

Q1.

Freshwater marshes have one of the highest rates of gross primary production (*GPP*) and net primary production (*NPP*) of all ecosystems.

Carbon use efficiency (*CUE*) is the ratio of *NPP*:*GPP*. Freshwater marshes have a high *CUE*.

- (a) Use your knowledge of *NPP* to explain why freshwater marshes have a high *CUE* **and** the advantage of this.

Do **not** refer to abiotic factors in your answer.

Explanation _____

Advantage _____

(2)

- (b) Freshwater marsh soils are normally waterlogged. This creates anaerobic conditions.

Use your knowledge of the nitrogen cycle to suggest why these soils contain relatively high concentrations of ammonium compounds and low concentrations of nitrite ions and nitrate ions.

(2)

A student investigated the growth rate of a freshwater marsh plant.

The growth rate (*R*) of a plant can be determined using this equation.

$$R = \frac{(\ln W_2 - \ln W_1)}{t}$$

Where

ln = natural logarithm

t = duration of the investigation in days

*W*₁ = plant biomass at the start of the investigation

*W*₂ = plant biomass at the end of the investigation

The student used the equation above; however, she substituted height for biomass. This was because she did not want to destroy the plants to measure their biomass.

- (c) State the assumption the student has made **and** suggest why this assumption might **not** be valid.

(2)

- (d) At the end of the investigation, the student noted the freshwater marsh plant had grown 268 mm in height, and now measured 387 mm. She calculated the rate of growth (R) to be $0.097 \text{ mm m}^{-1} \text{ day}^{-1}$

Use this information and, **substituting height for biomass**, use the equation to calculate the duration of the student's investigation.

Give your answer to the nearest full day. Show your working.

_____ days

(2)

(Total 8 marks)

Q2.

- (a) Describe the role of saprobionts in the nitrogen cycle.

(2)

- (b) One environmental issue arising from the use of fertilisers is eutrophication. Eutrophication can cause water to become cloudy.

You are given samples of water from three different rivers.

Describe how you would obtain a quantitative measurement of their cloudiness.

(3)

(Total 5 marks)

Q3.

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

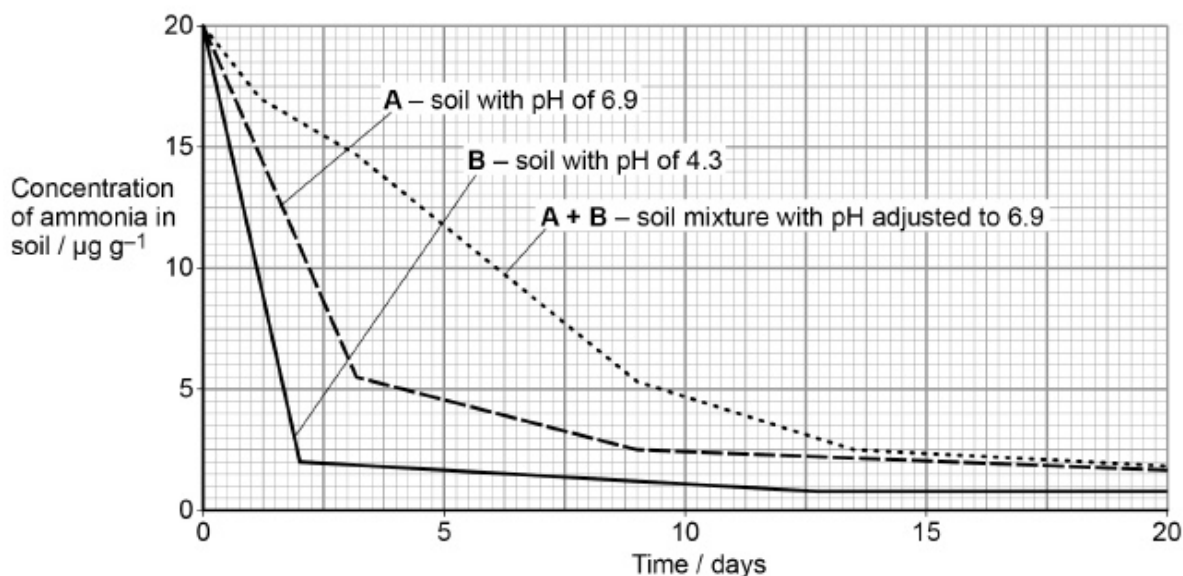
- the soil from site **A** had a pH of 6.9
- the soil from site **B** had a pH of 4.3

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 1**.

Figure 1



- (a) The scientists used units of $\mu\text{g g}^{-1}$ for the concentration of ammonia in soil. Suggest why, in this investigation, the scientists used these units.

μg _____

g⁻¹ _____

(2)

- (b) 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.

Difference in rate = _____

(2)

- (c) The scientists concluded that the soil mixture experiment showed there were different communities of bacteria in soils A and B.

What evidence from **Figure 1** supports their conclusions? Give reasons for your answer.

(3)

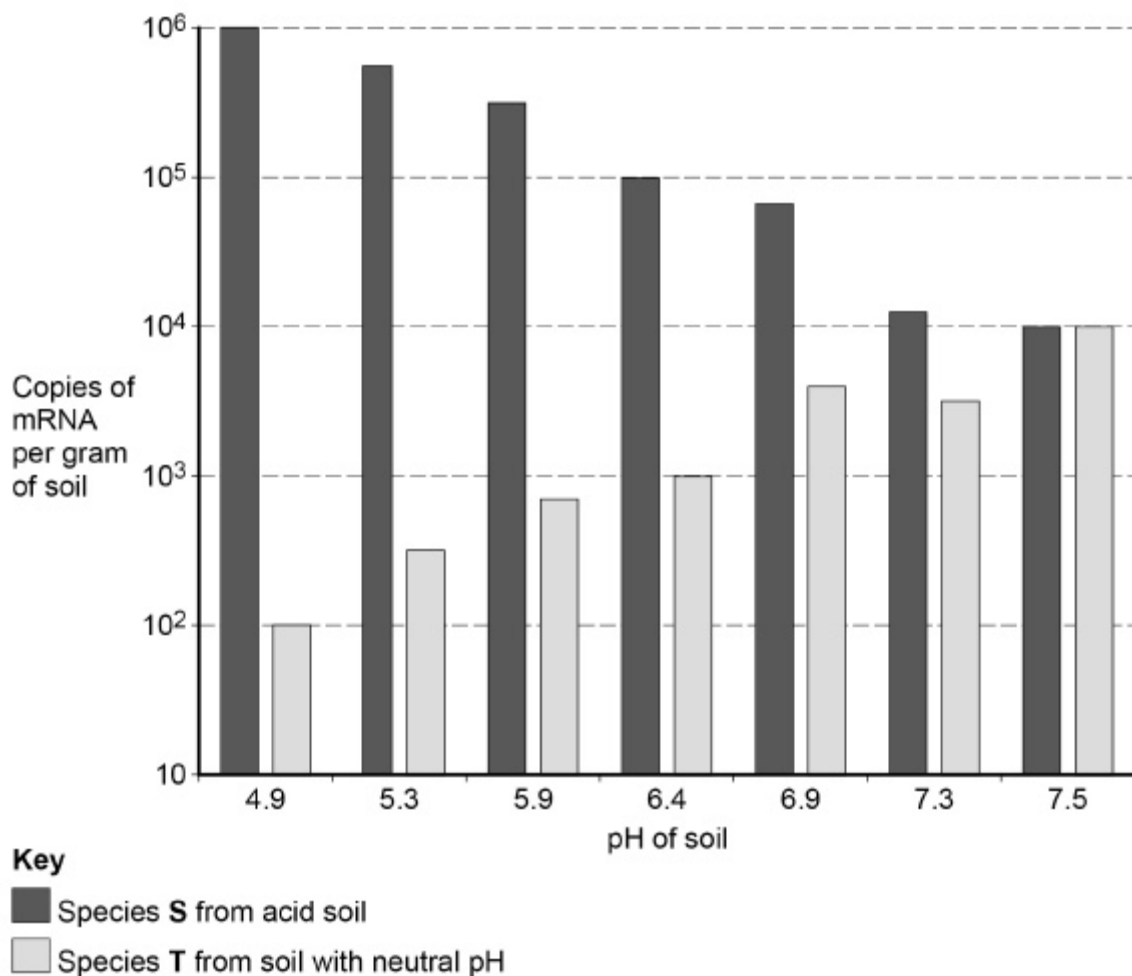
The oxidation of ammonia by nitrifying bacteria involves the enzyme ammonia monooxygenase. Each species of nitrifying bacteria has its own specific *amoA* gene that codes for production of ammonia monooxygenase.

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 2**.

Figure 2



- (d) 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)

- (e) 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)

- (f) 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)

(Total 15 marks)

Q4.

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

- (a) 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.

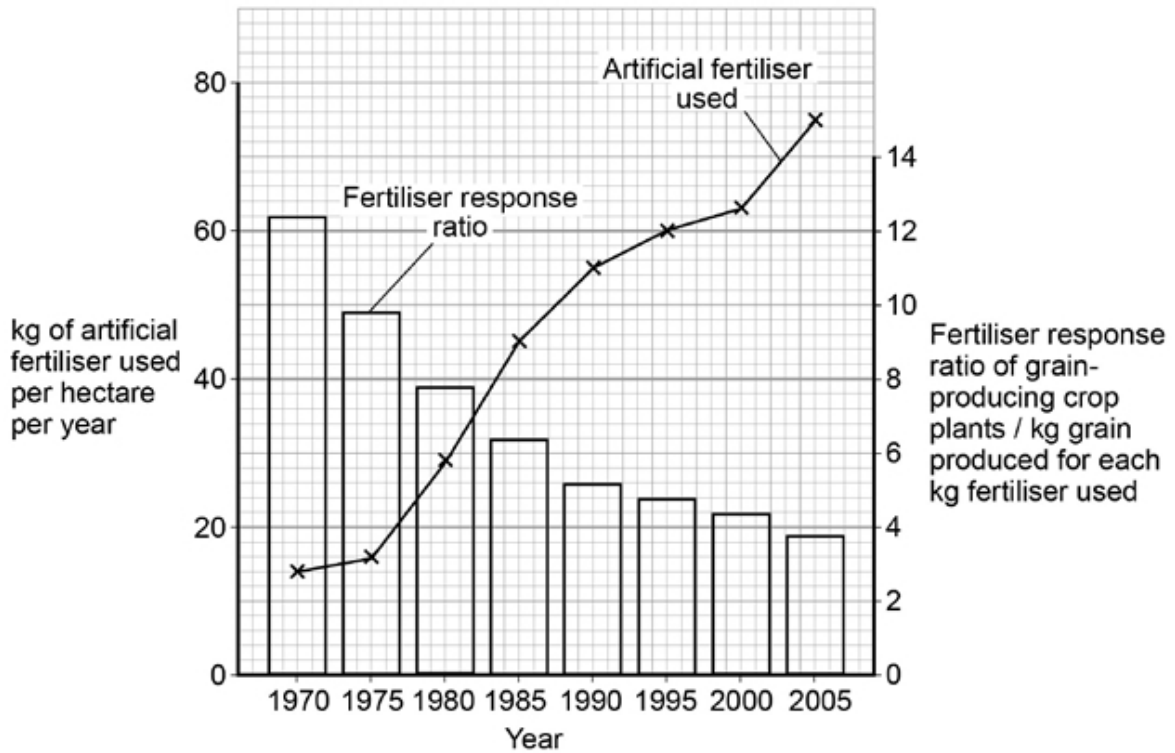
1. _____

2. _____

(2)

- (b) 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.

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



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

Show your working.

Difference _____ kg hectare⁻¹

(2)

- (c) Use the data in the graph above to evaluate the use of artificial fertilisers on grain-producing crops in India.

(2)

Q5.

Scientists investigated the effect of a mycorrhizal fungus on the growth of pea plants with a nitrate fertiliser or an ammonium fertiliser. The fertilisers were identical, except for nitrate or ammonium.

The scientists took pea seeds and sterilised their surfaces. They planted the seeds in soil that had been heated to 85 °C for 2 days before use. The soil was sand that contained no mineral ions useful to the plants.

- (a) Explain why the scientists sterilised the surfaces of the seeds and grew them in soil that had been heated to 85 °C for 2 days.

(2)

- (b) Explain why it was important that the soil contained no mineral ions useful to the plants.

(1)

The pea plants were divided into four groups, **A**, **B**, **C** and **D**.

- **Group A** – heat-treated mycorrhizal fungus added, nitrate fertiliser
- **Group B** – mycorrhizal fungus added, nitrate fertiliser
- **Group C** – heat-treated mycorrhizal fungus added, ammonium fertiliser
- **Group D** – mycorrhizal fungus added, ammonium fertiliser

The heat-treated fungus had been heated to 120 °C for 1 hour.

- (c) Explain how groups **A** and **C** act as controls.

(2)

After 6 weeks, the scientists removed the plants from the soil and cut the roots from the shoots. They dried the plant material in an oven at 90 °C for 3 days. They then determined the mean dry masses of the roots and shoots of each group of pea plants.

- (d) Suggest what the scientists should have done during the drying process to be sure that all of the water had been removed from the plant samples.

(2)

The scientists' results are shown in the table below.

Treatment	Mean dry mass / g per plant (standard deviation)	
	Root	Shoot
A – heat-treated fungus and nitrate fertiliser	0.40 (±0.05)	1.01 (±0.12)
B – fungus and nitrate fertiliser	1.61 (±0.28)	9.81 (±0.33)
C – heat-treated fungus and ammonium fertiliser	0.34 (±0.03)	0.96 (±0.26)
D – fungus and ammonium fertiliser	0.96 (±0.18)	4.01 (±0.47)

- (e) What conclusions can be drawn from the data in the table about the following?

The effects of the fungus on growth of the pea plants.

The effects of nitrate fertiliser and ammonium fertiliser on growth of the pea plants.

(4)

The scientists determined the dry mass of the roots and shoots separately. The reason for this was they were interested in the ratio of shoot to root growth of pea plants. It is the shoot of the pea plant that is harvested for commercial purposes.

- (f) Explain why determination of dry mass was an appropriate method to use in this investigation.

(2)

- (g) Which treatment gave the best result in commercial terms? Justify your answer.

(2)

(Total 15 marks)