Q1.

Scientists investigated biodiversity in prokaryote communities found in soil.

The scientists:

- took soil samples from fields that had been managed for 20 years with two different farming methods
- sequenced all the DNA that coded for prokaryotic ribosomal RNA in the soil samples
- compared these base sequences to give a measure of species richness and an index of diversity for the prokaryote community
- recorded the total prokaryotic biomass and the mass of stored carbon for each soil sample
- obtained the mean wheat yield from the fields.

The table below shows the scientists' results.

Data collected	**Farming method 1**	**Farming method 2**
Mean species richness (± 2 × standard deviation)	517 (± 17)	560 (± 24)
Mean index of diversity (± 2 × standard deviation)	0.251 (± 0.011)	0.230 (± 0.014)
Mean total prokaryotic biomass / kg m^{-3}	0.24	0.40
Mean carbon stored in soil organisms / μg g^{-1}	203	342
Mean wheat yield / g m^{-2}	451	377

The mean ± 2 × standard deviation includes 95% of the data.

(a) Using the standard deviation data from the table, describe the differences in prokaryotic biodiversity found in the soil with these two farming methods.

In your answer, give the definitions of **species richness** and **index of diversity**.

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(4)

(b) Genetic diversity in soil species was traditionally inferred by making observations after growing prokaryotes on agar plates.

However, it is estimated that less than 10% of prokaryotes found in soil will grow if spread on an agar plate in a laboratory.

In recent years, our knowledge of prokaryotic biodiversity in the soil has increased.

Suggest why.

(2)

(c) Evaluate the balance between conservation and farming for these two farming methods.

Use the information provided in the table above.

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(2)

(Total 8 marks)

Q2.

A student investigated the use of cinnamon oil as an antimicrobial substance. She investigated the effect of cinnamon oil on the growth of five different bacterial cultures grown on agar plates.

(a) The student added 100 mm^3 of each bacterial culture from its glass bottle onto a separate agar plate. She spread each bacterial culture evenly over the agar using a spreader.

Describe the aseptic techniques she should use.

(3)

(b) On each agar plate, the student cut a well (a hole) in the agar.

The well had a diameter of 6 mm. The student added 50 mm^3 of cinnamon oil into the well.

Calculate the minimum depth of the well to allow the addition of 50 mm^3 of cinnamon oil.
Use the following equation in your calculation:

$$\text{Volume of a cylinder} = \pi r^2 \times l$$

Use 3.14 as the value for π.

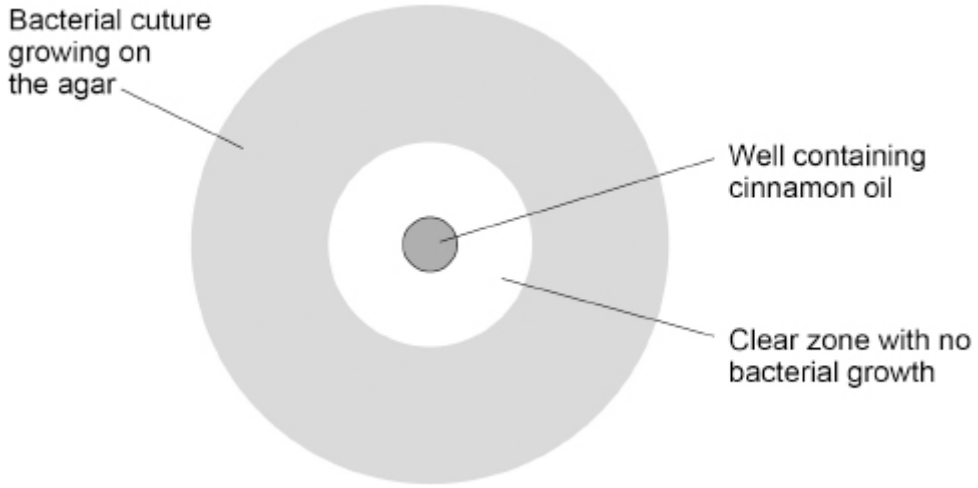
Show your working.

Answer _____ mm

(2)

The student kept the plates at 25 °C for 24 hours.

The figure below shows what one of her plates looked like after 24 hours.



The student measured the diameter of the clear zone with no bacterial growth around each well. She made these measurements to the nearest whole mm

The table shows her results.

Bacterial culture	Diameter of clear zone / mm		
	Cinnamon oil	Positive control	Negative control
Bacillus spp.	15	14	0
Staphylococcus aureus	20	17	0
Listeria monocytogenes	18	12	0
Escherichia coli	16	12	0
Klebsiella spp.	14	12	0
Median for all cultures			0
Mean for all cultures			0
Standard deviation for all cultures	2.4	2.2	0

(c) Suggest exactly what the student added to the wells to get the positive control **and** negative control results.

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(2)

(d) Complete the table above to show the median and mean diameters.

(1)

(e) The mean ± 2 standard deviations includes over 95% of the data.

Use this information to consider whether the standard deviations suggest the differences in means are likely to be due to chance.

Explain your answer, including at least **one** calculation.

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(2)

(Total 10 marks)