HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.3.4 Mass transport

Topic question bank

Version 1 · 9 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
12	78	No time limit	/ 78

Contents

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Total		**78**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA AS and A-level Biology (7401/7402), specification section 3.3.4. Not affiliated with or endorsed by AQA.

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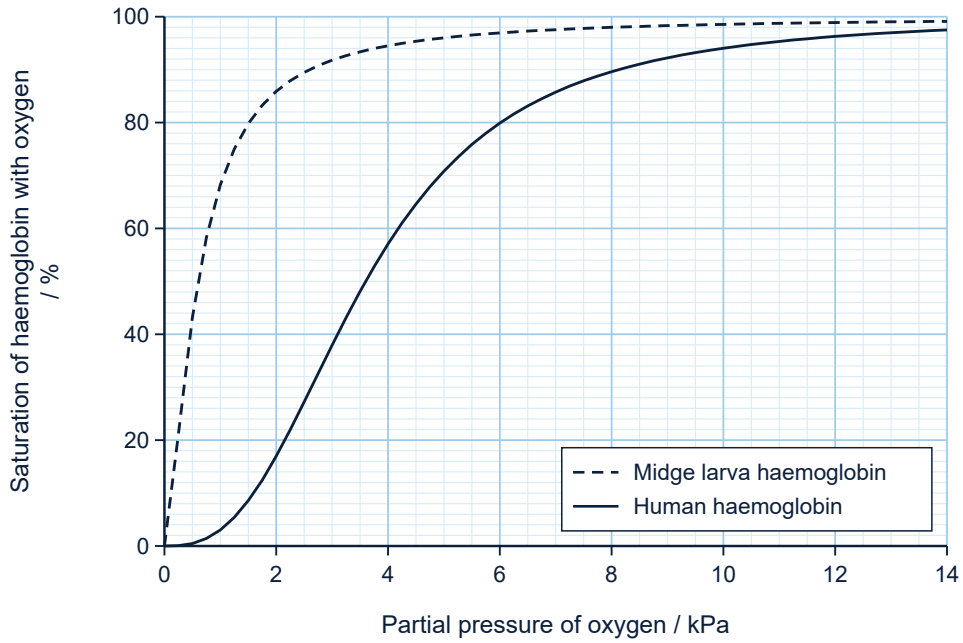
Haemoglobin and oxygen transport 3.3.4.1

The larvae of some species of midge live in tubes in the mud at the bottom of ponds. They are red because their blood contains haemoglobin. A larva absorbs oxygen from the water across its body surface. In warm weather, the partial pressure of oxygen in the water next to the mud can fall to 1.5 kPa.

Figure 1 shows oxygen dissociation curves for the haemoglobin of a midge larva and for human haemoglobin.

Figure 1



0 1 . 1 Explain the shape of the curve for human haemoglobin between 0 and 6 kPa.

[2 marks]

Question 1 continues on the next page

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0 1 . 2 In the lungs, the partial pressure of oxygen is 13 kPa. In an exercising muscle, it is 2 kPa.
Use Figure 1 to calculate the percentage of the oxygen carried by human haemoglobin leaving the lungs that is unloaded in this muscle.

[2 marks]

Answer ..... **%**

0 1 . 3 Use Figure 1 to explain how the haemoglobin of the midge larva is adapted to the conditions in the mud at the bottom of a pond.

[3 marks]

7

Turn over for the next question

Do not write outside the box

Table 1 shows the percentage saturation of human haemoglobin with oxygen at two different partial pressures of carbon dioxide.

Table 1

Partial pressure of oxygen / kPa	Saturation of haemoglobin with oxygen / %	
	Partial pressure of carbon dioxide 5.3 kPa	Partial pressure of carbon dioxide 8.0 kPa
2	17	10
4	57	41
6	80	67
8	90	82
10	94	89
12	96	93

When it is fully saturated with oxygen, 100 cm^3 of blood carries 20 cm^3 of oxygen.

0 2 . 1 Blood leaves the lungs with a partial pressure of oxygen of 12 kPa and a partial pressure of carbon dioxide of 5.3 kPa. In an exercising muscle, the partial pressure of oxygen is 2 kPa and the partial pressure of carbon dioxide is 8.0 kPa.
Use Table 1 to calculate the volume of oxygen unloaded from 100 cm^3 of blood in this muscle.

[2 marks]

Answer ..... **cm^3**

Question 2 continues on the next page

Do not write outside the box

0 2 . 2 A student concluded that, in this exercising muscle, most of the oxygen is unloaded because of the high partial pressure of carbon dioxide.
Use Table 1 to evaluate this conclusion.

[2 marks]

4

0 3 Haemoglobin is a protein with a quaternary structure.
Which statement explains why haemoglobin has a quaternary structure?
Tick (✓) one box.

[1 mark]

Its primary structure contains more than 100 amino acids. ☐

It is made of more than one polypeptide chain. ☐

Its polypeptide is folded into a specific three-dimensional shape. ☐

It contains regions coiled into a helix that are held by hydrogen bonds. ☐

1

Turn over for the next question

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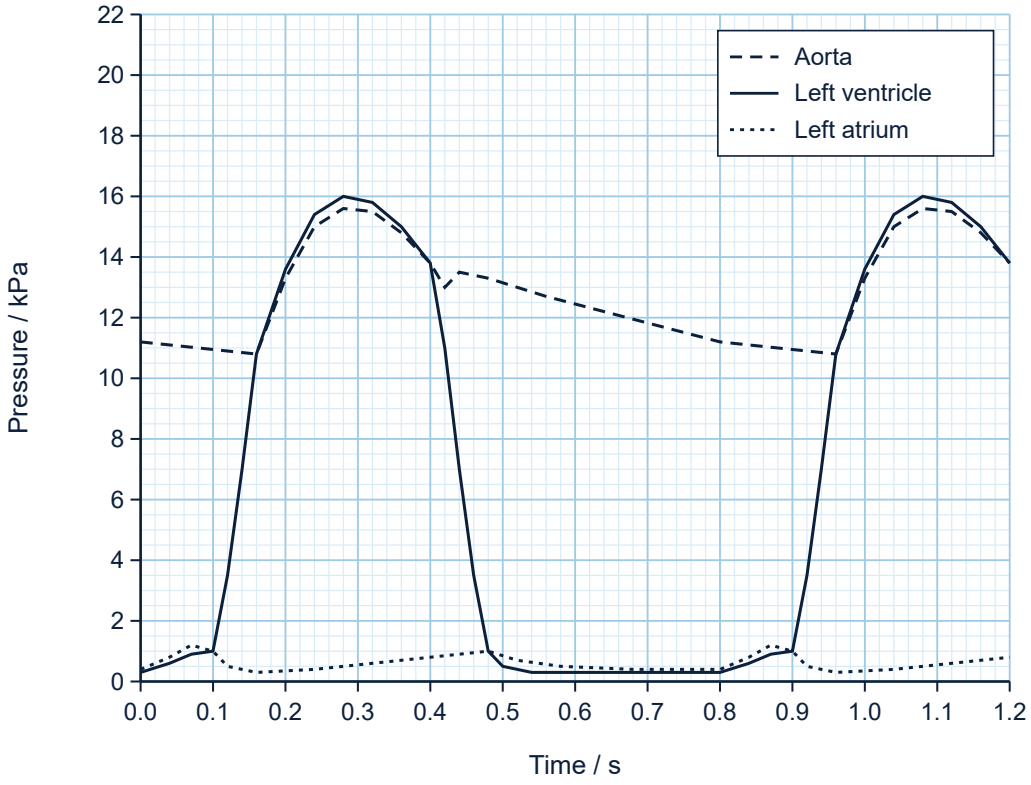
The heart and the cardiac cycle 3.3.4.1

Figure 2 shows the pressure changes in the left atrium, the left ventricle and the aorta of a person at rest.

Figure 2



0 4 . 1 During which period does the volume of blood in the left ventricle decrease?
Tick (✓) one box.

[1 mark]

- 0.00–0.10 s ☐
- 0.10–0.16 s ☐
- 0.16–0.40 s ☐
- 0.40–0.48 s ☐

Question 4 continues on the next page

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0 4 . 2 This person's cardiac output was 5.1 dm^3 min^{-1}.
cardiac output = stroke volume × heart rate
Use Figure 2 and this equation to calculate the person's stroke volume in cm^3.

[2 marks]

Answer ..... **cm^3**

0 4 . 3 Use Figure 2 to explain how the opening and closing of the valves on the left side of the heart keep blood flowing in one direction during one cardiac cycle.

[4 marks]

7

Turn over for the next question

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0 5 . 1 A drug is injected into a vein in a person's arm.
Which capillaries will the drug reach first?
Tick (✓) one box.

[1 mark]

Capillaries in the lungs ☐

Capillaries in the heart muscle ☐

Capillaries in the kidneys ☐

Capillaries in the other arm ☐

A student dissected a sheep's heart. The student pushed a blunt probe into the right ventricle and out through the blood vessel that leaves it.

0 5 . 2 Name this blood vessel.

[1 mark]

.....

0 5 . 3 The student then cut across the heart through both ventricles.
Describe how the student could identify the left ventricle. Explain the difference you describe.

[2 marks]

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Question 5 continues on the next page

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0 5 . 4 The student held the heart upright and slowly poured water into the aorta from above. The water filled the aorta but did not enter the left ventricle.
Explain this observation.

[2 marks]

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6

Turn over for the next question

Do not write outside the box

Blood vessels and tissue fluid 3.3.4.1

Table 2 shows the total cross-sectional area of each type of blood vessel, and the mean blood pressure in each type, in the blood vessels that carry blood from the left ventricle around the body and back to the right atrium.

Table 2

Type of blood vessel	Total cross-sectional area / cm^2	Mean blood pressure / kPa
Aorta	4.0	12.4
Arteries	20	12.0
Arterioles	400	7.0
Capillaries	4800	3.0
Veins	60	0.9
Venae cavae	14	0.4

0 6 . 1 During exercise, the flow of blood to the skeletal muscles increases.
Which change in the arterioles that supply the muscles causes this increase?
Tick (✓) one box.

[1 mark]

Smooth muscle in their walls relaxes, so the lumen widens. ☐

Smooth muscle in their walls contracts, so the lumen widens. ☐

Elastic tissue in their walls stretches, so the lumen narrows. ☐

Valves in the arterioles open, so more blood enters the capillaries. ☐

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 Use Table 2 to explain how the structure of veins is related to their function.

[3 marks]

0 6 . 3 In this person, 90 cm^3 of blood flows through each type of blood vessel every second.
mean velocity of blood = volume of blood flowing per second ÷ total cross-sectional area
Calculate the mean velocity of blood in the capillaries in cm s^{-1}.
Give your answer in standard form to **two** significant figures.

[2 marks]

Answer ..... **cm s^{-1}**

0 6 . 4 Use Table 2 and your knowledge of the structure of capillaries to explain why capillary beds are efficient exchange surfaces.

[3 marks]

9

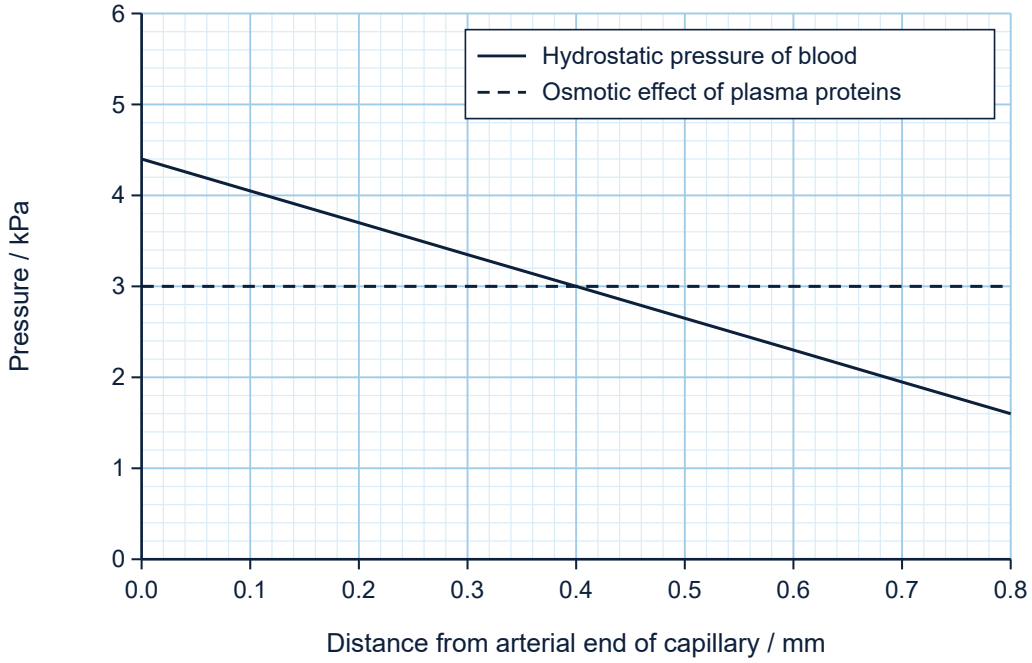
Turn over for the next question

Do not write outside the box

Tissue fluid forms from blood plasma as blood flows along a capillary. Two effects act on the water in the capillary: the hydrostatic pressure of the blood pushes water out, and the plasma proteins in the blood cause water to move in by osmosis.

Figure 3 shows the hydrostatic pressure of the blood along one capillary, and the osmotic effect of the plasma proteins, shown as an equivalent pressure.

Figure 3



0 7 . 1 Use Figure 3 to find the distance from the arterial end of the capillary at which net movement of fluid out of the capillary stops.

[1 mark]

Answer ..... **mm**

Question 7 continues on the next page

Do not write outside the box

0 7 . 2 Use Figure 3 and your knowledge to explain how tissue fluid is formed and how water is returned to the capillary.

[4 marks]

0 7 . 3 In some people with heart disease, the heart does not pump blood out effectively, so blood pressure in the veins rises. In one person, the hydrostatic pressure at the venous end of the capillary rose to 3.4 kPa. The hydrostatic pressure at the arterial end and the osmotic effect did not change.
Use Figure 3 to explain why tissue fluid builds up in this person's tissues.

[2 marks]

7

Turn over for the next question

Do not write outside the box

Risk factors for cardiovascular disease 3.3.4.1

Coronary heart disease (CHD) is a type of cardiovascular disease. In CHD, the coronary arteries become narrowed, so less blood reaches the heart muscle.

Study 1 recorded the diets of 24 000 adults aged 45–64 who did not have CHD. The scientists then recorded how many of them developed CHD over the next 12 years. Table 3 shows the results.

Table 3

Meals containing oily fish per week	Number of people	New cases of CHD per 1000 people in 12 years
0	7200	58
1	8900	49
2	5100	43
3 or more	2800	39

0 8 . 1 Calculate the percentage decrease in new cases of CHD per 1000 people between the group that ate no oily fish and the group that ate 3 or more meals containing oily fish per week.

[2 marks]

Answer ..... **%**

0 8 . 2 The scientists who carried out Study 1 concluded that eating oily fish reduces the risk of developing CHD.
Give **two** reasons why Study 1 does **not** show this.

[2 marks]

Question 8 continues on the next page

Do not write outside the box

Study 2 was a trial of fish-oil capsules. Scientists randomly divided 9000 adults aged 50–70 into two groups. For 5 years, one group took a fish-oil capsule each day and the other group took a placebo capsule containing olive oil each day. Neither the people nor the scientists knew who was in each group. Table 4 shows the results. The difference between the two groups was not statistically significant.

Table 4

Group	Number of people	New cases of CHD per 1000 people in 5 years
Fish-oil capsule each day	4500	34
Placebo capsule each day	4500	36

0 8 . 3 A health website advised: 'Take a fish-oil capsule every day to reduce your risk of coronary heart disease.'
Use the information about Study 1 and Study 2 to evaluate this advice.

[5 marks]

9

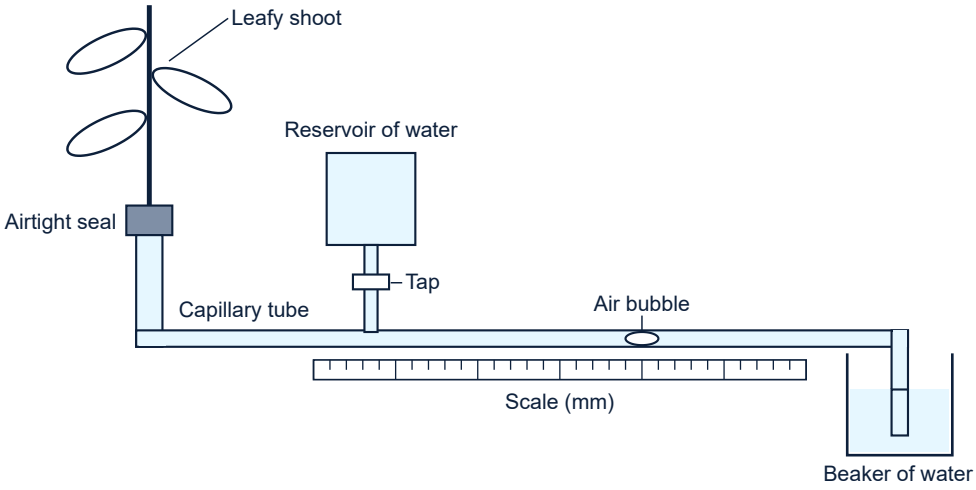
Turn over for the next question

Do not write outside the box

Xylem and transpiration 3.3.4.2

A student used the potometer shown in Figure 4 to measure the rate of water uptake by a leafy shoot. The student cut the shoot under water and fitted it into the potometer under water. As the shoot takes up water, the air bubble moves along the capillary tube towards the shoot. The internal radius of the capillary tube was 0.5 mm.

Figure 4



0 9 . 1 Explain why the student cut the shoot and fitted it into the potometer under water.

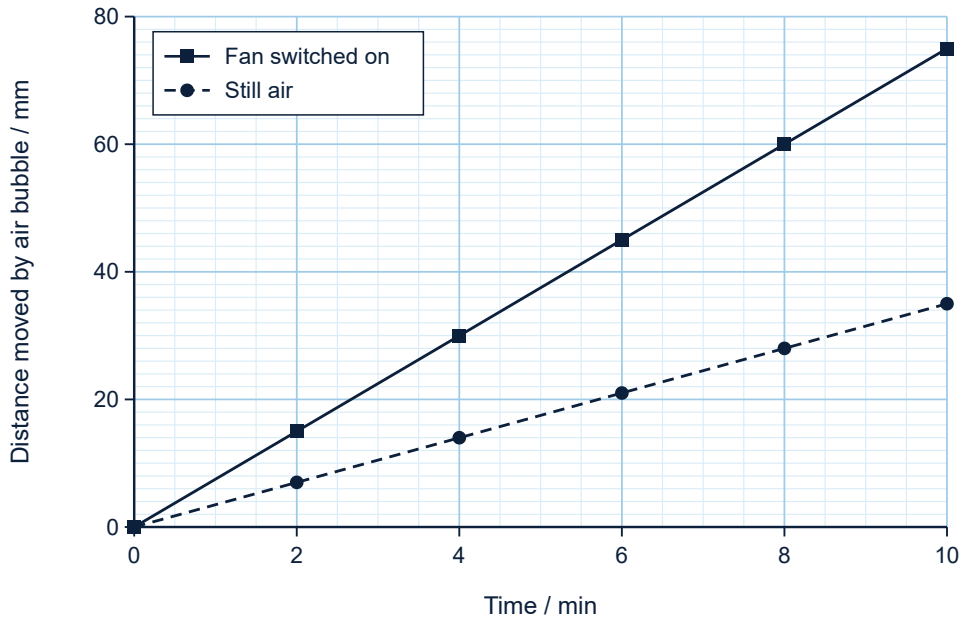
[2 marks]

Question 9 continues on the next page

Do not write outside the box

The student recorded the distance moved by the air bubble in still air. The student then reset the bubble using the tap, switched on a fan and repeated the measurements. Figure 5 shows the results.

Figure 5



0 9 . 2 Use Figure 5 to calculate the rate of water uptake by the shoot in still air, in mm^3 min^{-1}.
The volume of a cylinder is $\pi r^2 l$. Use $\pi = 3.14$
Give your answer to **two** significant figures.

[2 marks]

Answer ..... **mm^3 min^{-1}**

Question 9 continues on the next page

Do not write outside the box

0 9 . 3 Explain why the rate of water uptake was higher when the fan was switched on.

[3 marks]

0 9 . 4 Give **one** reason why the rate of water uptake measured by a potometer may not be the same as the rate of transpiration.

[1 mark]

0 9 . 5 The student wanted to compare the rate of transpiration of this shoot with that of a shoot from a different species of plant.
Suggest how the student should process the results to make a valid comparison.

[2 marks]

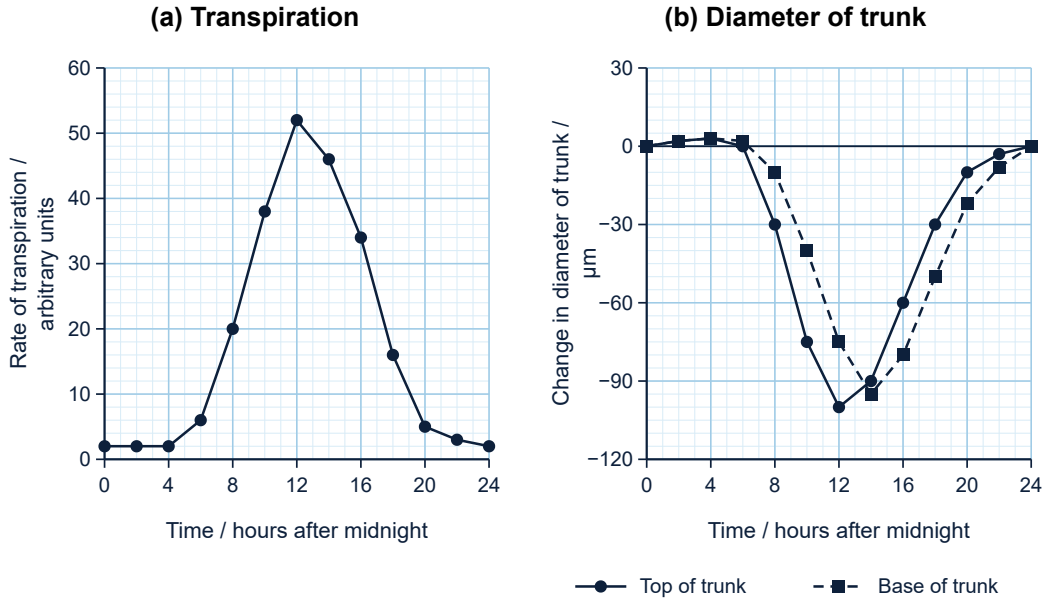
10

Turn over for the next question

Do not write outside the box

Scientists measured the rate of transpiration of a tree and the diameter of its trunk over 24 hours. They measured the diameter at the top of the trunk and at the base of the trunk. Figure 6 shows their results.

Figure 6



1 0 . 1 Use the cohesion-tension theory to explain the changes in the diameter of the top of the trunk between 6 and 18 hours after midnight.

[4 marks]

Question 10 continues on the next page

Do not write outside the box

1 0 . 2 Explain how the difference between the results for the top and the base of the trunk supports the cohesion-tension theory.

[2 marks]

1 0 . 3 Which observation provides evidence that water in the xylem of a transpiring plant is under tension?
Tick (✓) one box.

[1 mark]

When a xylem vessel in a transpiring shoot is cut, air is drawn into the vessel. ☐

When a stem is cut near the soil, water leaks out of the cut stump. ☐

Water enters root hair cells by osmosis. ☐

The rate of transpiration increases as light intensity increases. ☐

7

Turn over for the next question

Do not write outside the box

Phloem and translocation 3.3.4.2

Scientists investigated transport in young bean plants. They divided the plants into three groups.

- Group **A** was not treated.
- Group **B** had a ring of tissue removed from the outside of the stem just below one mature leaf, leaf L. The ring contained the phloem, but the xylem was not damaged.
- Group **C** had a ring of tissue removed in the same way just above leaf L.

The scientists then supplied leaf L of each plant with radioactive carbon dioxide ($^{14}CO_2$) for 1 hour in the light. After 8 hours, they measured the radioactivity in each part of the plant. Table 5 shows their results.

Table 5

Part of plant	Percentage of radioactivity recovered from the plant		
	Group A: no ring	Group B: ring below leaf L	Group C: ring above leaf L
Shoot tip and young leaves above leaf L	18	26	1
Leaf L	52	72	60
Stem and roots below leaf L	30	2	39

1 1 . 1 What do the results show about the transport of organic substances in these plants? Use data from Table 5 in your answer.

[3 marks]

Question 11 continues on the next page

Do not write outside the box

1 1 . 2 Suggest why the percentage of the radioactivity found in the shoot tip and young leaves was higher in group B than in group A.

[2 marks]

5

Turn over for the next question

Do not write outside the box

The mass flow hypothesis is one explanation of how organic substances are transported in the phloem. Observations **1**–**5** were made in different investigations of transport in the phloem.

1. When an aphid feeds, its mouthparts pierce the phloem in a stem. If the mouthparts are cut away from the aphid's body, phloem sap continues to flow out of them for several hours.
2. The concentration of sucrose in phloem sap is higher in the leaves than in the roots.
3. When a substance that stops respiration is applied only to a leaf, sucrose from that leaf stops entering the phloem.
4. In the same region of a stem, radioactively labelled sucrose moved at about 70 cm per hour, but radioactively labelled amino acids moved at about 25 cm per hour.
5. Two different tracers were supplied, one to a leaf near the top of a plant and one to a leaf near the base. In one small region of phloem in the stem between them, the two tracers were found moving in opposite directions.

Question 12 continues on the next page

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1 2 Describe the mass flow hypothesis. Evaluate how far observations **1**–**5** support it.

[6 marks]

6

END OF QUESTIONS

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