Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

A-level BIOLOGY

Paper 3

Monday 18 June 2018 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 space provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

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

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

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Section A

Answer **all** questions in this section.

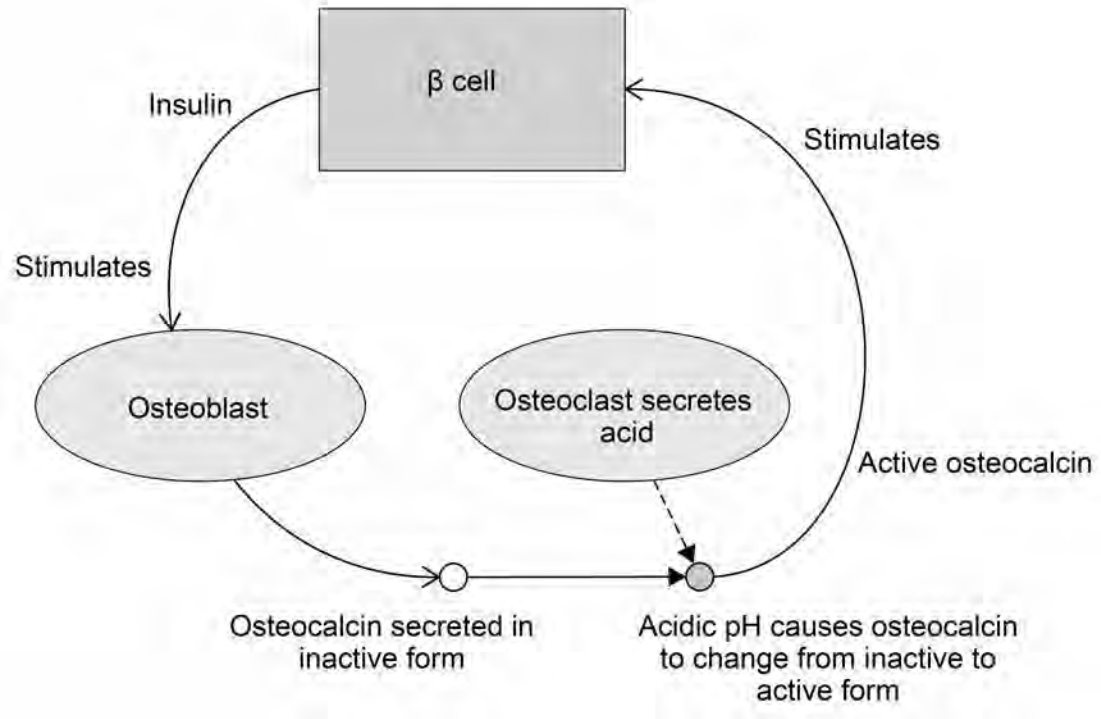
You are advised to spend no more than one hour and 15 minutes on this section.

0 1 Broken bones are repaired by cells called osteoclasts and osteoblasts.

Osteoblasts secrete a hormone called osteocalcin in an inactive form. Osteocalcin is a protein. The active form of osteocalcin binds to a receptor on beta (β) cells in the pancreas, stimulating them to release insulin. Osteoblasts have receptors for insulin.

Figure 1 shows how the production of osteocalcin by osteoblasts is controlled by positive feedback.

Figure 1



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0 1 . 1 The secretion of osteocalcin (in an inactive form) by osteoblasts is controlled by positive feedback.

Use information from **Figure 1** to explain why this is positive feedback.

[2 marks]

0 1 . 2 The acidic pH conditions created by osteoclasts cause the inactive form of the protein osteocalcin to change into the active form of osteocalcin.

Suggest how.

[2 marks]

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0 1 . 3 Binding of insulin leads to an increase in the rate of respiration in cells such as osteoblasts.

Explain how.

[2 marks]

6

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Turn over for the next question

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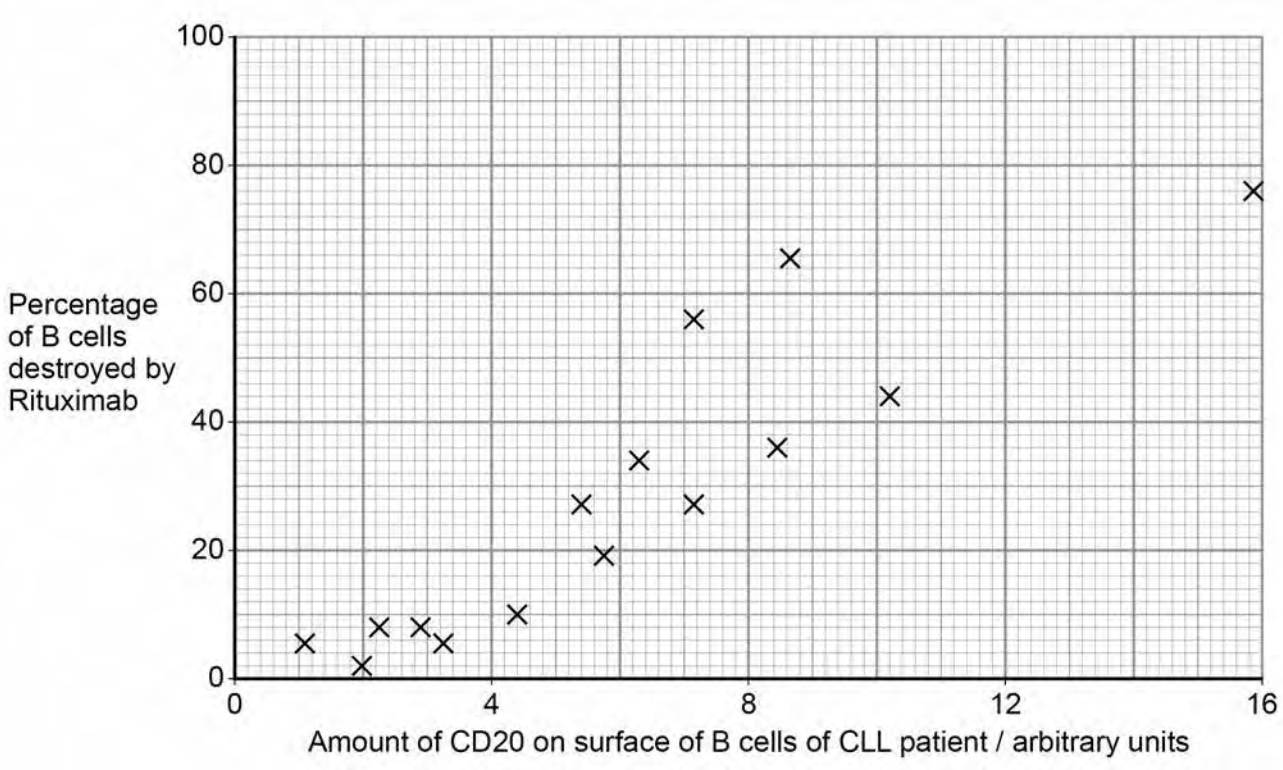
0 2 Chronic lymphocytic leukaemia (CLL) is a cancer that affects some B cells of a person's immune system.

Rituximab is a drug used to treat CLL. It binds to a protein called CD20 on the surface of B cells. If enough Rituximab binds to a B cell, it can kill the cell. Rituximab kills **both** healthy **and** cancerous B cells. The body then produces new B cells.

The amount of CD20 on the surface of B cells varies from one person to another. Doctors investigated the relationship between the amount of CD20 on the B cells of a patient and the percentage of B cells destroyed by Rituximab.

Figure 2 shows the doctors' results. Each cross is the result for one patient.

Figure 2



0 2 . 1 What statistical test could the scientists have used to determine whether there was a significant relationship between the amount of CD20 on the surface of B cells and the percentage of B cells destroyed by Rituximab?
Give a reason for your answer.

[1 mark]

Name of test _____

Reason _____

_____

_____

_____

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0 2 . 2 From these data, what can you conclude about the effectiveness of Rituximab in treating patients with CLL?

Do **not** include considerations of statistical analyses in your answer.

[3 marks]

Question 2 continues on the next page

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Approximately 11 percent of people with CLL also have mutations of a gene called *NOTCH1*. This leads to production of a non-functional transcription factor associated with CD20 production.

The doctors determined the median percentage of B cells destroyed by Rituximab in people with CLL who had the *NOTCH1* mutation and those who did not.

The doctors' results are shown in **Table 1**.

Table 1

	Median percentage of B cell destroyed by Rituximab
In people with CLL who had the *NOTCH1* mutation	**4**
In people with CLL who did **not** have *NOTCH1* mutation	**22**

0 2 . 3 Human blood contains (approximately) 1.0×10^9 B cells per dm^3.

Use the median values in **Table 1** to calculate the difference between the number of B cells per dm^3 in the blood of people treated with Rituximab with the *NOTCH1* mutation and people without the *NOTCH1* mutation.

Express your answer in standard form. Show your working.

[2 marks]

_____ cells per dm^3

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0 2 . 4 Use all of the information to suggest how the mutation of *NOTCH1* led to the difference in the percentage of B cells destroyed by Rituximab.

[3 marks]

9

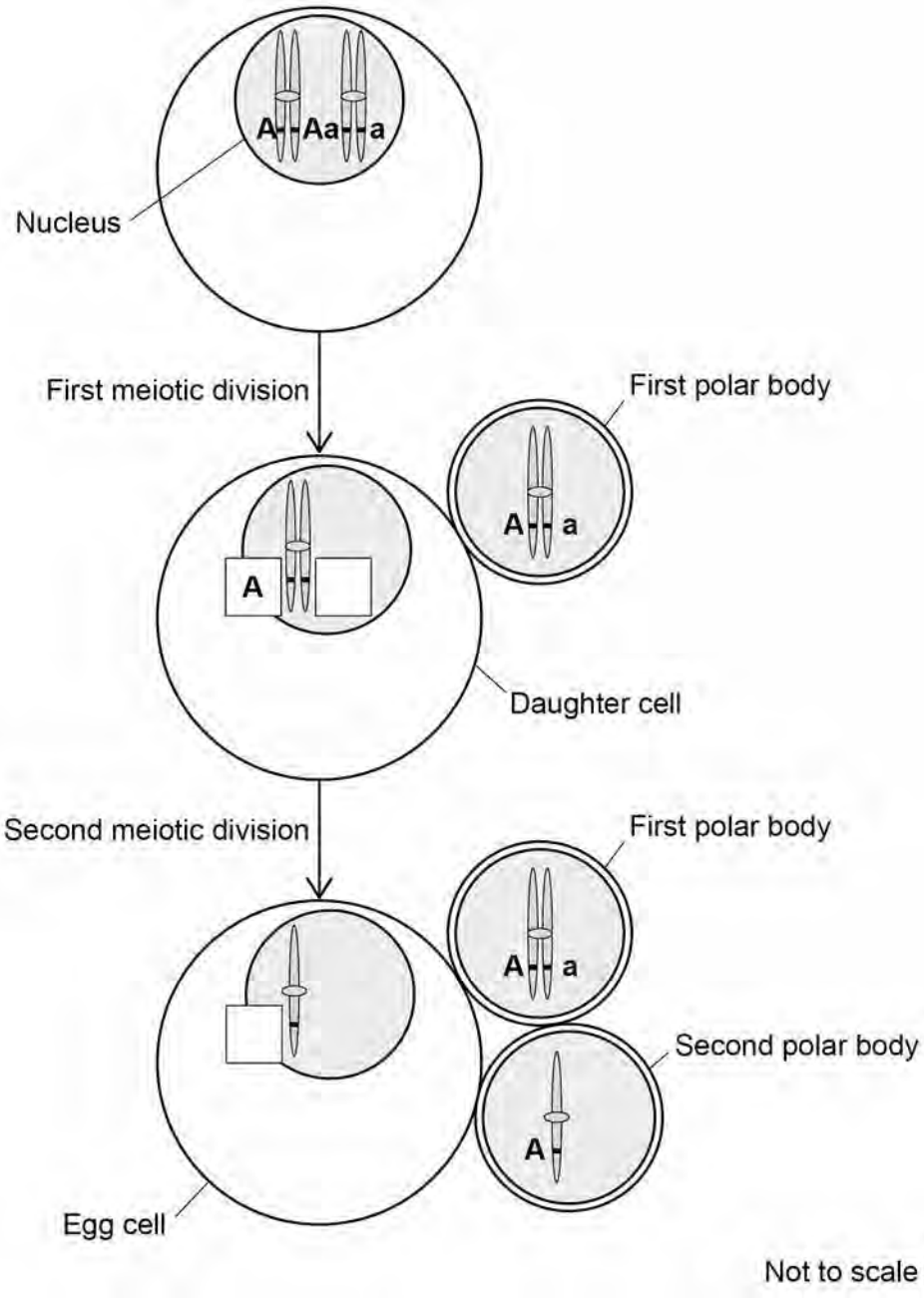
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0 3 In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell consists of a nucleus surrounded by a very small amount of cytoplasm and a cell-surface membrane. This very small daughter cell is called a polar body. Polar bodies do not usually divide. The same process occurs in the second division of meiosis, resulting in one egg cell and two polar bodies.

The diagram in **Figure 3** shows the formation of an egg cell and two polar bodies during meiosis. It also shows what happens to one pair of homologous chromosomes. This pair carries two alleles of gene A.

Figure 3



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0 3 . 1 Complete **Figure 3** by putting **A** or **a** in the boxes. One box has been completed for you with **A**.

[1 mark]

0 3 . 2 Put a tick (✓) in the box next to the name of the process that produced the combination of alleles on the chromosome in the first polar body in **Figure 3**.

[1 mark]

Anaphase ☐

Crossing over ☐

Independent assortment ☐

Semi-conservative replication ☐

0 3 . 3 A scientist measured the diameter of a polar body and the diameter of the nucleus inside it. The diameter of the polar body was 10.4 µm and the diameter of the nucleus was 7.0 µm. The density of mitochondria in the cytoplasm of the polar body (outside of the nucleus) was 0.08 mitochondria per μm^3.

Calculate the number of mitochondria in the polar body. You should assume polar bodies and nuclei are spherical.

The formula for the volume of a sphere is $\frac{4}{3}\pi r^3$ where $\pi = 3.14$

Show your working.

[2 marks]

Number of mitochondria = _____

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0 3 . 4 Mitochondrial diseases are caused by faulty mitochondria. All of a person's mitochondria are inherited from their mother via the egg cell. An egg cell contains approximately 3×10^5 mitochondria.

One proposed treatment to prevent passing on faulty mitochondria involves

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the contents of the polar body from a woman whose egg cells are affected by mitochondrial disease.

Suggest how this treatment prevents inheritance of mitochondrial diseases.

[2 marks]

Do not write outside the box

0 3 . 5 If most of the mitochondria in a cell are faulty, this prevents many important enzyme-catalysed reactions taking place or slows them down.

Suggest and explain **one** reason why.

[2 marks]

8

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0 4 . 1 Binding of one molecule of oxygen to haemoglobin makes it easier for a second oxygen molecule to bind.

Explain why.

[2 marks]

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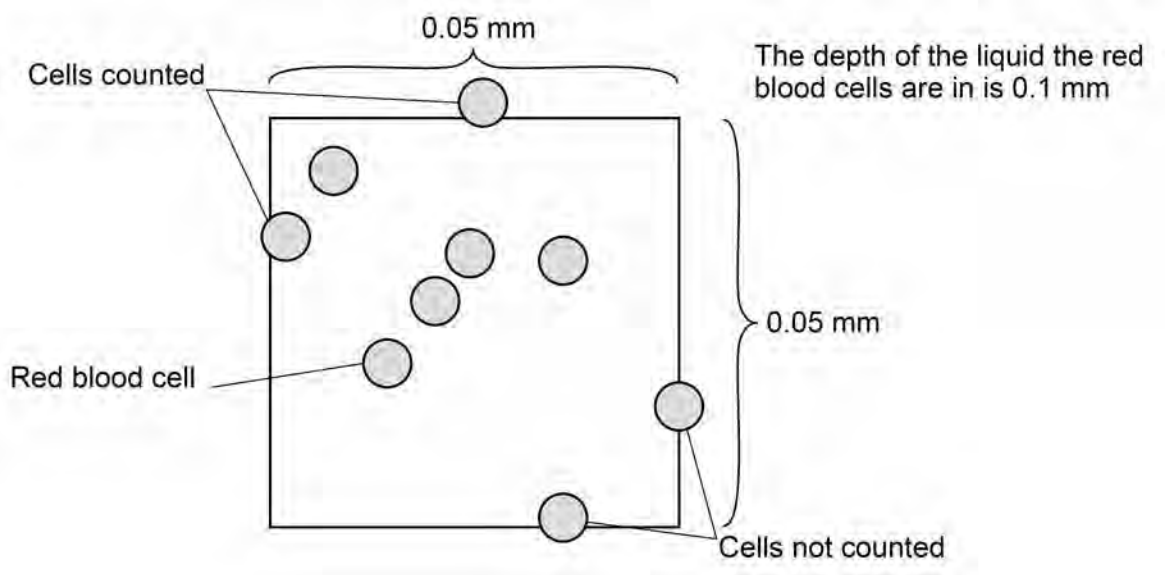
A haemocytometer is a special microscope slide which can be used to count the numbers of blood cells in a sample of blood.

- The surface of the slide has many small, equal-sized squares marked on it.
- The depth of the liquid under each square is 0.1 mm
- When counting, cells that touch top or left lines are counted but cells that touch right or bottom lines are not counted.

A doctor used a haemocytometer to determine the number of red blood cells per mm^3 in a blood sample. He diluted the original blood sample by a factor of 200 times before putting some on a haemocytometer.

Figure 4 shows the distribution of cells in a typical small square.

Figure 4



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0 4 . 2 The doctor counted the red blood cells in many small squares.
The **mean** number of red blood cells per small square was 7
The original blood sample was diluted by a factor of 200 times.

Calculate the number of red blood cells per mm^3 in the original blood sample.
Give your answer in standard form. **[2 marks]**

Answer = _____ red blood cells per mm^3

0 4 . 3 When counting, cells that touch top or left lines are counted but cells that touch right or bottom lines **are not** counted.

Suggest **two** reasons for this rule.

[2 marks]

1 _____

2 _____

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The doctor also wanted to know how many white blood cells per mm^3 there were in a different sample of blood. To do this he first diluted the sample by a factor of 20 times. He then made the white blood cells clearly visible by using a stain that makes nuclei appear dark blue.

0 4 . 4 When counting white blood cells, the doctor only diluted the blood sample by a factor of 20 times, instead of 200 times when counting red blood cells.

Suggest why he only diluted the sample by a factor of 20 times. **[1 mark]**

0 4 . 5 Explain how the stain allowed the doctor to count the white blood cells amongst all the red blood cells. **[1 mark]**

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0 5 Scientists investigated the role of a protein called CENP-W in mitosis. Their method involved cell fractionation and ultracentrifugation.

0 5 . 1 The scientists began by lysing (breaking open) cells and organelles using a detergent that dissolves lipids in water.

Suggest how the detergent releases CENP-W from cells.

[2 marks]

0 5 . 2 Explain how ultracentrifugation separates CENP-W from other molecules.

[2 marks]

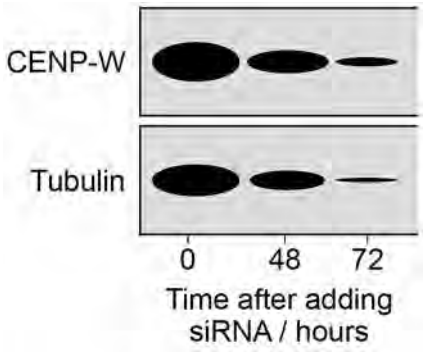
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0 5 . 3 CENP-W is involved in the formation of spindle fibres in mitosis. Spindle fibres are made of molecules of a protein called tubulin.

The scientists treated cells in a culture with small interfering RNA (siRNA). This siRNA causes RNA interference of expression of the *CENP-W* gene. The scientists took samples of cells at 0, 48 and 72 hours after adding the siRNA. They then used gel electrophoresis to separate CENP-W and tubulin from these samples.

Figure 5 shows the results of the electrophoresis. The size of each band is proportional to the amount of CENP-W or tubulin present.

Figure 5



Suggest how the siRNA produced these results. **[3 marks]**

7

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0 6 Ammonia in soil is oxidised to nitrites and nitrates by species of nitrifying bacteria.

Scientists investigated whether two soils with a different pH contained different communities of nitrifying bacteria. These communities consist of all the nitrifying bacteria of different species in each soil. They took samples of soil from two sites, **A** and **B**.

They measured the pH of the samples and found that

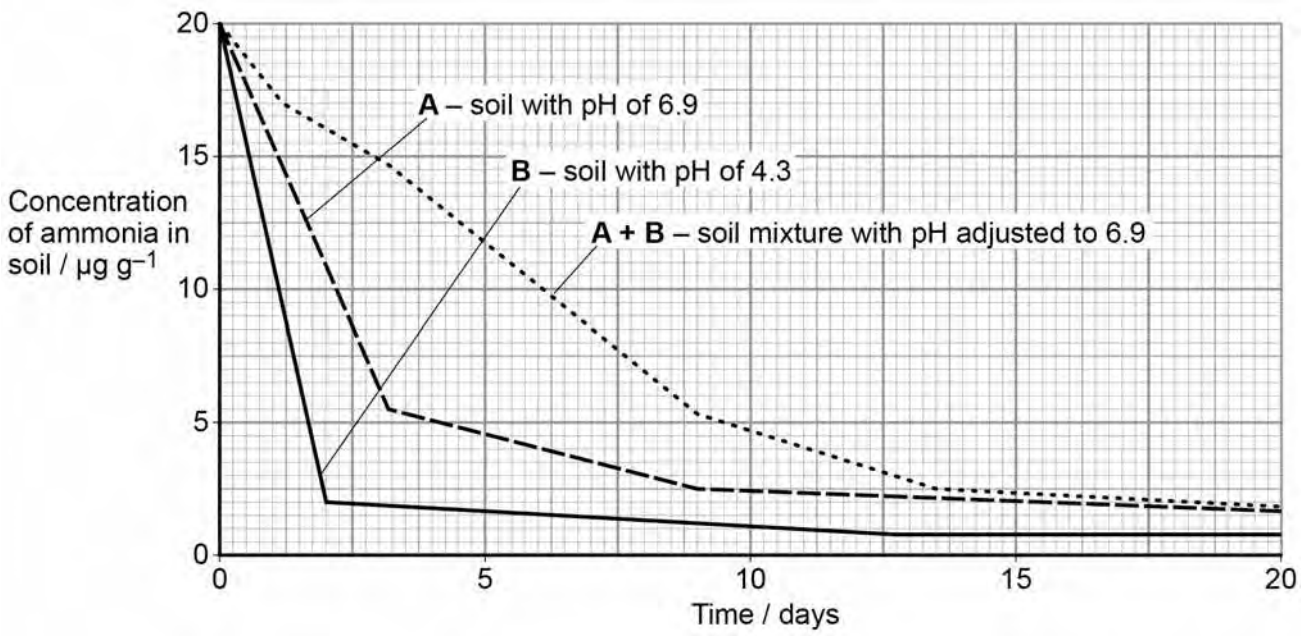
- the soil from site **A** had a pH of 6.9
- the soil from site **B** had a pH of 4.3

The scientists measured the concentration of ammonia in soil samples over 20 days. Each sample contained the same concentration of ammonia at the start and had the same mass. They recorded the concentration of ammonia in

- soil **A** with a pH of 6.9
- soil **B** with a pH of 4.3
- a mixture of equal masses of soils **A** and **B** with its pH adjusted to 6.9

Their results are shown in **Figure 6**.

Figure 6



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0 6 . 1 The scientists used units of µg g^{-1} for the concentration of ammonia in soil.

Suggest why, in this investigation, the scientists used these units. **[2 marks]**

µg _____

_____

_____

_____

_____

g^{-1} _____

_____

_____

_____

_____

0 6 . 2 Calculate the difference in the rate of breakdown of ammonia per day between day 0 and day 2 in soil **A** and soil **B**.

Show your working and the units for your answer. **[2 marks]**

Difference in rate = _____

Question 6 continues on the next page

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0 6 . 3 The scientists concluded that the soil mixture experiment showed there were different communities of bacteria in soils **A** and **B**.

What evidence from **Figure 6** supports their conclusions? Give reasons for your answer. **[3 marks]**

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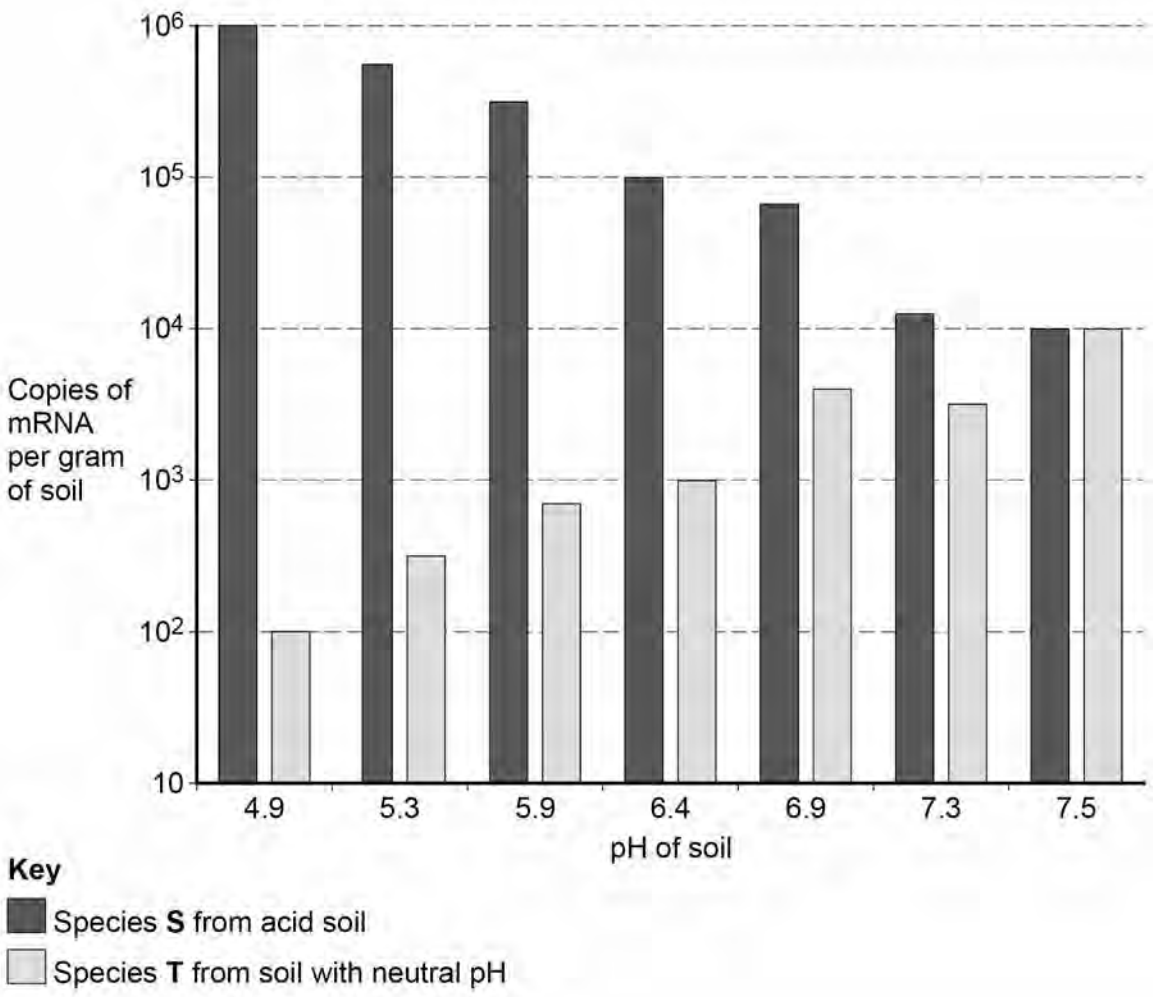
The oxidation of ammonia by nitrifying bacteria involves the enzyme ammonia monooxygenase. Each species of nitrifying bacteria has its own specific *amoA* gene that codes for production of ammonia monooxygenase.

In a second investigation, the scientists determined the expression of the *amoA* gene in two species of bacteria, **S** and **T**. Species **S** was from acid soil and species **T** was from soil with a neutral pH.

The scientists grew cultures of each species separately in soils of different pH. They determined the amount of mRNA from the *amoA* gene in each culture.

Their results are shown in **Figure 7**.

Figure 7



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0 6 . 4 In which species was the number of copies of mRNA more affected by changes in soil pH from 4.9 to 7.5? Use a calculation to support your answer.

[2 marks]

Question 6 continues on the next page

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0 6 . 5 This method allowed the scientists to estimate the expression of the *amoA* gene in each culture but not the growth of the bacterial population in each culture.

Explain why.

[4 marks]

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0 6 . 6 The scientists set up their cultures in sterile glass bottles.

Suggest **one** suitable method for sterilising the bottles and explain why it was necessary to sterilise them.

[2 marks]

15

Turn over for Section B

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Section B

Answer **one** question.

You are advised to spend no more than 45 minutes on this section.

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

EITHER

0 7 . 1 The importance of the control of movement in cells and organisms.

[25 marks]

OR

0 7 . 2 The importance of interactions between cells and between organisms.

[25 marks]

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END OF QUESTIONS

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