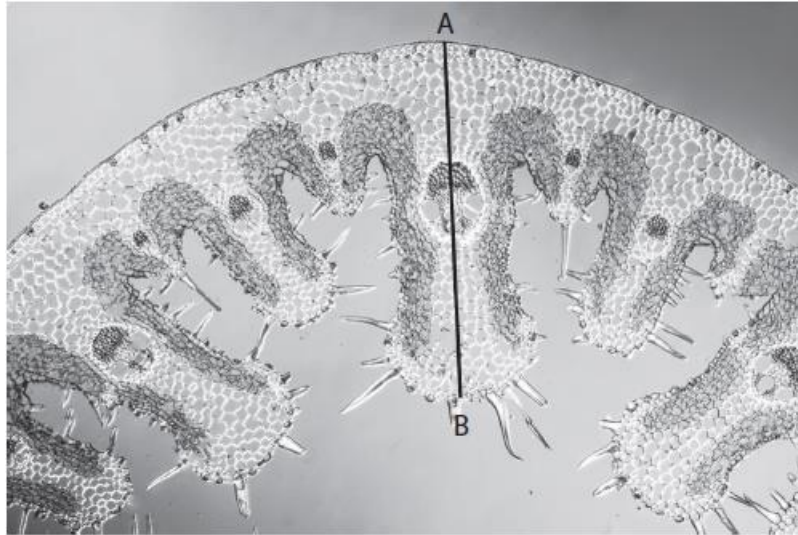
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(Total for question = 2 marks)

Q15.

The photograph shows a cross-section of a leaf from marram grass, *Ammophila arenaria*, as seen using a light microscope.



Source: © Dr. Norbert Lange/Shutterstock

Marram grass grows in sand dunes where little freshwater is available.

(i) The line AB shown on the actual leaf sample is 4 mm.

Calculate the magnification of the photograph.

(2)

Answer

(ii) Explain how **two** of these adaptations enable this plant to survive in dry sand.

(2)

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(iii) Marram grass also contains extra xylem tissue that strengthens the leaves.

Explain why these plants need extra xylem in their leaves.

(2)

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(Total for question = 6 marks)

Q16.

The rate of transpiration in plants can be measured using a potometer.

(i) Explain why the stem of a plant should be cut under water before it is inserted into a potometer.

(2)

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(ii) Which combination of the following factors would increase the rate of transpiration the most?

(1)

- A** high wind speed, low humidity, high temperature
- B** low wind speed, low humidity, high temperature
- C** high wind speed, high humidity, high temperature
- D** high wind speed, low humidity, low temperature

(Total for question = 3 marks)

Q17.

Water enters a plant through root hair cells and then travels by the apoplastic and by the symplastic pathways.

Herbicides are chemicals used to control the growth of weeds.

Herbicides that are absorbed from the soil also travel through the apoplastic and symplastic pathways.

The rate of absorption of herbicides is affected by their chemical properties.

(i) Explain how the properties of herbicide molecules affect their ability to pass through plant cell membranes.

(3)

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(ii) Some herbicides are applied to the soil.

Explain how these herbicides will be transported to the leaves.

(2)

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(Total for question = 5 marks)

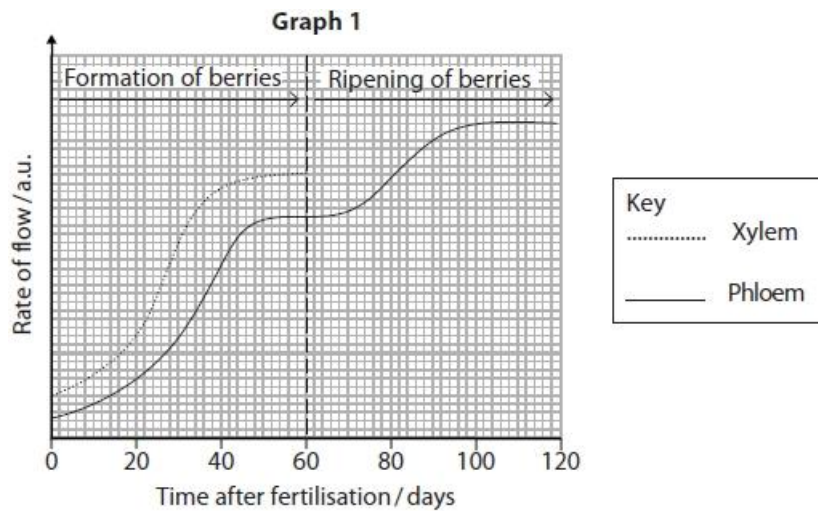
Q18.

Xylem and phloem are involved in transport in plants.

* Double fertilisation in some plants leads to the development of fruits, such as berries.

In an investigation, the rate of flow in xylem during the formation of berries was measured. The rate of flow in the phloem during the formation and ripening of the berries was also measured.

The results are shown in graph 1.

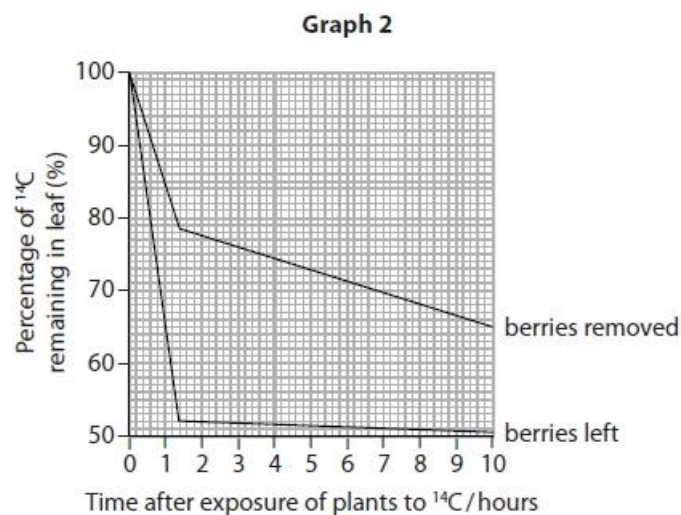


In a second investigation, two plants with berries were exposed to radioactive carbon dioxide (¹⁴C).

After exposure to ¹⁴C, the berries were removed from one plant and left on the second plant.

The percentage of ¹⁴C remaining in the leaves of each plant was determined during the next 10 hours.

The results are shown in graph 2.



Analyse the data to explain the role of double fertilisation, xylem and phloem in the development of the berries.

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(Total for question = 6 marks)

Q19.

Xylem and phloem are involved in transport in plants.

(i) Which row of the table shows some of the substances transported in xylem and phloem? (1)

	Xylem	Phloem
<input type="checkbox"/> A	water only	sucrose only
<input type="checkbox"/> B	water only	water and sucrose
<input type="checkbox"/> C	water and mineral ions	sucrose only
<input type="checkbox"/> D	water and mineral ions	water and sucrose

(ii) Describe the differences between the structure of xylem and that of phloem. (3)

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(Total for question = 4 marks)

Q20.

Which of the following shows the order of the structures a water molecule would pass through as it moves from the soil along the symplastic pathway in a root?

- A cell wall only
 - B cell wall, cell membrane, cytoplasm
 - C cytoplasm only
 - D cell membrane, cytoplasm, cell wall
- (1)

(Total for question = 1 mark)

Q21.

Water moves through xylem vessels in a plant during transpiration.

Phloem tissue is responsible for transport of organic materials such as sucrose.

Compare and contrast the structure of xylem tissue and phloem tissue.

(3)

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(Total for question = 3 marks)

Q22.

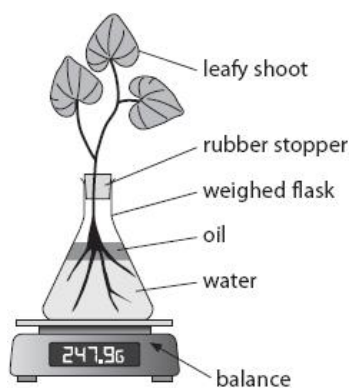
Mineral ions are transported from the soil into the cytoplasm of plant root cells.

The table shows the concentration of sodium ions and chloride ions in soil and in the cytoplasm of plant root cells.

Location	Ion concentration / mg dm^{-3}	
	Sodium	Chloride
soil	28	25
cytoplasm	1988	3750

Transpiration involves the loss of water vapour from leaves.

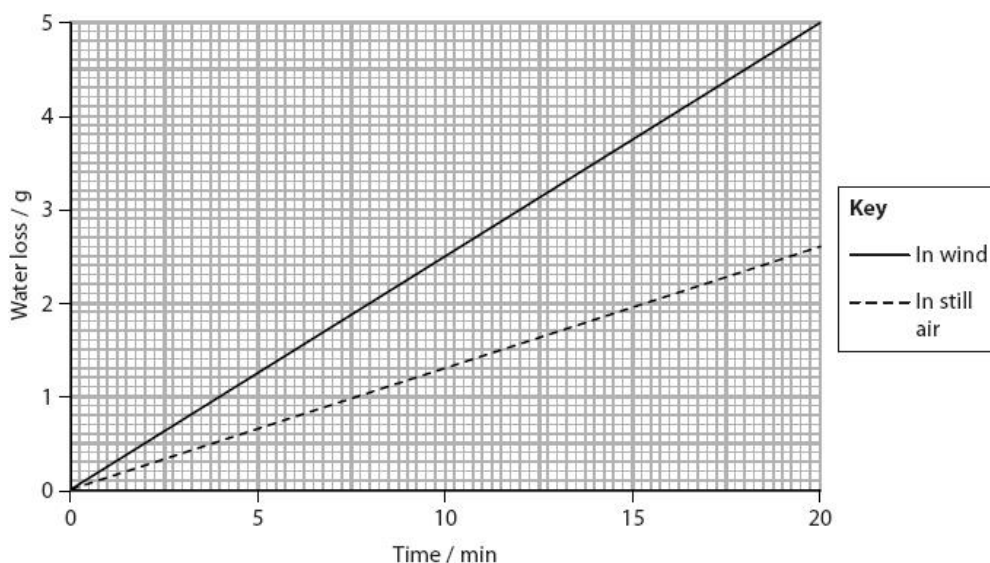
The rate of transpiration can be measured using the apparatus shown in the diagram.



A student used this apparatus to investigate how wind affected the rate of transpiration by a plant.

The mass of water lost by a plant was measured during a twenty-minute period in still air. This was repeated in wind.

The graph shows the results.



(i) Calculate the increase in the rate of water loss caused by wind.

(2)

Answer g min⁻¹

(ii) The student was told that this investigation was not valid because certain variables had not been controlled.

Explain how the student could modify this investigation to improve its validity.

(2)

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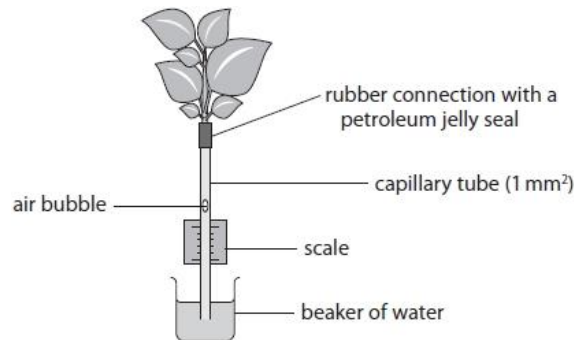
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(Total for question = 4 marks)

Q23.

A student investigated the effect of moving air on transpiration in a leafy shoot. The diagram shows the potometer used by the student.



The student measured the distance in millimetres that the air bubble moved during a five-minute period in moving air and in still air.

(i) Explain how the student could convert these readings into a transpiration rate using the units $\text{mm}^3 \text{cm}^{-2} \text{min}^{-1}$.

(3)

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(ii) The table shows the mean results and standard deviations of this investigation.

Mean rate of transpiration / $\text{mm}^3 \text{cm}^{-2} \text{min}^{-1}$	
In moving air	In still air
3.2 ± 0.3	0.8 ± 0.2

Explain the results of this investigation.

(2)

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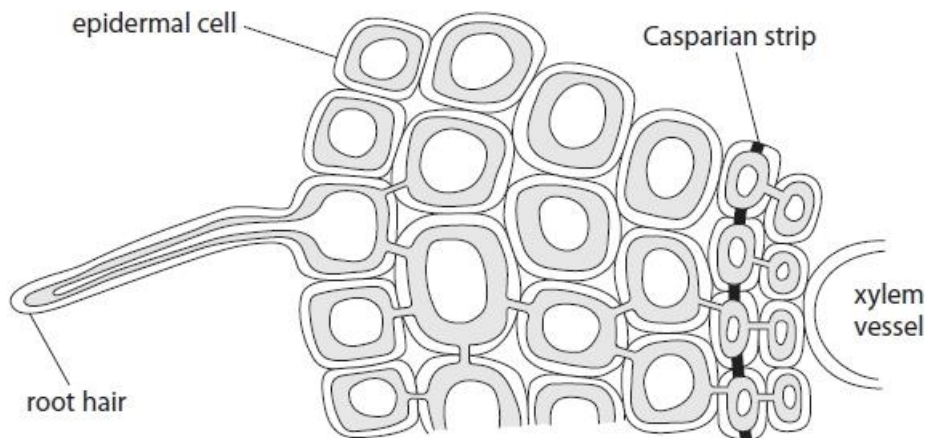
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(Total for question = 5 marks)

Q24.

Water can move through plant cells.

The diagram shows the cells in a plant root.



(Source from: https://cronodon.com/BioTech/Plant_Transport.html)

(i) On the diagram, draw the symplastic pathway that water takes from the soil to the xylem vessel.

(2)

(ii) The length of the root hair cell in the diagram is 60 mm.

The magnification of the diagram is $\times 100$.

Calculate the actual length of the root hair cell in micrometres.

(2)

Answer μm

(Total for question = 4 marks)

Q25.

Water can move through plant cells.

Explain how the cohesion-tension model accounts for the transport of water from plant roots to leaves.

(4)

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(Total for question = 4 marks)

(ii) This potometer measures the uptake of water by a plant shoot.

Give **two** reasons why the water lost by transpiration is less than the water taken up by the plant shoot.

(2)

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(Total for question = 6 marks)

Q27.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

Transpiration moves water and mineral ions from the roots to the leaves of plants.

Water enters the root hair cells and moves through the root tissues by the apoplastic and symplastic pathways.

(i) Root hairs have a large surface area that increases the rate of uptake of water.

The surface area of a root hair is rounded up to $3.14 \times 10^5 \mu\text{m}^2$.

Which is the actual surface area of this root hair?

(1)

- A 31 460 μm^2
 B 314 600 μm^2
 C 313 900 μm^2
 D 3 139 000 μm^2

(ii) Which row of the table shows the movement of water through the apoplastic and symplastic pathways?

(1)

	Apoplastic pathway	Symplastic pathway
<input type="checkbox"/> A		
<input checked="" type="checkbox"/> B		
<input type="checkbox"/> C		
<input type="checkbox"/> D		

(iii) Water moves through the root tissue due to a difference in water potential between one cell and the next cell.

Which row of the table describes this movement?

(1)

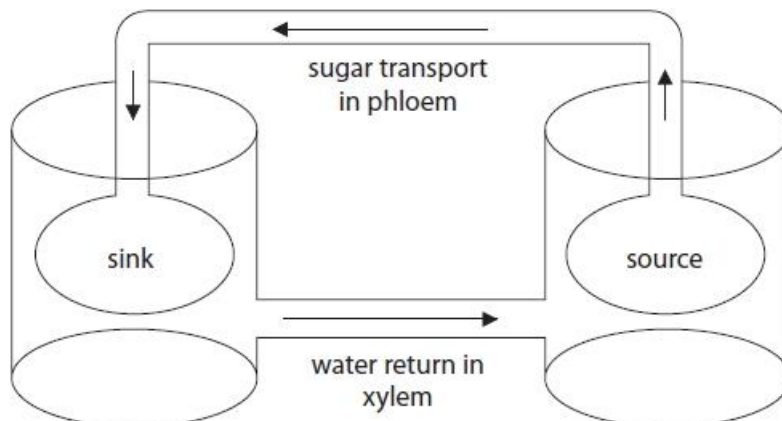
	Direction of water movement with respect to water potential	Direction of water movement with respect to concentration of solutions
<input type="checkbox"/> A	higher to lower	concentrated to dilute
<input type="checkbox"/> B	higher to lower	dilute to concentrated
<input type="checkbox"/> C	lower to higher	concentrated to dilute
<input type="checkbox"/> D	lower to higher	dilute to concentrated

(Total for question = 3 marks)

Q28.

Sucrose is synthesised and transported through plants.

The diagram represents the mass-flow hypothesis for sucrose transport in a plant.



Which row in the table shows the conditions present in the sink and the source of a plant carrying out rapid photosynthesis?

(1)

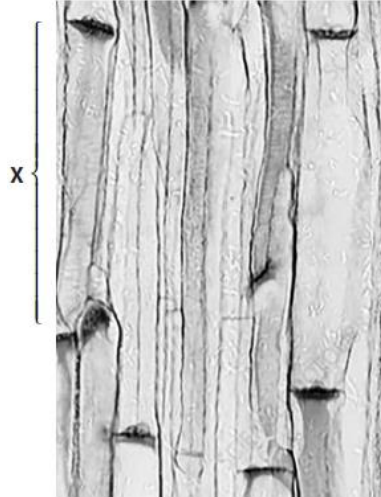
	Sink		Source	
	Sucrose concentration	Water potential	Sucrose concentration	Water potential
<input type="checkbox"/> A	high	low	high	low
<input type="checkbox"/> B	high	low	low	high
<input type="checkbox"/> C	low	high	high	low
<input type="checkbox"/> D	low	high	low	high

(Total for question = 1 mark)

Q29.

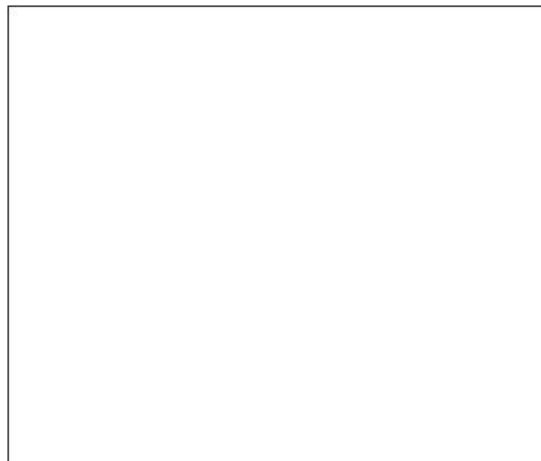
Plant stems contain xylem and phloem, tissues specialised for transport.

The photomicrograph shows a longitudinal section of phloem tissue.



(i) Draw the cell labelled **X**.

(2)



(ii) Explain how phloem tissue is adapted for its function.

(3)

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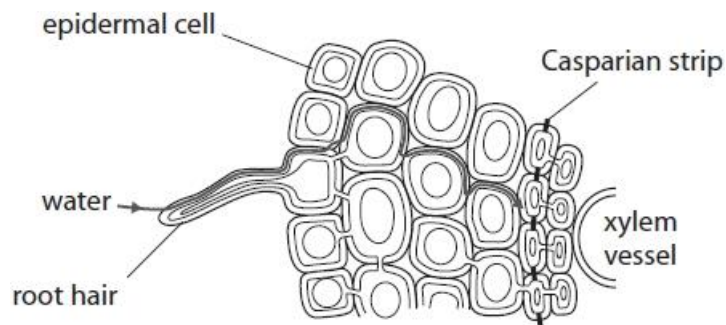
(Total for question = 5 marks)

Q30.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

The primary productivity of plants depends on their ability to synthesise carbohydrates and transport solutes to cells.

The diagram shows the movement of water across a root.



What is the name of the water movement pathway shown in the diagram?

(1)

- A apoplastic pathway
- B diffusion pathway
- C osmotic pathway
- D symplastic pathway

(Total for question = 1 mark)

Q31.

Mineral ions are transported from the soil into the cytoplasm of plant root cells.

The table shows the concentration of sodium ions and chloride ions in soil and in the cytoplasm of plant root cells.

Location	Ion concentration / mg dm ⁻³	
	Sodium	Chloride
soil	28	25
cytoplasm	1988	3750

Water is also taken up by plant root cells.

(i) Which of the following describes the pathway taken by this water before entering the xylem?

(1)

- A apoplast only
- B apoplast and symplast
- C neither apoplast nor symplast
- D symplast only

(ii) Explain how this water is transported in the xylem to the leaves.

(3)

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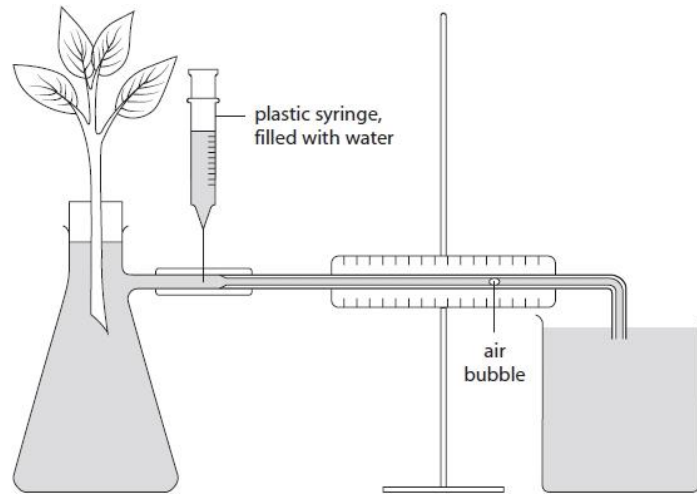
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(Total for question = 4 marks)

Q32.

The diagram shows apparatus used by a student to investigate water uptake by a leafy shoot.



This apparatus was used in a variety of environmental conditions and the following results were obtained.

Environmental condition	Rate of water uptake / mm min ⁻¹				
	minute 1	minute 2	minute 3	minute 4	Mean
control	20	19	17	21	19
increased humidity	14	14	15	16	15
increased wind speed	26	24	25	25	25
increased air temperature	26	28	26	25	
lower light intensity	17	16	15	17	16
removal of 50% of leaves	10	12	11	11	

(i) Give the name of the apparatus.

(1)

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(ii) Explain **one** precaution that needs to be taken when setting up this apparatus before it can be used to measure the water uptake of the leafy shoot.

(2)

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(iii) Explain why the water uptake of the leafy shoot may not be the same as the water transpired.

(2)

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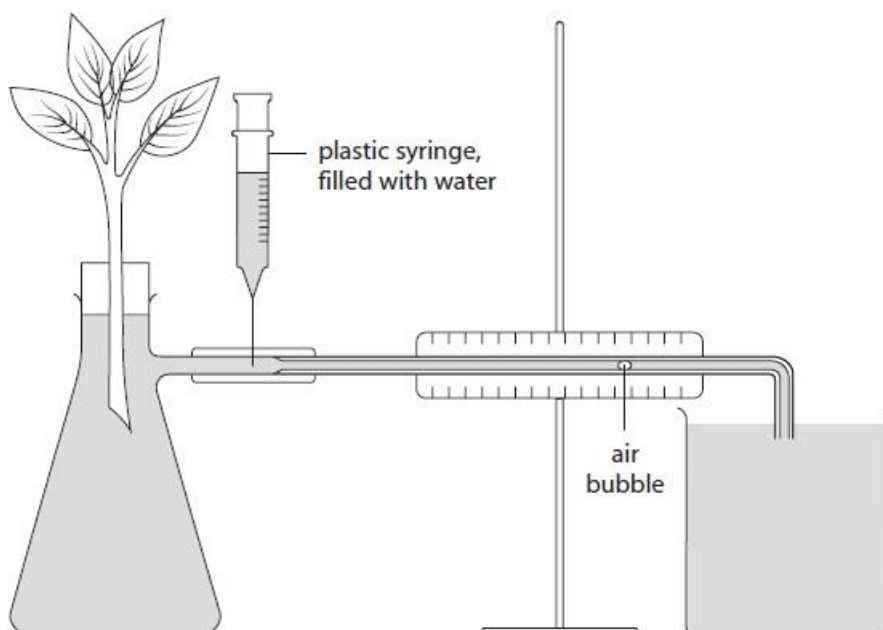
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(Total for question = 5 marks)

Q33.

The diagram shows apparatus used by a student to investigate water uptake by a leafy shoot.



Environmental condition	Rate of water uptake / mm min ⁻¹				
	minute 1	minute 2	minute 3	minute 4	Mean
control	20	19	17	21	19
increased humidity	14	14	15	16	15
increased wind speed	26	24	25	25	25
increased air temperature	26	28	26	25	
lower light intensity	17	16	15	17	16
removal of 50% of leaves	10	12	11	11	

Determine which condition produced the greatest change in the mean rate of water uptake.

(2)

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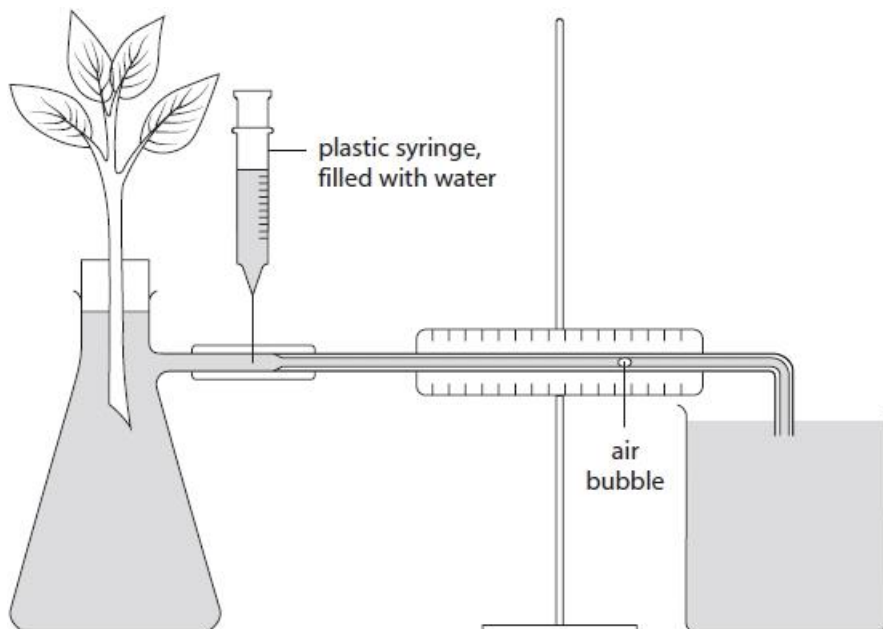
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.....

(Total for question = 2 marks)

Q34.

The diagram shows apparatus used by a student to investigate water uptake by a leafy shoot.



Environmental condition	Rate of water uptake / mm min ⁻¹				
	minute 1	minute 2	minute 3	minute 4	Mean
control	20	19	17	21	19
increased humidity	14	14	15	16	15
increased wind speed	26	24	25	25	25
increased air temperature	26	28	26	25	
lower light intensity	17	16	15	17	16
removal of 50% of leaves	10	12	11	11	

(i) State how the student could vary the humidity around the shoot.

(1)

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(ii) Give **one** way in which the temperature could be increased without affecting the validity of this investigation.

(1)

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(iii) Describe how the student would use the syringe to convert the results into a measure of the volume of water uptake in $\text{mm}^3 \text{min}^{-1}$.

(2)

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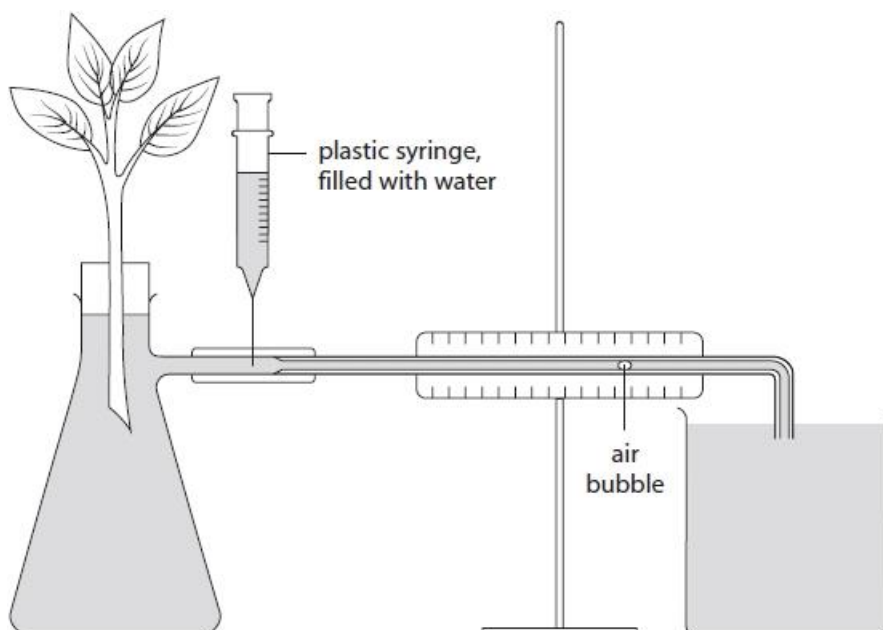
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(Total for question = 4 marks)

Q35.

The diagram shows apparatus used by a student to investigate water uptake by a leafy shoot.



Environmental condition	Rate of water uptake / mm min ⁻¹				
	minute 1	minute 2	minute 3	minute 4	Mean
control	20	19	17	21	19
increased humidity	14	14	15	16	15
increased wind speed	26	24	25	25	25
increased air temperature	26	28	26	25	
lower light intensity	17	16	15	17	16
removal of 50% of leaves	10	12	11	11	

Explain the effect of increasing humidity on the rate of water uptake by the leafy shoot.

(2)

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(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>A calculation that shows the following stages</p> <ul style="list-style-type: none"> • use manipulation of units to mm (1) • calculation of volume of cylinder (1) • rate per minute calculated to 2sf (1) 	<p>Example of calculation:</p> <p>eg mean is 64 (mm)</p> <p>4.522 / 4.524 (this gets mp1 and 2 if 64 not seen) 45.2 is correct value if 6.4 is used</p> <p>0.90</p> <p>Correct answer with no working gains 3 marks</p> <p>0.9 gets 2 marks (not 2sf) 0.09 gets 2 marks (if 6.4 is used for distance) 18 gets 2 marks (if diameter is used) 4.5 gets 2 marks (2sf if they do not divide by 5)</p>	Exp (3)
Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that includes three of the following</p> <ul style="list-style-type: none"> • {water uptake / transpiration} is fastest in moving air in the light (1) • {water uptake / transpiration} {is very slow / stops / decreases} in the dark as stomata close (1) • {water uptake / transpiration} is faster in moving air (than still air) as the diffusion gradient is {maintained / steeper} (1) • comment on decline in rate (of transpiration / water uptake) as trials continue in darkness with explanation (1) • effect of light is greater than effect of moving air (1) 	<p>Accept {water uptake / transpiration} is slowest in still air in the dark</p> <p>Not converse</p> <p>Accept concentration gradient / water potential gradient / diffusion shells around stomata or leaf Accept converse</p> <p>Accept stomata do not close completely until trial 3</p>	Exp (3)

Question Number	Answer	Additional Guidance	Mark
(iv)	<p>A description that includes four of the following:</p> <ul style="list-style-type: none"> cover one surface of leaves with vaseline / petroleum jelly / clear tape (to prevent transpiration) measure {rate / distance moved in 5 mins / volume of water taken up in 5 mins} (1) ensure that covering is fully removed or use another shoot with same surface area (1) repeat for other surface of leaves (and compare results) (1) method of control of one named variable / monitoring named variable which cannot be controlled (1) repeats for each set up and calculate standard deviation (1) 	<p>Accept clear nail varnish / clingfilm</p> <p>Accept other times Accept time how long it takes to move a set distance</p> <p>Accept same number of leaves / similar surface area Accept calculate rate of water loss per unit area</p> <p>Piece together</p> <p>Accept eg. temperature – AC room / room temperature humidity - clear bag over plant light intensity – distance from lamp air movement - distance from fan</p> <p>Accept repeat and carry out appropriate stats test eg t-test, 95% confidence limits, Mann Whitney U test</p>	Exp (4)

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	calculated mean (1)	<p><u>Example of Calculation</u></p> <p>$200 \div 1.79$</p> <p>$= 111.73$</p> <p>ACCEPT 111.7</p>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> change in temperature has {no / little (1) effect} in nitrogen increase in temperature in air increases rate of transport (1) because temperature affects enzyme activity / affects kinetic energy (of molecules) (1) oxygen increases rate of transport (1) because {transport/ loading of sucrose / translocation} is an {active process / requires respiration} (1) 	<p>ACCEPT converse statements</p> <p>ACCEPT no oxygen / not in air</p> <p>ACCEPT translocation is faster / time taken is less</p> <p>ACCEPT lack of oxygen reduces rate of transport</p>	(4)

Q3.

Question Number	Indicative content
*	<p>Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>P (Patterns)</p> <ul style="list-style-type: none"> rate of transpiration increases in the day fluctuations in rate of transpiration could be due to environmental changes (wind speed / rain / humidity / cloud cover / dehydration) change in pattern of xylem diameter follows the same trend as change in transpiration <p>R (reasons)</p> <ul style="list-style-type: none"> light causes stomata to open increase temperature increases kinetic energy reduced humidity increases concentration gradient increased wind speed increased / maintains concentration gradient evaporation from leaves reduces water potential in the leaves <p>C (cohesion tension)</p> <ul style="list-style-type: none"> water molecules are polar cohesion is due to hydrogen bonding between water molecules column of water is under tension as water evaporates evaporation causes pressure to decrease, narrowing the xylem

Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.
Level 2	3-4	An explanation will be given with occasional evidence of analysis and interpretation of two pieces of evidence.
Level 3	5-6	An analysis is made, which is supported throughout by sustained application of relevant evidence of analysis, and interpretation of the information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured
	Level 1 Level 2 Level 3	(P or R or C) (P and R) or (P and C) or (R and C) (P and R and C) For level 3 science must be correct

Q4.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that that makes reference to the following:</p> <ul style="list-style-type: none"> • apoplastic non-living (1) • apoplastic uses cell walls / intercellular spaces (1) • apoplastic {faster / less resistance} (1) • apoplastic by diffusion / passive (1) • apoplastic blocked by Casparian strip (1) 	<p>symplastic living</p> <p>symplastic uses protoplast / cytoplasm / cell membrane / plasmodesmata</p> <p>symplastic {slower / more resistance}</p> <p>symplastic by osmosis / active / affected by metabolism / cytoplasmic streaming</p> <p>symplastic does not have to cross Casparian strip</p>	(3)

Q5.

Question Number	Answer	Mark
	<p>The only correct answer is B</p> <p><i>A is not correct because bright conditions increase rate</i></p> <p><i>C is not correct because warm dry conditions increases rate</i></p> <p><i>D is not correct because warm and bright conditions increases rate</i></p>	(1)

Q6.

Question Number	Answer	Mark
	<p>The only correct answer is A</p> <p><i>B is not correct because it did not lose more water</i></p> <p><i>C is not correct because we have no information on this</i></p> <p><i>D is not correct because absorption and loss are not equal</i></p>	(1)

Q7.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to five of the following:</p> <ul style="list-style-type: none"> because there would be less water to take up from the soil (1) therefore there will be fewer {mineral ions / minerals} (transported to the rest of the plant / taken up) (1) example of a mineral ion deficiency on the plant explained (1) there will be less water for {photolysis / light-dependent reaction / photosynthesis} (1) therefore there will be less GALP produced in the {light-independent reaction / Calvin cycle} (1) therefore less {NPP / plant biomass} (1) 	<p>ACCEPT plants will {wilt / die} without water</p> <p>ACCEPT less glucose produced</p>	(5)

Q8.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> as the pressure gradient increases there is (a linear) increase in the velocity (for all three radii) (1) as the radius of the xylem increases the velocity increases (1) 	<p>ACCEPT converse for both points</p> <p>ACCEPT higher the pressure gradient the higher the velocity</p> <p>ACCEPT greater the radius the higher the velocity</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<ul style="list-style-type: none"> • velocities read from graph (1) • correct percentage calculated (1) 	<p>156 / 157 and 61 / 62</p> <p>$(156 - 61) \times 100 \div 61 = 155.73$ / 155.7 / 156 %</p> <p>$(156 - 62) \times 100 \div 62 = 151.61$ / 151.6 / 152 %</p> <p>$(157 - 61) \times 100 \div 61 = 157.38$ / 157.4 / 157 %</p> <p>$(157 - 62) \times 100 \div 62 = 153.23$ / 153.2 / 153 %</p> <p>CE applies if 155 / 158 and / or 63 given as values from graph</p> <p>$(155 - 61) \times 100 \div 61 = 154.1$ / 154 %</p> <p>$(155 - 62) \times 100 \div 62 = 150$ %</p> <p>$(155 - 63) \times 100 \div 63 = 146.03$ / 146 %</p> <p>$(156 - 63) \times 100 \div 63 = 147.62$ / 147.6 / 148 %</p> <p>$(157 - 63) \times 100 \div 63 = 149.21$ / 149.2 / 149 %</p> <p>$(158 - 61) \times 100 \div 61 = 159.02$ / 159 %</p> <p>$(158 - 62) \times 100 \div 62 = 154.84$ / 154.8 / 155 %</p> <p>$(158 - 63) \times 100 \div 63 = 150.79$ / 150.8 / 151 %</p>	(2)

Q9.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that that makes reference to four the following:</p> <ul style="list-style-type: none"> • summer is warmer / lighter (1) • therefore (more) evaporation / transpiration (1) • stomata open longer / open wider (1) • water molecules have more kinetic energy (1) • more leaf (area) (1) 	ACCEPT converse for spring	(5)

Q10.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to two of the following: <ul style="list-style-type: none">• keep air-tight so as to not allow any air bubbles to enter (1)• so that continuous column of water to connect leaves to water in potometer (1)		(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to two of the following: <ul style="list-style-type: none">• as water on leaves will prevent transpiration / diffusion / evaporation (1)• as no (diffusion / concentration) gradient (1)• as stomata are covered / occluded (by water) (1)		(2)

Q11.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that makes reference to the following:</p> <p>Similarities:</p> <ul style="list-style-type: none"> • both measure uptake of water (1) • both use seal to prevent evaporation (1) <p>Differences:</p> <ul style="list-style-type: none"> • bubble potometer uses shoot / mass potometer uses {plant with roots / plant} (1) • bubble potometer is {quicker to get results / allows repeats} / mass potometer takes longer (to get results) (1) • bubble potometer only measures water absorbed / mass potometer measures water absorbed and lost (1) 		(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A description that includes four of the following:</p> <ul style="list-style-type: none"> • measure distance bubble moves (1) • measure time / cm min^{-1} / $\text{cm}^3 \text{min}^{-1}$ (1) • method described to vary wind speed (1) • use same {light / temperature / humidity / carbon dioxide} (1) • repeat readings / calculate a mean (1) 	<p>ACCEPT change fan speed / use fan at different distances</p>	(4)

Q12.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer that makes reference to four from the following:</p> <ul style="list-style-type: none"> • sugars are loaded / pumped / transferred into phloem / sieve tubes in leaf (1) • lowering water potential so that water enters phloem (1) • pressure in phloem increases (moving sugars) (1) • sugars are converted to (insoluble) starch in root cells / low sugar concentration in root cells (1) • increasing the water potential, so water moves out (1) 		4

Q13.

Question Number	Answer	Additional Guidance	Mark
	<p>A explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • attach syringe / reservoir and (3-way) tap (1) • to return bubble to scale / reset bubble (1) <p>or</p> <ul style="list-style-type: none"> • use longer capillary tube / longer scale (1) • bubble on scale for longer (1) 		(2)

Q14.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> • dry leaves / do not put leaves under water (1) • because wet leaves reduce diffusion (1) <p>or</p> <ul style="list-style-type: none"> • {seal / use stem that fits} rubber connection (1) • therefore prevent loss of water from apparatus / maintain cohesion between water molecules (1) <p>or</p> <ul style="list-style-type: none"> • do not cut in air / cut under water (1) • prevents blocking xylem / prevent air getting into xylem / maintain {transpiration stream / water column / cohesion between water molecules} (1) 	<p>ACCEPT stem same size as capillary tube</p> <p>DO NOT ACCEPT entry of air</p>	(2)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> measurements of line AB and correct units (1) calculation of magnification (1) 	= 51 mm allow 50-52 mm ÷ 4mm = allow 12.75 allow range 12.5 -13 Correct answer gains full marks allow 1 mark for dividing by 4	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following points: <ul style="list-style-type: none"> curved leaves so stomata are on inside of leaf {decrease concentration gradient /increase humidity} (1) hairs reduce air movement (1) stomata in pits to {increase humidity / decrease concentration gradient} (1) (thick) waxy cuticle reduces water evaporation/ loss (from outer surface)(1) 	ACCEPT reduces transpiration rate	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to two of the following points: <ul style="list-style-type: none"> because it transports minerals (to the cells) (1) because it transports water (to the cells) (1) to support leaves to absorb light (1) 		(2)

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: <ul style="list-style-type: none"> • prevent {air / bubbles} entering the {stem / xylem} (1) • allowing water transport (to leaves) / water uptake / transpiration stream / breaks cohesion (1) 	ACCEPT oxygen IGNORE phloem Needs to be in appropriate context of transport	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	A (high wind speed, low humidity, high temperature)		(1)

Q17.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three of the following: <ul style="list-style-type: none"> • small (non-polar / polar) via {phospholipid / lipid bilayer} membrane (1) • large non-polar / lipid soluble via {phospholipid / lipid bilayer} membrane (1) • large / polar / ionic / charged / water soluble via protein channels (1) • large (polar) / ionic / charged use facilitated diffusion / active transport (1) • small (non-polar / polar) use diffusion (1) 		(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that that makes reference to two of the following:</p> <ul style="list-style-type: none">• into roots by diffusion / active transport (1)• transport in xylem due to transpiration (stream) (1)• in phloem by {mass flow / translocation} (1)		(2)

Q18.

Question Number	Indicative content
*	<p>Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>Indicative content:</p> <ul style="list-style-type: none"> • male gamete fertilise female gamete to produce embryo • one male gamete fuses with {both polar nuclei / (diploid) endosperm nucleus} to form a triploid endosperm nucleus • endosperm is a store of {starch / protein / oils} • ovules will become the seeds inside the berries • xylem transports the water needed for berry formation shown in graph 1 • xylem transports the water needed for hydrolysis of food stores • xylem transports mineral ions for berry formation • phloem transports the sucrose needed for berry formation and ripening in graph 2 • more sucrose is transported from the leaves when berries are present in graph 2 • ^{14}C incorporated into glucose during photosynthesis • glucose converted into sucrose for transport in the phloem

Level 0	Marks	No awardable content
Level 1	1-2	<p>An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information.</p> <p>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p> <p>2 or 3 comments made which may include description of graphs and / or explanations</p>
Level 2	3-4	<p>An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows some linkages and lines of scientific reasoning with some structure.</p> <p>4 of 5 comments that include explanations with reference to at least two components</p>
Level 3	5-6	<p>An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> <p>6 or 7 comments that include explanations with reference to all three components</p>

Q19.

Question Number	Answer	Mark
(i)	<p>The only correct answer is D</p> <p>A is not correct because xylem carries water and mineral ions and the sucrose is in solution in the phloem</p> <p>B is not correct because xylem carries water and mineral ions</p> <p>C is not correct because the sucrose is in solution in the phloem</p>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> xylem cell walls contain {cellulose and lignin / lignin} but phloem cell walls contain {only cellulose / no lignin} (1) xylem is {hollow / no end walls} but phloem has {cell contents / sieve plates} (1) xylem has pits but phloem does not (1) xylem {does not have companion cells / is dead} but phloem has companion cells (1) 	<p>Do not piece together unless points are clearly paired in adjacent sentences</p> <p>ACCEPT xylem has thick cell walls but phloem has thinner cell walls {xylem is / xylem cells are} lignified</p> <p>ACCEPT {modified / enlarged} plasmodesmata</p>	(3)

Q20.

Question Number	Answer	Additional Guidance	Mark
	B (cell wall, cell membrane, cytoplasm)		(1)

Q21.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer including at least one similarity</p> <ul style="list-style-type: none"> • both tissues contain tubes (1) • both have cell walls containing cellulose (1) <p>and</p> <p>at least one difference</p> <ul style="list-style-type: none"> • xylem vessels contain lignin, but phloem does not (1) • in xylem, end walls of cells break down completely (to leave hollow tubes), but in phloem there are sieve plates (1) • phloem (sieve tubes) have companion cells, but xylem does not (1) • phloem (sieve tubes) contains cytoplasm, but xylem does not (1) 	<p>Accept both have vessels which are cylindrical</p> <p>Accept xylem has thicker walls / xylem vessels have pits in side walls and phloem does not</p> <p>Accept phloem has sieve plates, but xylem does not</p> <p>Accept phloem contains plasmodesmata but xylem does not / phloem contains organelles but xylem does not</p>	Exp (3)

Q22.

Question Number	Answer	Additional guidance	Mark
(i)	<ul style="list-style-type: none"> rates calculated from gradients for wind and for still air (1) rate in still air subtracted from rate in wind (1) 	<p>Example of calculation</p> <p>Wind = $(5.0 \div 20) = 0.25$</p> <p>Still air = $(2.6 \div 20) = 0.13$</p> <p>$(5.0 - 2.6) \div 20 = 0.12$</p> <p>$0.25 - 0.13 = 0.12$</p> <p>Allow calculations based on other times</p> <p>eg $1.9 \div 7.5 = 0.25$</p> <p>$1 \div 7.5 = 0.13$</p> <p>$0.25 - 0.13 = 0.12$</p> <p>or</p> <p>$1.9 \div 7.5 = 0.253$</p> <p>$1 \div 7.5 = 0.133$</p> <p>$0.253 - 0.133 = 0.116$</p> <p>Allow one mark for calculation of one rate if answer incorrect</p> <p>Correct answer gains full marks, with no working shown.</p>	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> control {light intensity / temperature / humidity} (1) therefore use same {wattage bulb / lamp / distance from light source / time of day / room / thermostat / greenhouse} (1) 	<p>Ignore dark room</p> <p>Ignore water bath / incubator / oven</p> <p>Ignore plastic bag</p>	(2)

Q23.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> multiply cross-sectional area by distance moved by bubble / $\pi r^2 \times d$ / $\pi r^2 \times h$ (1) divide by total area of leaves (1) divide by 5 (1) 		(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> moving air moves {water molecules / droplets} away (from leaf) (1) therefore increases concentration gradient / diffusion gradient / water potential gradient (1) difference is significant because SDs do not overlap (1) 	<p>ACCEPT converse</p> <p>ACCEPT wind</p>	(2)

Q24.

Question Number	Answer	Additional guidance	Mark
(i)	<p>two marks from</p> <ul style="list-style-type: none"> passes from cell cytoplasm to cell cytoplasm (1) via plasmodesmata of cells (1) 	<p>The diagram illustrates the pathway of water transport in a root. It shows a cross-section with a root hair extending from an epidermal cell. Water moves from the root hair, through the epidermal cell, and then through cortical parenchyma cells. It crosses the Casparian strip in the endodermis and enters a xylem vessel. Labels include: Epidermal cell, Root hair, Cortical parenchyma cell, Casparian strip, Endodermis, and Xylem vessel.</p>	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	<ul style="list-style-type: none"> conversion of measurement in mm to μm (x 1000) (1) and division by 100 (1) 	<p>Example of calculation</p> 60×1000 $\div 100$ $= 600\mu\text{m}$ <p>Correct answer with no working gains fullmarks allow 1 mark for 60×1000 or $\div 100$</p>	(2)

Q25.

Question Number	Answer	Additional guidance	Mark
	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> • water is {evaporated / lost / transpired / diffused} from {leaves / stomata} (1) • therefore (leaf) cells have a low water potential / waterpotential gradient created (1) • because of cohesion of water molecules that {are polar / form hydrogen bonds} (1) • adhesion of water molecules to xylem walls (1) 	allow water enters root hair down waterpotential gradient (1)	(4)

Q26.

Question Number	Answer	Additional guidance	Mark
(i)	<p>An explanation that makes reference to four of the following points:</p> <ul style="list-style-type: none"> • take several readings (at each light intensity) after {stated timeperiod} calculate mean / average (1) • reset using syringe between readings (1) • control named abiotic variable such as temperature / wind /humidity (1) • at 5 different light intensities (1) • vary light intensity by {moving light source away from potometerusing light dimmer / rheostat} (1) 		(4)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> • some water used in photosynthesis (1) • to maintain turgor (1) 		(2)

Q27.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>The only correct answer is C</p> <p>A is incorrect because 31 460 would be rounded up to 3.15×10^4</p> <p>B is incorrect because 314 600 would be rounded up to 3.15×10^5</p> <p>D is incorrect because 3 139 000 would be rounded up to 3.14×10^6</p>		(1)
(ii)	<p>The only correct answer is C</p> <p>A is incorrect because symplast pathway does not go through cell walls</p> <p>B is incorrect because it shows the pathways the wrong way round</p> <p>D is incorrect because it shows apoplastic going through the cytoplasm</p>		(1)
(iii)	<p>The only correct answer is B</p> <p>A is incorrect because water moves from a dilute solution to a more concentrated one</p> <p>B is incorrect because water moves from a high water potential to a lower one</p> <p>D is incorrect because water moves from a high water potential to a lower one</p>		(1)

Q28.

Question Number	Answer	Additional Guidance	Mark
	C (low, high, high, low)		(1)

Q29.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following: <ul style="list-style-type: none"> one cell drawn with correct shape / proportion (1) clear lines used to represent correct shape of cell, with no shading of any feature (1) 	Must be a drawing not a diagram	(2)
(ii)	An explanation that makes reference to three of the following: <ul style="list-style-type: none"> companion cells for ATP production (1) because sieve tubes are for transport of organic molecules (1) because energy is needed for transport (both up and down the stem) (1) sieve tubes have no organelles, so less barriers to transport (1) 	<p>Allow named organic molecule eg {sugar / sucrose}</p> <p>Allow energy needed for active transport (of sugars)</p> <p>Allow sieve tubes have {sieve plates / plasmodesmata} so less barriers to transport</p>	(3)

Q30.

Question Number	Answer	Additional Guidance	Mark
	<p>A is correct <i>apoplastic pathway</i></p> <p>B is incorrect as this is an incorrect term</p> <p>C is incorrect as the water passes through cell walls</p> <p>D is incorrect as the water passes through cell walls</p>		1

Q31.

Question number	Answer	Mark
(i)	<p>The only correct answer is B</p> <p>A is not correct because the symplast is also involved</p> <p>C is not correct because both the apoplast and symplast are involved</p> <p>D is not correct because the apoplast is also involved</p>	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> • water is {evaporated / lost / transpired / diffused } from {leaves / stomata} (1) • therefore leaf cells have a low water potential / water potential gradient created (1) • because of cohesion of water molecules that {are polar / form hydrogen bonds} (1) • adhesion of water molecules to xylem walls (1) 	Accept osmotic potential	(3)

Q32.

Question Number	Answer	Mark
(i)	<ul style="list-style-type: none"> • potometer (1) 	clerical (1)

Question Number	Answer	Mark
(ii)	<p>An explanation that makes reference to a pair of the following:</p> <ul style="list-style-type: none"> • cut shoot (at an angle) under water (1) • so that no air enters xylem (1) or • ensure no air is left in capillary tube • so that bubble can move (1) or • seal using petroleum jelly (1) • so that no air leaks into system / make airtight (1) or • move the air bubble to the zero / record the starting position of the air bubble (1) • so that water lost can be accurately measured (1) 	EXP (2)

Question Number	Answer	Mark
(iii)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> • not all water taken up by shoot is lost in transpiration / may absorb more water than it transpires (1) • because some used in photosynthesis / some used in cell expansion / elongation / keep cells turgid (1) 	EXP (2)

Q33.

Question Number	Answer	Mark
	<p>An answer that makes reference to two of the following:</p> <ul style="list-style-type: none"> • removing half of the leaves (1) • greatest change as decreases by 8 (mm per min) / decreases from 19 to 11 (1) 	EXP (2)

Q34.

Question Number	Answer	Mark
(i)	<ul style="list-style-type: none"> by putting (transparent) plastic bag / use humidifier / water spray / fan / hairdryer (1) 	EXP (1)

Question Number	Answer	Additional guidance	Mark
(ii)	<ul style="list-style-type: none"> change the temperature of the room or use a heater (without affecting other variables) (1) 	Not water bath or heat lamp or oven	EXP (1)

Question Number	Answer	Additional guidance	Mark
(iii)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> use syringe to deliver (known) volume of water (1) note how much bubble moves in mm (on scale) (1) 	<p>Allow</p> <p>note volume of water required (1)</p> <p>to move bubble certain distance (1)</p>	exp (2)

Q35.

Question Number	Answer	Mark
	<p>An explanation that makes reference to two of the following points :</p> <ul style="list-style-type: none"> increased humidity increases the amount of water (molecules) in the air surrounding stomata (1) so reduces diffusion gradient / concentration gradient (of water molecules) (1) so less water loss / transpiration/ less diffusion therefore less water uptake (1) 	exp (2)