Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level
BIOLOGY

Paper 3

Monday 26 June 2017 Morning Time allowed: 2 hours

Materials

For this paper you must have:
- a ruler with millimetre measurements
- a scientific calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A**.
- Answer **one** question from **Section B**.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All work must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for the questions are shown in brackets.
- The maximum mark for this paper is 78.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

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There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED

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Section A

Answer **all** questions in this section.

0 1 . 1 When a nerve impulse arrives at a synapse, it causes the release of neurotransmitter from vesicles in the presynaptic knob.

Describe how.

[3 marks]

Question 1 continues on the next page

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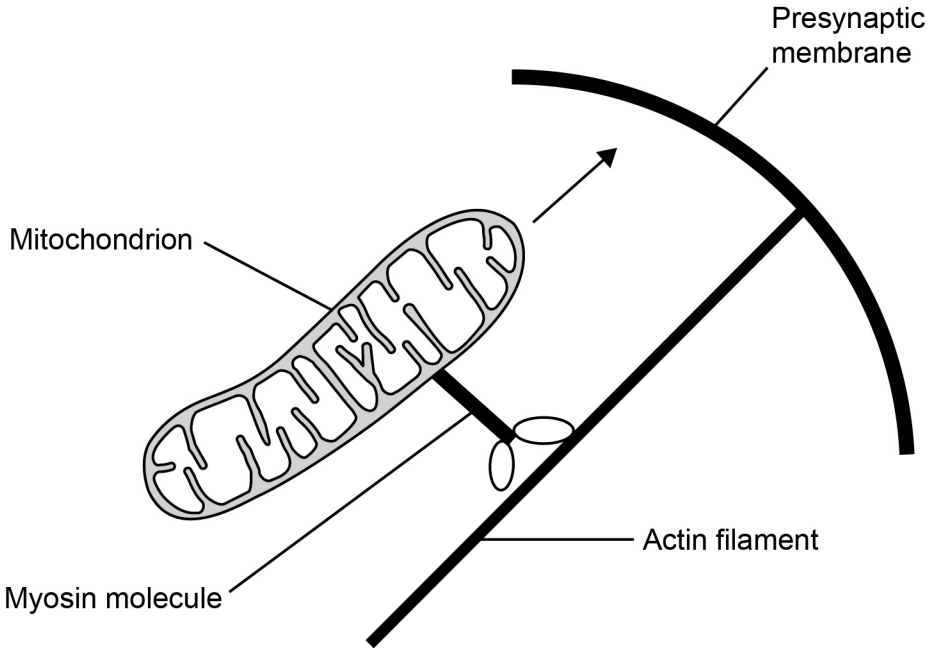
0 1 . 2 The presynaptic knob contains actin filaments and myosin molecules.

The myosin molecules can attach to mitochondria and move them towards the presynaptic membrane, as shown in **Figure 1**.

Figure 1



Use your knowledge of how myosin and actin interact to suggest how the myosin molecule moves the mitochondrion towards the presynaptic membrane.

Do **not** include the roles of calcium ions and tropomyosin in your answer.

[2 marks]

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0 1 . 3 This movement of mitochondria happens when nerve impulses arrive at the synapse.

Suggest and explain **one** advantage of the movement of mitochondria towards the presynaptic membrane when nerve impulses arrive at the synapse.

[2 marks]

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7

Turn over for the next question

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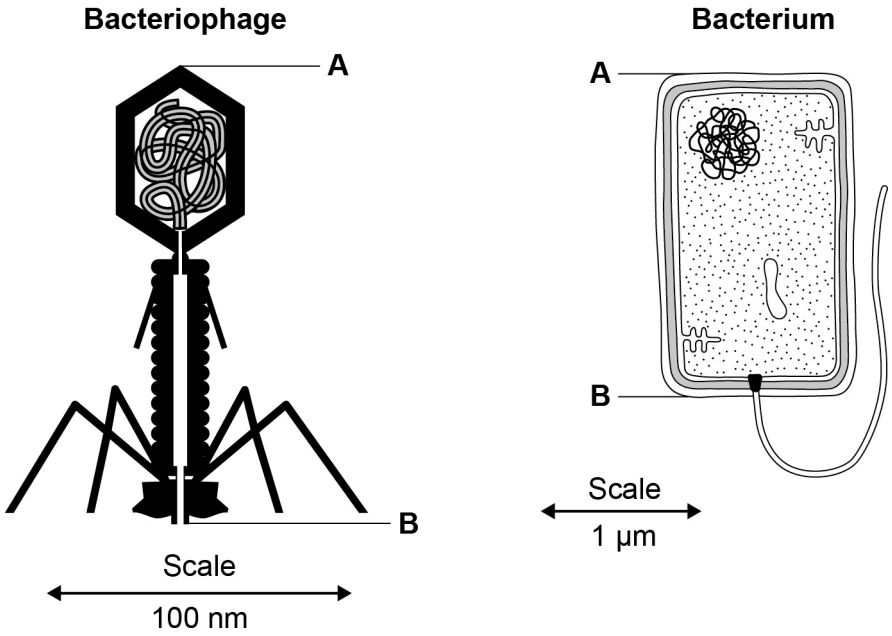
0 2 Bacteriophages are viruses that kill bacteria.

Figure 2 shows drawings of a bacteriophage and a bacterium.

Figure 2



0 2 . 1 Using **Figure 2** and your own knowledge, put a tick (✓) in the box next to the **only** correct statement about the structures of the bacteriophage and the bacterium.

[1 mark]

Both have ribosomes. ☐

Both have a cell-surface membrane. ☐

The bacteriophage has a capsid and the bacterium has a cell-surface membrane. ☐

The bacteriophage has a cell wall and the bacterium has a capsid. ☐

Do not write outside the box

0 2 . 2 Using the scales in **Figure 2**, calculate how many times longer the bacterium is than the bacteriophage.

Use the distance between the points labelled **A** and **B** on each drawing in your calculations. Show your working.

[2 marks]

The bacterium is _____ times longer

Question 2 continues on the next page

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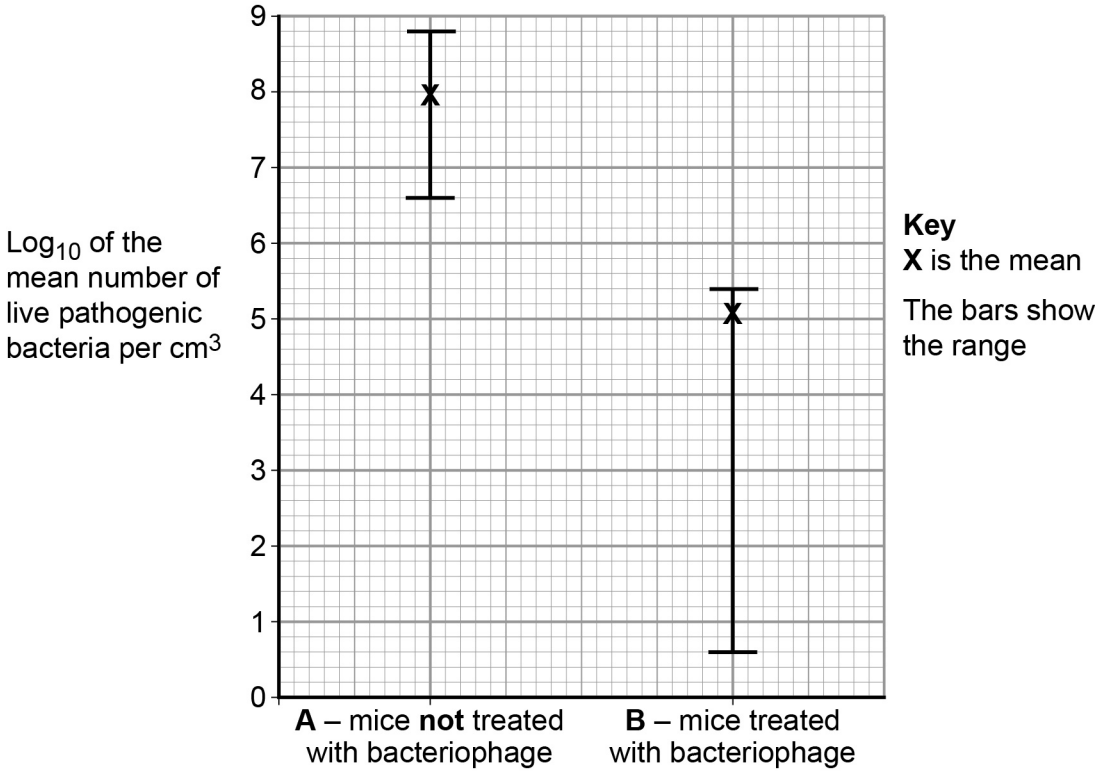
0 2 . 3 Scientists investigated the use of bacteriophages to treat lung infections caused by bacteria. They infected the lungs of mice with a pathogenic species of bacterium. The mice were then divided into two groups, **A** and **B**.

- The mice in group **A** were **not** treated with bacteriophage.
- The mice in group **B** were treated by breathing in a spray containing bacteriophage particles.

After 3 days, the scientists killed the mice and removed their lungs. They washed out each set of lungs with a set volume of liquid. The scientists determined the number of live bacteria in the liquid.

Figure 3 shows the scientists' results. **Figure 3** shows the mean and the range of the data about the mean for each group. Standard deviations of the means are **not** shown.

Figure 3



What would the scientists' null hypothesis be for this investigation?

[1 mark]

_____

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0 2 . 4 With some samples, the scientists decided they needed to carry out a series of dilutions of the sample before counting the bacteria.

Use evidence from **Figure 3** to explain why dilutions were necessary for some samples but not for others.

[2 marks]

0 2 . 5 Using only **Figure 3**, what can you conclude from these data about the effectiveness of the bacteriophage in treating this lung infection in mice?

Do **not** consider statistical analyses in your answer.

[3 marks]

9

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0 3 Farmers use artificial fertilisers to maintain or increase yield from grain-producing crop plants such as wheat.

0 3 . 1 Artificial fertiliser is used to replace mineral ions removed from the land when crops are harvested. One of the mineral ions is nitrate.

Give **two** examples of biological molecules containing nitrogen that would be removed when a crop is harvested.

[2 marks]

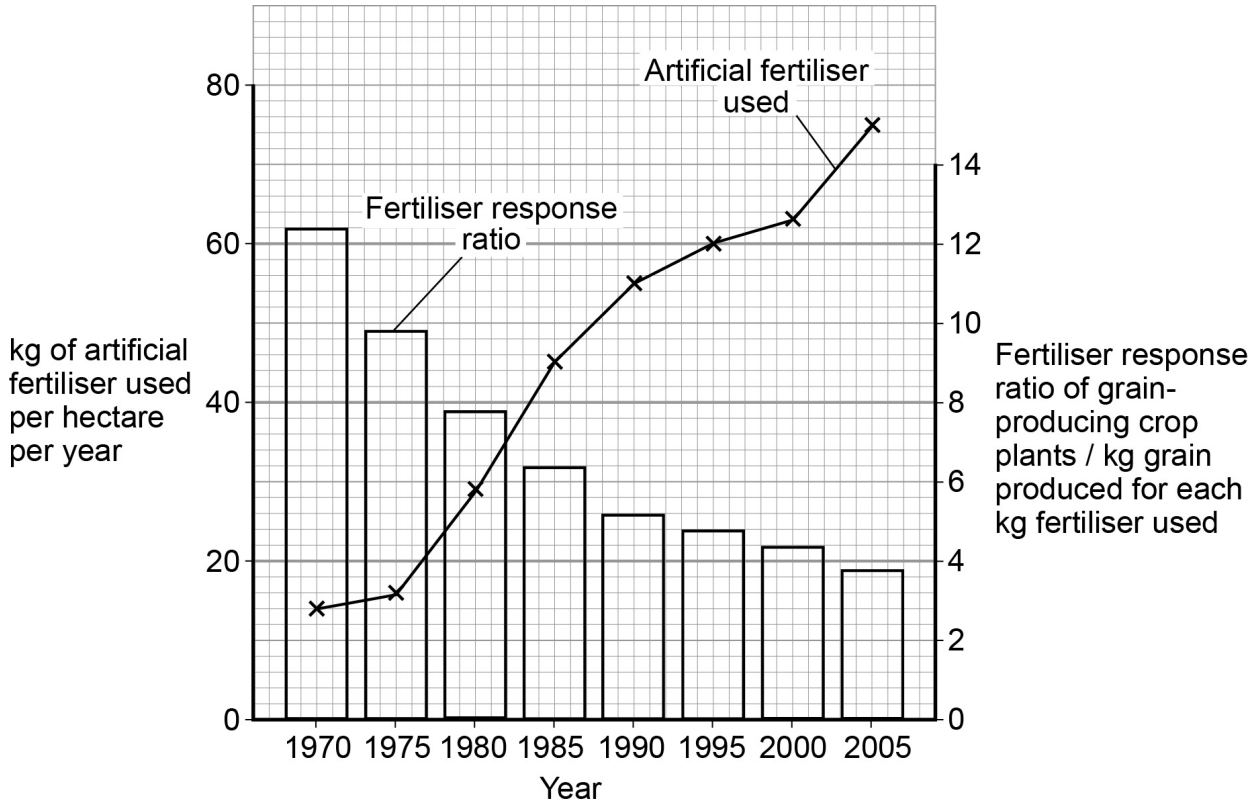
1 _____

2 _____

0 3 . 2 Scientists investigated changes in the use of artificial fertiliser in India between 1970 and 2005. They also investigated changes in the **fertiliser response ratio**. This ratio shows how many kg of grain are produced for each kg of fertiliser used.

Figure 4 shows their results in the form the scientists presented them.
(A hectare is a unit of area commonly used in agriculture)

Figure 4



Do not write outside the box

Use these data to calculate the difference in the mass of grain produced per hectare in 1970 compared with 2005.

Show your working.

[2 marks]

Difference _____ kg hectare^{-1}

0 3 . 3 Use the data in **Figure 4** to evaluate the use of artificial fertilisers on grain-producing crops in India.

[2 marks]

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6

Turn over for the next question

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0 4 Ecologists investigated changes in grassland communities on large islands off the coast of Scotland between 1975 and 2010. On each island, they used data from a number of sites to determine the change in mean species richness and the change in mean index of diversity.

0 4 . 1 **Table 1** shows plant species recorded at one site, on one island, in 1975.

Table 1

Species	**Number of individuals**
Hydrocotyle vulgaris	3
Plantago maritima	19
Ranunculus acris	3
Hieracium pilosella	3
Calliergon cuspidatum	10
Prunella vulgaris	16
Pseudoscleropodium purum	6

Calculate the index of diversity for this site using the formula:

$$d = \frac{N(N-1)}{\Sigma n(n-1)}$$

[2 marks]

d = _____

Do not write outside the box

0 4 . 2 Outline a method the ecologists could have used to determine the plant species richness at one site.

[3 marks]

Question 4 continues on the next page

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0 4 . 3 Some of the ecologists' results are shown in **Table 2**. They carried out a statistical test to find out whether any differences between the 1975 and 2010 means were significant. The values for P that they obtained are also shown in **Table 2**.

Table 2

Island	Change in mean species richness between 1975 and 2010	Value of P	Change in mean index of diversity between 1975 and 2010	Value of P
Islay	+8.89	≤0.001	+0.22	>0.05
Colonsay	+14.70	≤0.001	+2.68	≤0.01
Harris	–5.13	≤0.001	–2.44	≤0.01

Do these data show that there were any significant changes in the grassland communities on these islands? Give reasons for your answer.

[3 marks]

8

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0 5 . 1 Name **two** enzymes involved in the semi-conservative replication of DNA.

[2 marks]

1 _____

2 _____

0 5 . 2 Sometimes, damage occurs during DNA replication. One enzyme involved in repairing damage to DNA is called ATR.

ATR works as follows.

- ATR phosphorylates other enzymes involved in repairing DNA.
- ATR **also** phosphorylates substrates required to repair DNA.

When ATR phosphorylates other enzymes, these enzymes become able to bind to their substrates.

Use your knowledge of enzyme structure to suggest why.

[2 marks]

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0 5 . 3 The enzyme-catalysed reactions activated by ATR only occur if the substrates have been phosphorylated.

Use your knowledge of energy changes in enzyme-catalysed reactions to suggest why.

[1 mark]

0 5 . 4 Sometimes, a mutagenic agent causes DNA to break. A different enzyme called ATM binds to the broken DNA. This leads to the activation of a protein coded for by a tumour suppressor gene. The effect of ATM binding is to stop cell division until DNA is repaired.

A mutation could result in a person having non-functional forms of the gene that produces ATM.

What can you predict about the possible effects of having a non-functional form of ATM?

[3 marks]

Turn over for the next question

8

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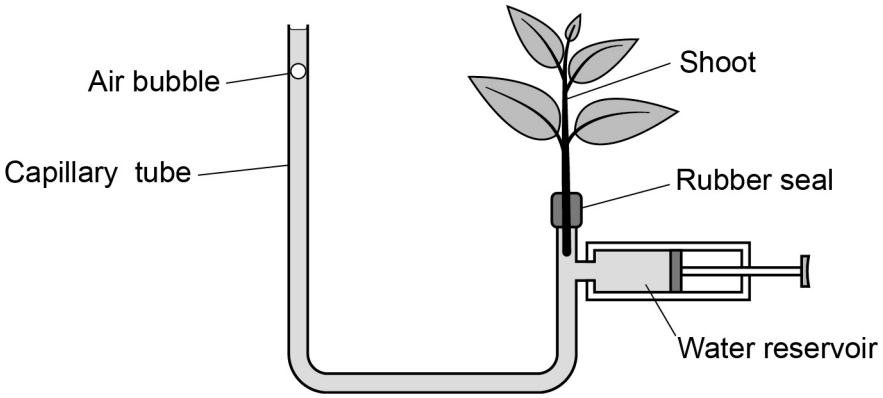
0 6 A student used a potometer to measure the movement of water through the shoot of a plant. The potometer is shown in **Figure 5**. As water is lost from the shoot, it is replaced by water from the capillary tube.

Figure 5



0 6 . 1 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)

[2 marks]

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

Do not write outside the box

0 6 . 2 The student wanted to determine the rate of water loss per mm^2 of surface area of the leaves of the shoot in **Figure 5**.

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 marks]

0 6 . 3 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 mark]

[Extra space]

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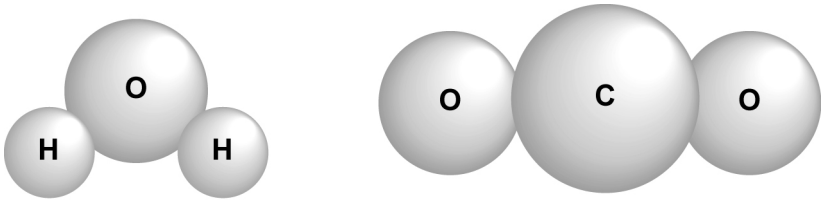
0 6 . 4 Aquaporins are channel proteins that allow the diffusion of water across membranes. One type of aquaporin, called PIP1, can also transport carbon dioxide molecules across membranes.

Figure 6 shows the structure of a water molecule and of a carbon dioxide molecule. They are drawn to the same scale.

Figure 6



Water molecule (H_2O) **Carbon dioxide molecule (CO_2)**

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

[2 marks]

1 _____

_____

_____

[Extra space] _____

_____

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2 _____

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[Extra space] _____

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0 6 . 5 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 marks]

0 6 . 6 The transgenic poplars still produced some PIP1.

Suggest why.

[1 mark]

Question 6 continues on the next page

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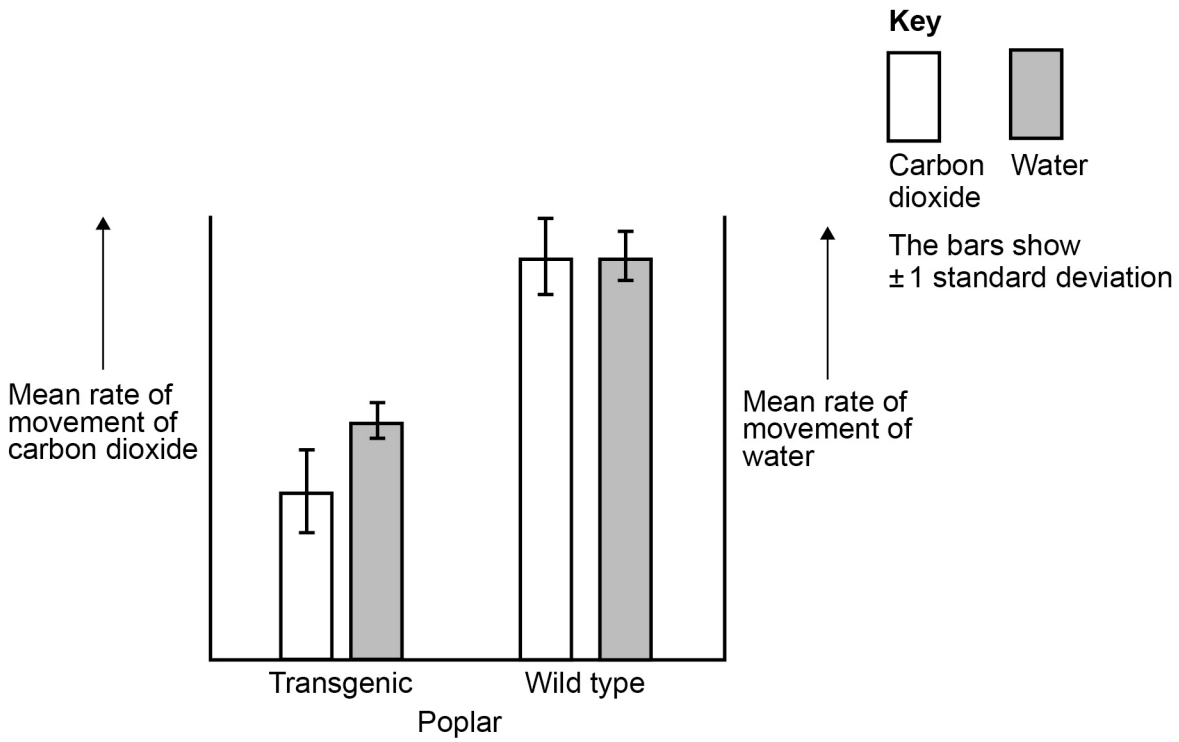
0 6 . 7 The scientists investigated the importance of PIP1 in the movement of water and carbon dioxide through the tissues of leaves of poplar trees.

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 **Figure 7**.

Figure 7



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Using only **Figure 7**, evaluate the importance of PIP1 in the movement of carbon dioxide and water through leaves of poplar trees.

[3 marks]

15

Turn over for the next question

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Section B

Answer **one** question.

0 7 Write an essay on **one** of the topics below.

EITHER

0 7 . 1 The importance of nitrogen-containing substances in biological systems.

[25 marks]

OR

0 7 . 2 The importance of diffusion in organisms.

[25 marks]

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END OF QUESTIONS

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