A-Level Biology

Mass Transport in Plants

Question Paper

Time available: 82 minutes
Marks available: 61 marks

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1. (a) A scientist measured the pressure in a phloem tube in a willow plant stem. He repeated his measurements to obtain nine readings.

His results are shown in the table below.

Phloem pressure / arbitrary units								
7.4	8.0	7.0	8.6	8.2	9.3	7.4	9.1	8.8

The percentage error of the mean phloem pressure in this phloem tube is calculated using this equation.

$$\text{Percentage error} = \frac{\text{uncertainty in measurement}}{\text{mean}} \times 100$$

The uncertainty in measurement is half the range of the measured values.

Calculate the percentage error of the mean phloem pressure in this phloem tube.

Show your working.

Percentage error _____ %

(2)

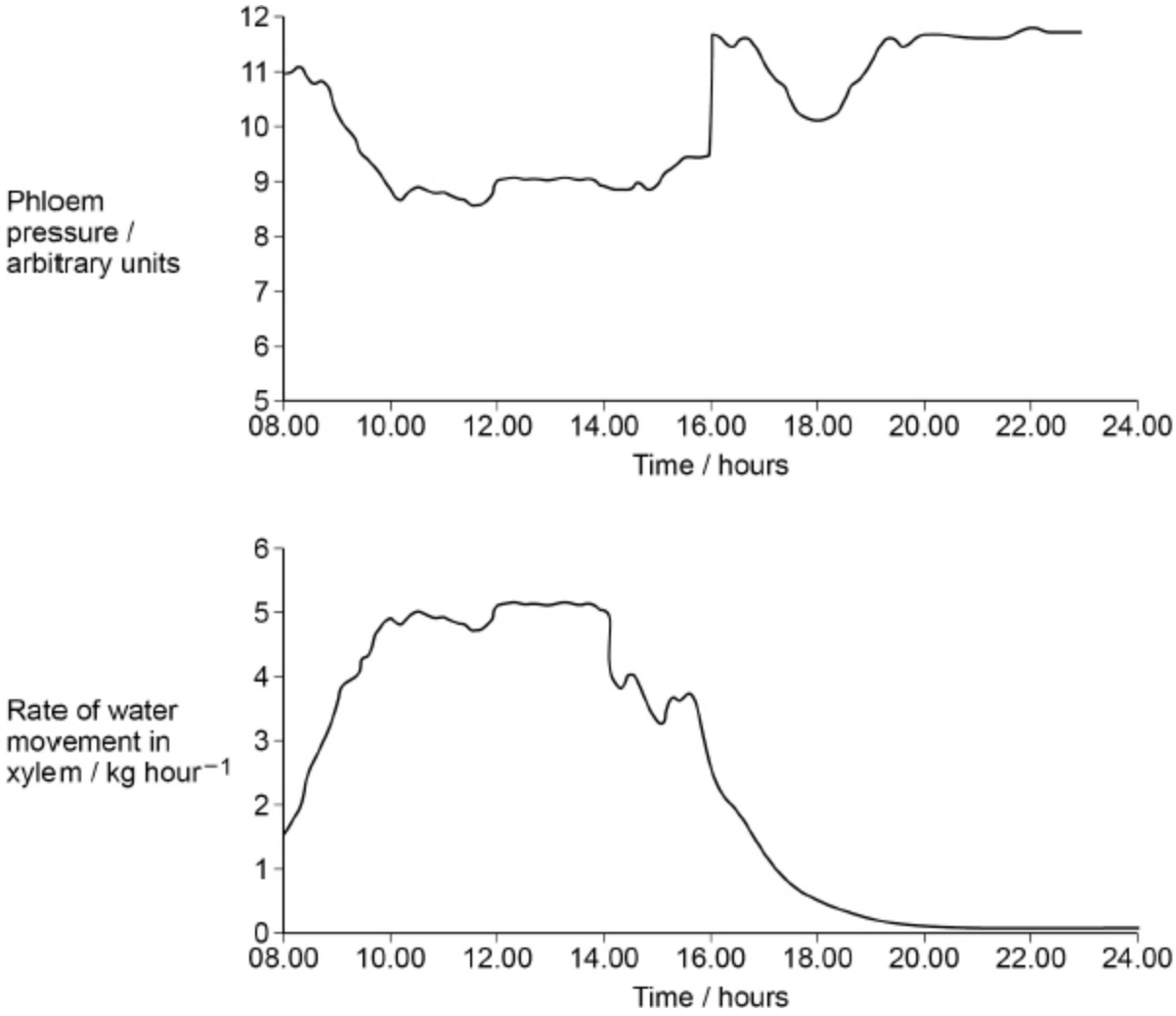
(b) The mass flow hypothesis is used to explain the movement of substances through phloem.

Use your understanding of the mass flow hypothesis to explain how pressure is generated inside this phloem tube.

(3)

(c) The scientist also measured changes in the phloem pressure and changes in the rate of water movement in the xylem of a willow plant at intervals during a day.

His results are shown in the graph below.



Describe the relationship between phloem pressure and the rate of water movement in xylem in this plant.

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(1)

(d) Phloem pressure is reduced during the hottest part of the day. Use information in the graph above along with your understanding of transpiration and mass flow to explain why.

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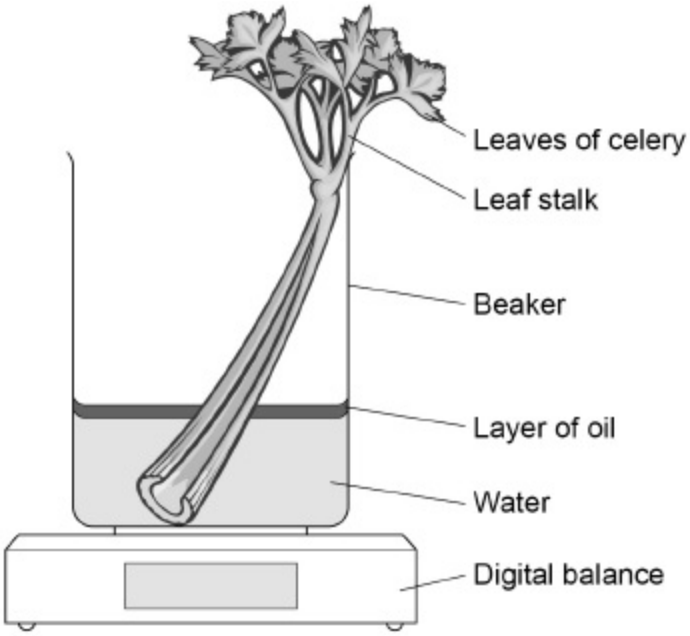
(3)

(Total 9 marks)

2. A student used the apparatus shown in **Figure 1** and a digital balance to determine the rate of water movement in a celery stalk in grams per hour per group of xylem vessels.

Figure 1



(a) The student measured the time taken for water movement.

Give **two** other measurements he made to calculate the rate of water movement.

1 _____

_____

_____

2 _____

_____

_____

(2)

(b) Give the reason for adding a layer of oil to the water in the beaker.

_____

_____

_____

_____

(1)

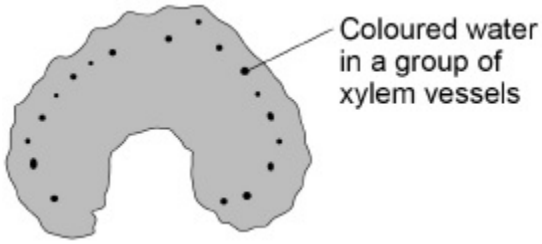
(c) A different student used coloured water to investigate the movement of water in leaf stalks of celery.

During the procedure she:

- cut equal lengths of stalk from each plant
- put the cut end of each stalk into coloured water
- left these stalks to take up the coloured water for 20 minutes
- used a sharp scalpel to cut slices from the stalks at 1 mm intervals until she reached a slice with no coloured water.

Figure 2 shows a slice of leaf stalk with coloured water inside groups of xylem vessels.

Figure 2



Explain why coloured water moved up the stalks.

(3)

(d) The student used a sharp scalpel to cut the celery. Describe how she should ensure she handled the scalpel safely during this procedure.

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_____

_____

_____

_____

(2)

The student measured the distance the coloured water had travelled in eight celery stalks. Her results are shown in the table.

Distance / mm							
70	35	40	35	30	80	42	44

(e) The student had to choose whether to summarise her measurements by calculating the mean, the median or the mode.

Circle the most appropriate measure for this set of measurements.
Give a reason for your choice and find the value using the measurements from all eight stalks.

Mean* Median* Mode*

*circle one word.

Reason: _____

_____

_____

Calculation:

Answer = _____

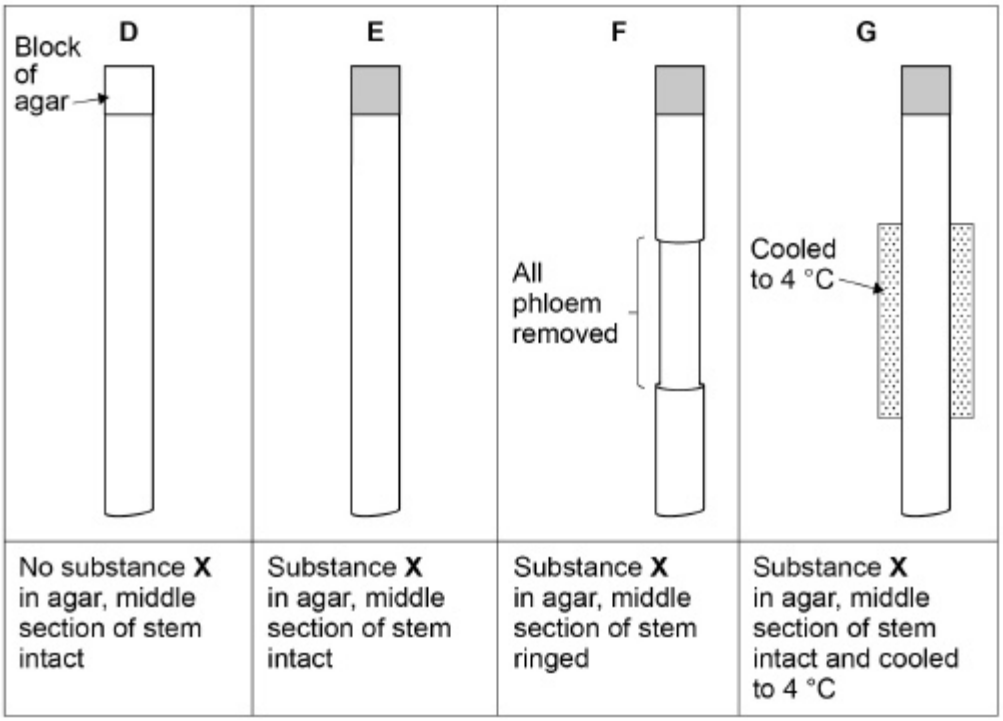
(2)

(Total 10 marks)

3. Under the correct conditions, new roots grow from the cut end of a plant stem. A scientist investigated the effect of substance X on the growth of new roots.

She used a ringing experiment to investigate the movement of substance X in stems taken from lemon plants. She cut out a length of stem from each plant. She then put a small block of agar on the top of each length of stem. Some agar blocks contained substance X.

The diagram below shows how she treated each length of stem.



She grew the lengths of stem in the same environmental conditions for 6 weeks, and then found the number of roots per length of stem. Roots grew at the other end of the stem from where the agar blocks were placed.

The table below shows the scientist's results.

Treatment	Mean number of roots per length of stem
D	5
E	11
F	4
G	3

(a) Treatment **D** is a control. Explain how the measurement obtained from this control is used by the scientist.

(2)

(b) Using the diagram and the table above, what can you conclude from treatments **D** and **E** about root growth?

(3)

(c) The mass flow hypothesis is used to explain the movement of substances through phloem.

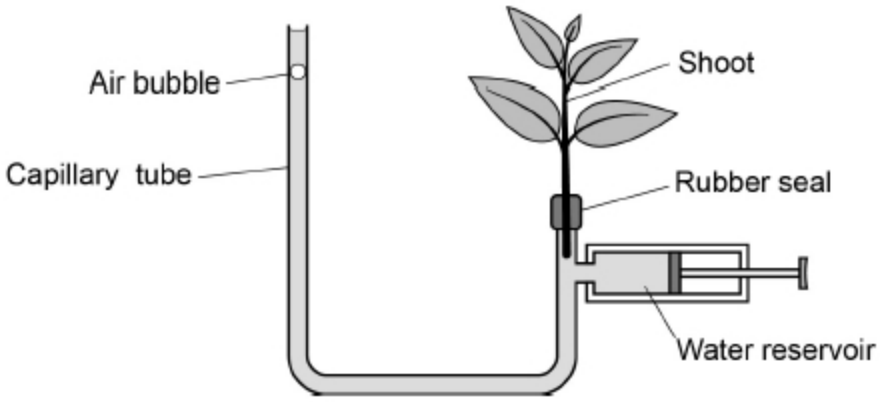
Evaluate whether the information from this investigation supports this hypothesis.
Do **not** consider statistical analysis in the answer.

(4)

(Total 9 marks)

4. A student used a potometer to measure the movement of water through the shoot of a plant. The potometer is shown in **Figure 1**. As water is lost from the shoot, it is replaced by water from the capillary tube.

Figure 1



(a) In one experiment, the air bubble moved 7.5 mm in 15 minutes. The diameter of the capillary tube was 1.0 mm.

Calculate the rate of water uptake by the shoot in this experiment.

Give your answer in mm^3 per hour. Show your working. (The area of a circle is found using the formula, area = πr^2)

_____ $mm^3\ hour^{-1}$

(2)

(b) The student wanted to determine the rate of water loss per mm^2 of surface area of the leaves of the shoot in **Figure 1**.

Outline a method she could have used to find this rate. You should assume that all water loss from the shoot is from the leaves.

(3)

(c) The rate of water movement through a shoot in a potometer may not be the same as the rate of water movement through the shoot of a whole plant.

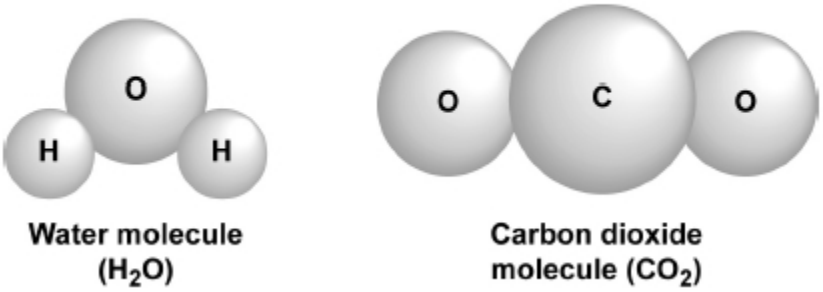
Suggest **one** reason why.

(1)

(d) Aquaporins are channel proteins that allow the diffusion of water across membranes. One type of aquaporin, called PIP1, can also transport carbon dioxide molecules across membranes.

Figure 2 shows the structure of a water molecule and of a carbon dioxide molecule. They are drawn to the same scale.

Figure 2



Suggest **two** reasons why water molecules **and** carbon dioxide molecules can both pass through PIP1.

1. _____

_____

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2. _____

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_____

(2)

(e) The scientists first produced transgenic poplar trees. These trees all had a length of foreign DNA inserted into them. This DNA led to the production of single-stranded RNA that specifically inhibited expression of the gene for PIP1.

The scientists then measured the difference in the amount of PIP1 in leaves of transgenic poplars and in leaves of wild type poplars without the foreign DNA. The amount of PIP1 in the transgenic poplars was approximately 15% of that in the wild type poplars.

Using this information, what can you conclude about the effect of the foreign DNA in the transgenic poplar trees?

(3)

(f) The transgenic poplars still produced some PIP1.

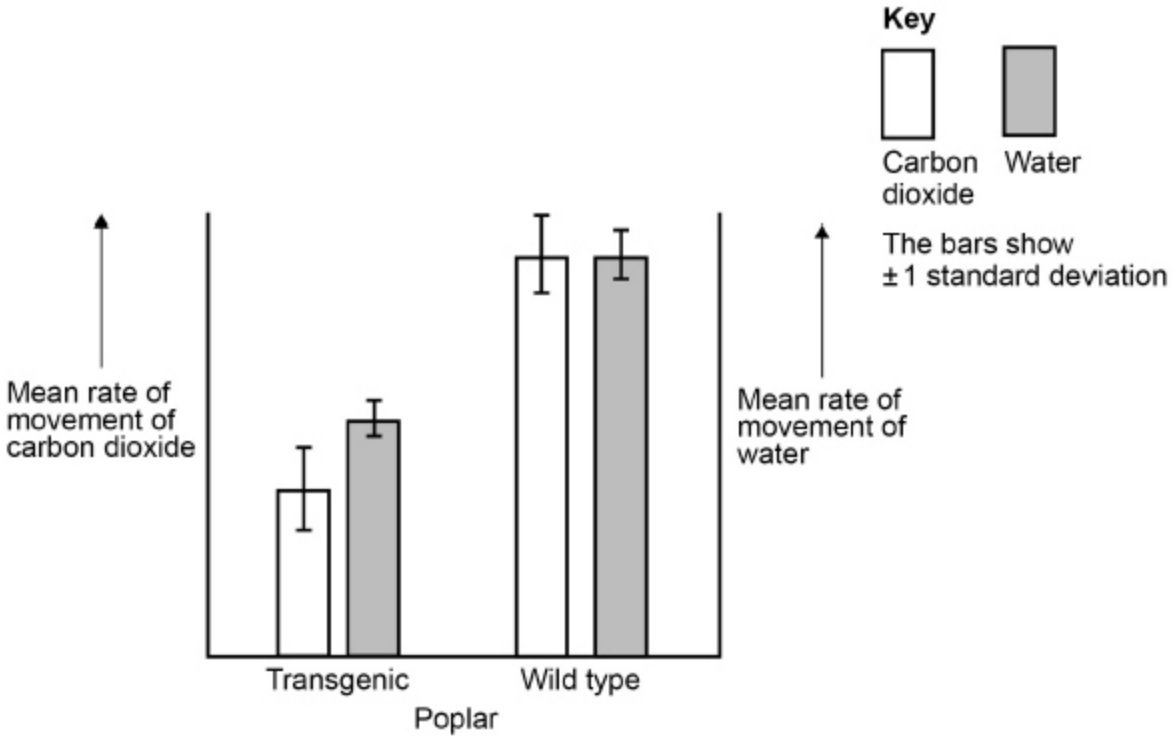
Suggest why.

(1)

(g) The scientists investigated the importance of PIP1 in the movement of water and carbon dioxide through the tissues of leaves of poplar trees.

They measured the mean rates of movement of carbon dioxide and water through the tissues of leaves of transgenic poplars and through the tissues of leaves of wild type poplars.

Their results are shown in the graph below.



Using only the graph above, evaluate the importance of PIP1 in the movement of carbon dioxide and water through leaves of poplar trees.

(3)

(Total 15 marks)

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

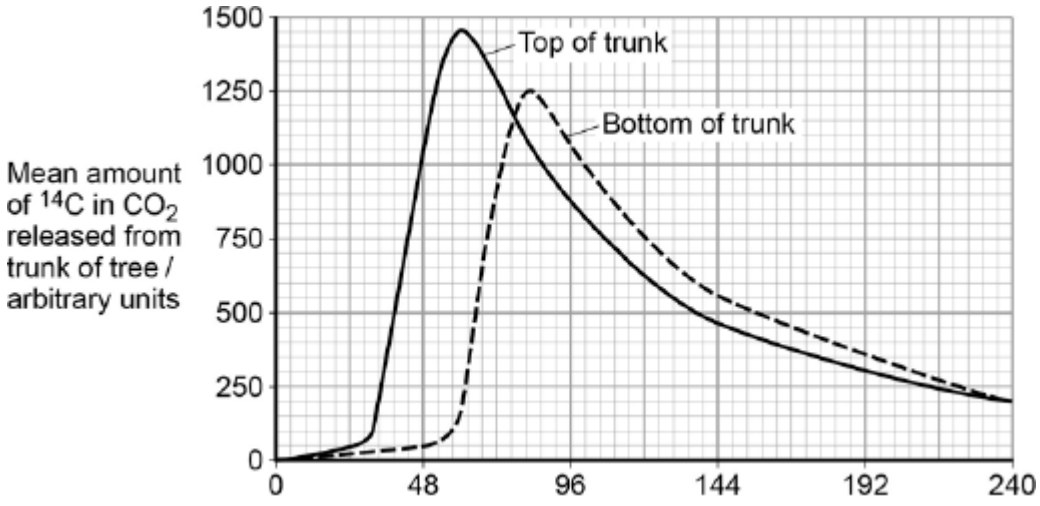
(4)

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.

(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.

_____

_____

_____

_____

(2)

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

_____

_____

(1)

(Total 8 marks)

6. 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.

(3)

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

(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.

(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. _____

_____

2. _____

_____

(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.

_____

_____

_____

(1)

(Total 10 marks)