AQA A-LEVEL · 7402

BIOLOGY



EXAM QUESTION PACK

3.5.4 NUTRIENT CYCLES

SCORE	PERCENTAGE
/375	%

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Q1.

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

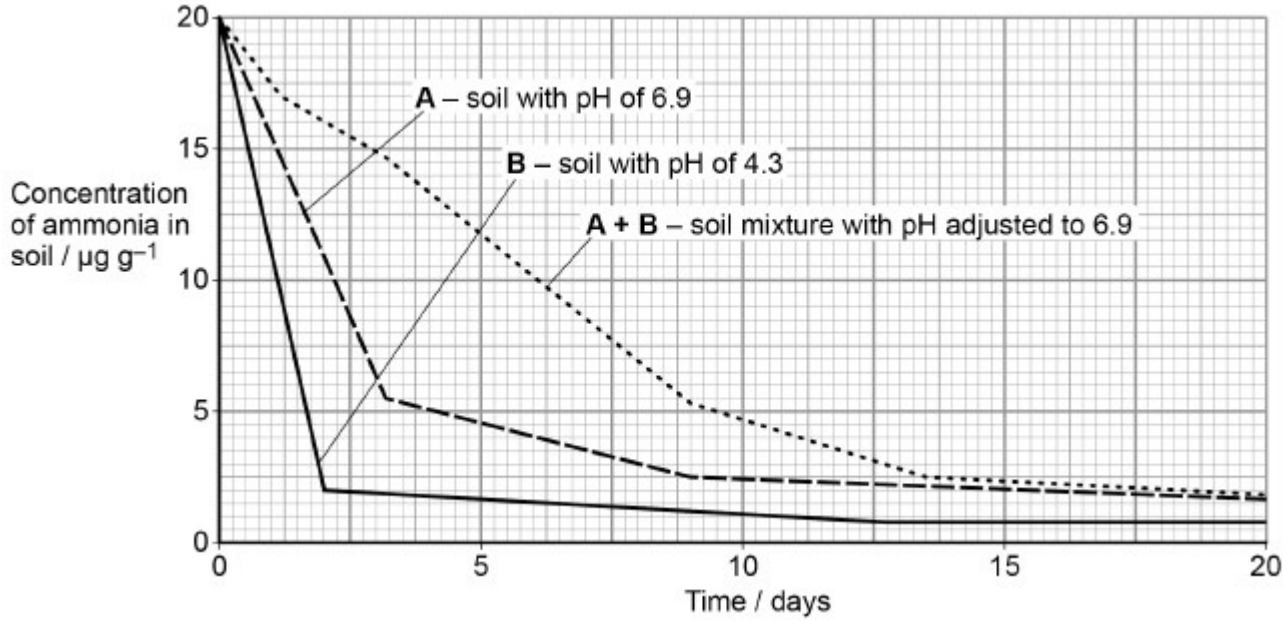
- the soil from site **A** had a pH of 6.9
- the soil from site **B** had a pH of 4.3

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 µg 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.

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(3)

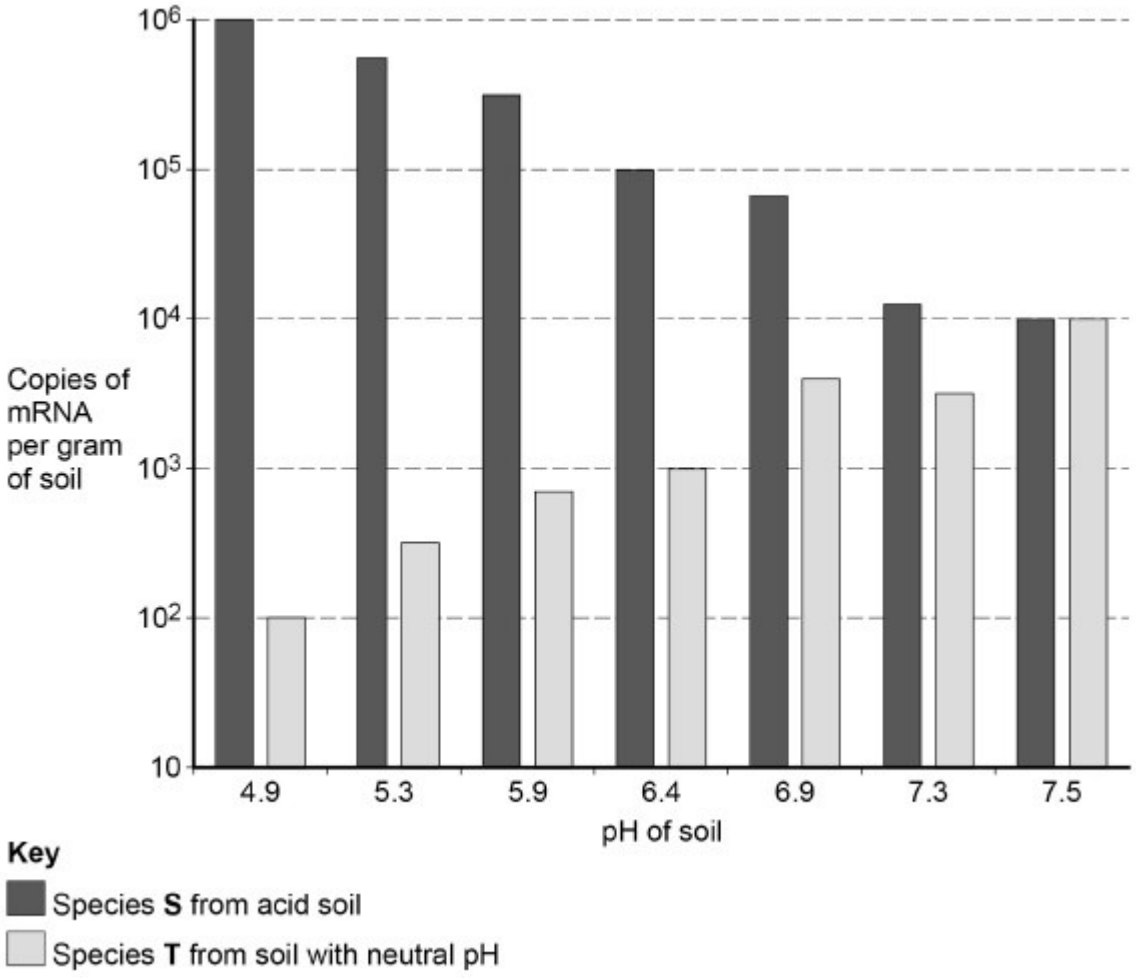
The oxidation of ammonia by nitrifying bacteria involves the enzyme ammonia monooxygenase. Each species of nitrifying bacteria has its own specific *amoA* gene that codes for production of ammonia monooxygenase.

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.

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(2)

(Total 15 marks)

Q2.

Arbuscular mycorrhiza fungi (AMF) are fungi which grow on, and into, the roots of plants. AMF can increase the uptake of inorganic ions such as phosphate.

(a) Suggest **one** way in which an increase in the uptake of phosphate could increase plant growth.

_____

_____

(1)

(b) Suggest **one** way in which AMF may benefit from their association with plants.

_____

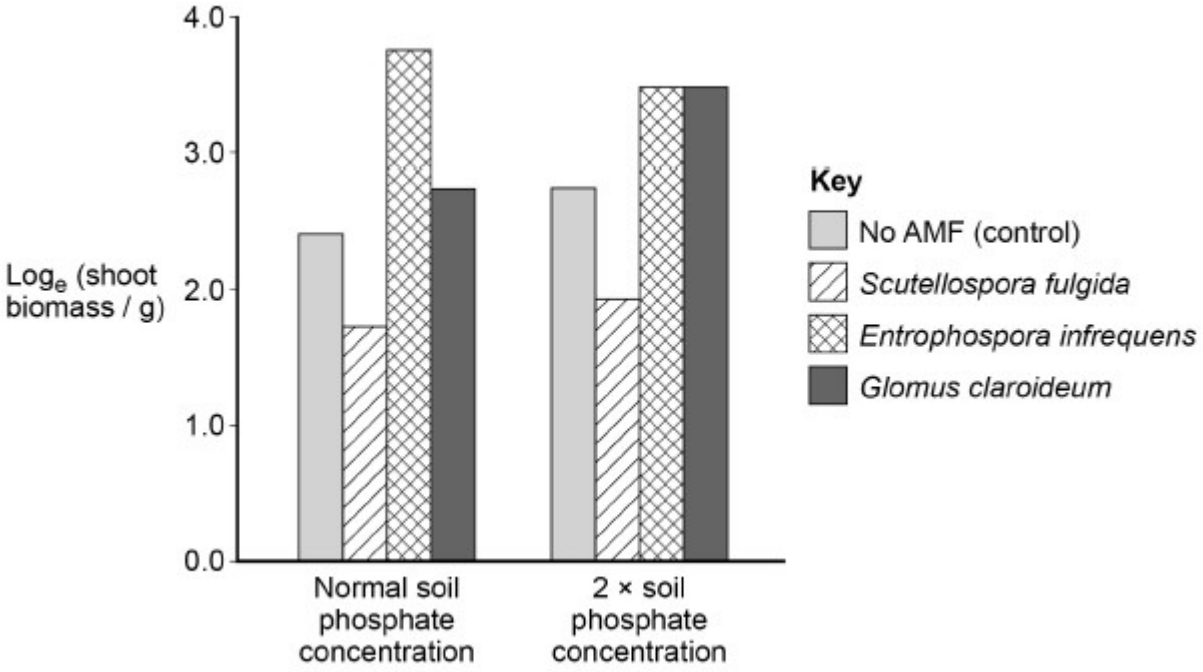
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(1)

(c) Scientists investigated the effects of different AMF species on the productivity of the plant community of a prairie grassland ecosystem when growing in/on soil containing different phosphate concentrations.

The scientists set up identical plots of prairie grassland soil containing seeds of the plant species found in the ecosystem. The scientists added different AMF species and different concentrations of phosphate to particular plots. Control plots without AMF species were also set up. After 20 weeks the scientists determined the shoot biomass for each plot.

The results the scientists obtained are shown in the graph.



Explain why an increase in shoot biomass can be taken as a measurement of **net** primary productivity.

(2)

(d) Using the data from the graph in part (c), evaluate the effect on plant productivity of adding AMF species and adding phosphate to the soil.

(4)

(e) Using the e^x button on your calculator, determine the rate of shoot biomass production in grams per day for the control plot in soil with normal phosphate concentration.

Answer = _____ g day^{-1}

(2)

(Total 10 marks)

Q3.

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.

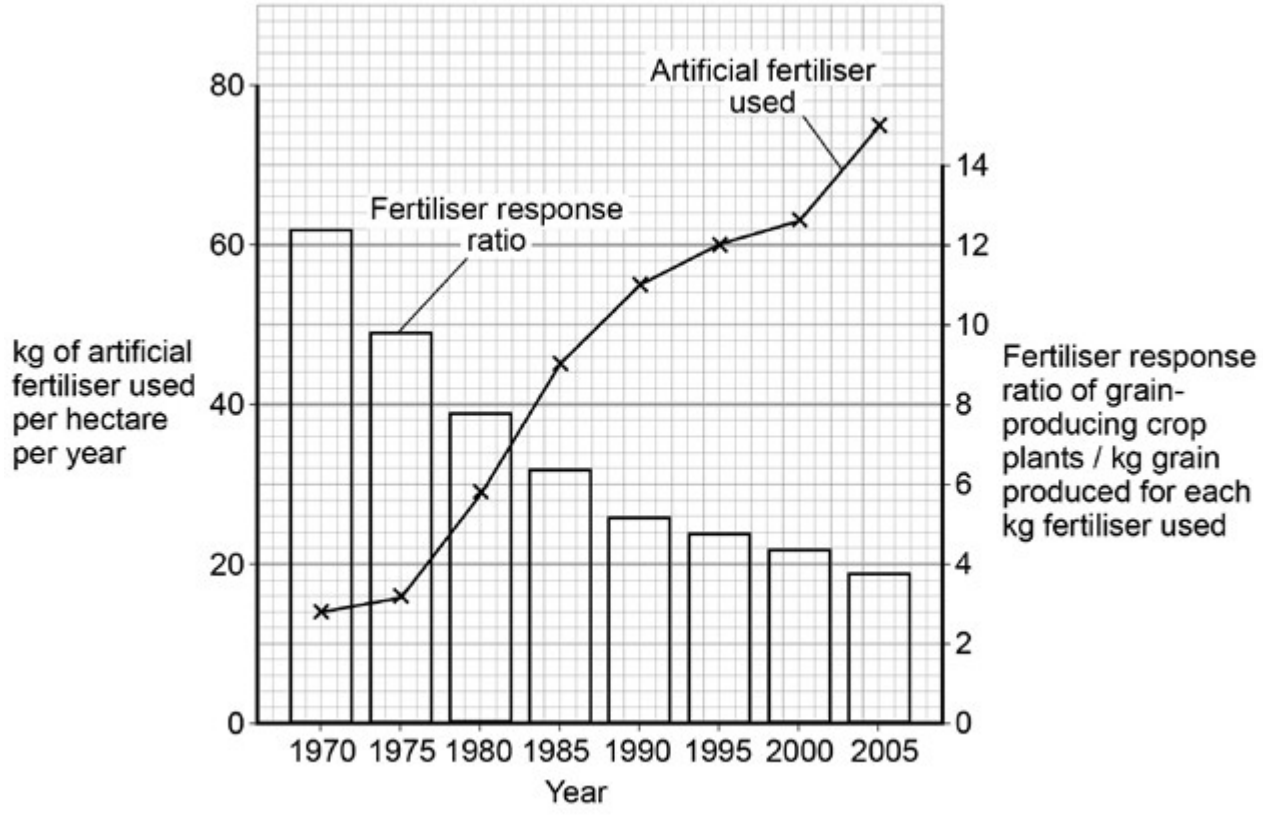
1. _____

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.

_____

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(2)

(Total 6 marks)

Q4.

Read the following passage.

Plants require phosphate ions that they get from soil. These ions are often in poor supply and this results in poor growth of the plants. Most plants have mycorrhizae that help the plants to obtain nitrates. Mycorrhizal networks can connect the roots of plants growing next to each other. The use of fertilisers containing phosphate and nitrates in farming inhibits the growth of mycorrhizae. As a result, intensively farmed crop plants do not have mycorrhizae.

Plants can defend themselves by producing defensive enzymes that destroy pathogens such as bacteria. Some plants express the genes for defensive enzymes in response to signal proteins secreted by other plants that are being attacked by a pathogen. These signal proteins can be released into the air.

Scientists have discovered that tomato plants increase production of defensive enzymes if plants next to them become infected with a pathogen. These tomato plants were connected by a mycorrhizal network that can carry signal proteins between them. The largest increase in defensive enzyme secretion that the scientists found in a tomato plant in response to the signal protein was by 122.6 per cent.

Use the information in the passage and your own knowledge to answer the following questions.

(a) Suggest and explain **two** reasons why a poor supply of phosphate ions results in poor growth of plants (lines 1–2).

1. _____

_____

2. _____

_____

(2)

(b) Suggest how defensive enzymes produced by plants destroy bacteria (lines 8–9).

_____

_____

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(2)

(c) The signal proteins secreted into the air by a plant being attacked by a pathogen act as stimuli leading to the expression of genes for defensive enzymes in other plants (lines 9–12).

Suggest how they lead to the expression of these genes.

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(3)

(d) Suggest and explain **the** advantage to tomato plants of transmitting signal proteins through mycorrhizal networks, rather than releasing them into the air (line 11–12 and lines 14–16).

_____

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(2)

(e) The largest increase in defensive enzyme secretion that the scientists found in a tomato plant in response to the signal protein was by 122.6 percent (lines 16–18).

The rate of secretion of the defensive enzymes before the signal protein was produced was 450 μmol dm^{-3} g^{-1} $hour^{-1}$.

Calculate the rate of secretion **per second** after the response to the signal protein.

Answer = _____ μmol dm^{-3} g^{-1} $second^{-1}$

(2)

(f) A student who read this passage concluded that farmers should **not** use fertilisers to increase yields when growing tomato plants.

Evaluate his conclusion.

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(4)

(Total 15 marks)

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.

_____

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(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.

_____

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(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.

_____

_____

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(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.

_____

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(2)

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

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(2)

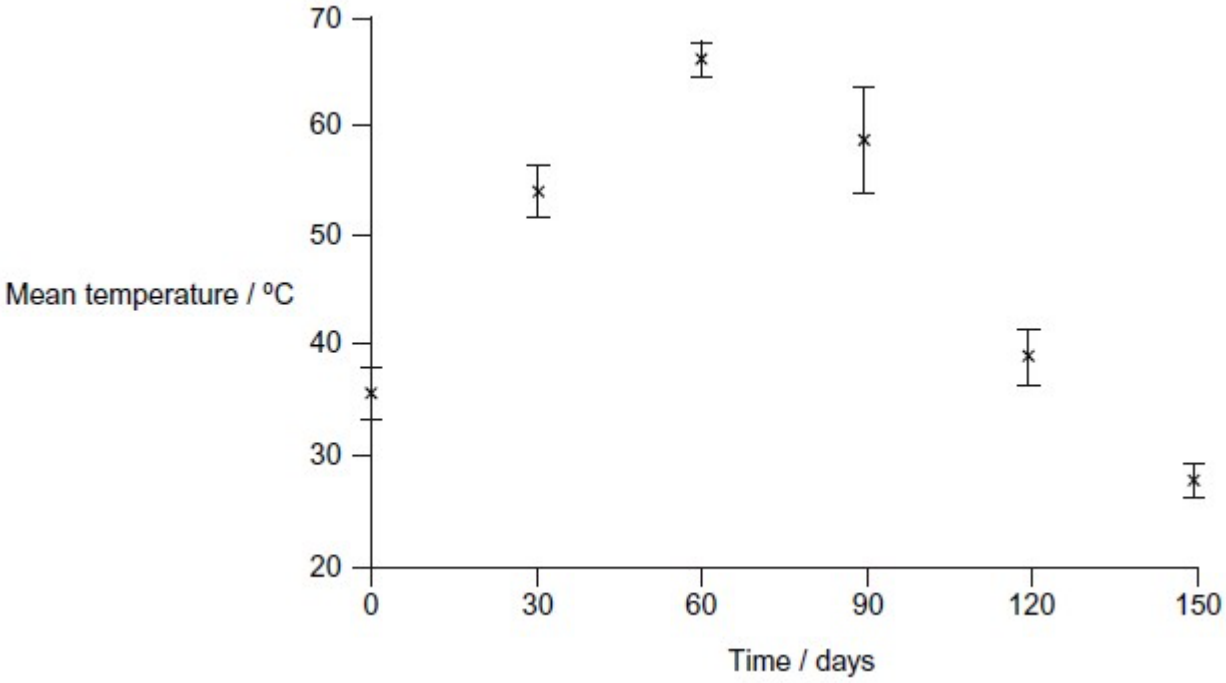
(Total 15 marks)

Q6.

The organic material in household waste can be used to make compost for use as a fertiliser. Scientists investigated changes during one process used to make this compost. The method involved placing the waste in large containers for 150 days. At regular intervals the containers were rotated. The scientists measured the temperature of samples of waste during the investigation.

Figure 1 shows the results they obtained. The vertical bars show standard deviations.

Figure 1



(a) Explain how microorganisms contributed to the increase in temperature during processing of organic waste.

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_____

_____

_____

(2)

(b) Explain the advantage of showing the data using standard deviations rather than ranges.

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(2)

(c) Suggest **two** advantages of rotating the containers during the process.

1. _____

_____

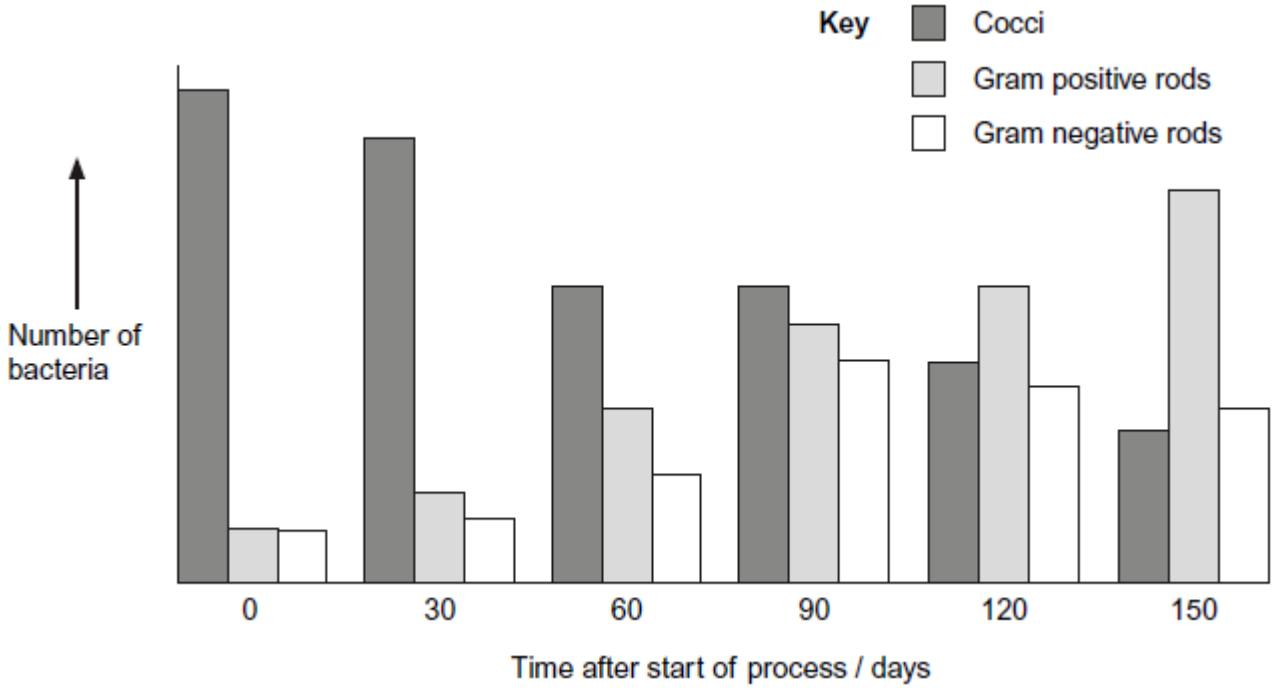
2. _____

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(2)

(d) The scientists took a sample of the waste at the start of the process. They then took samples every 30 days. In each sample, they determined the numbers of particular types of bacteria.
Figure 2 shows the changes in the number of three types of bacteria during the process.

Figure 2



The scientists concluded that the results in **Figure 1** and **Figure 2** are evidence for a form of succession during the process.

Use the information to suggest how they reached this conclusion.

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(3)

(Total 9 marks)

Q7.

(a) Crops use light energy to produce photosynthetic products.
Describe how crop plants use light energy during the light-dependent reaction.

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_____

_____

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_____

(5)

(b) After harvesting, the remains of crop plants are often ploughed into the soil.
Explain how microorganisms in the soil produce a source of nitrates from these remains.

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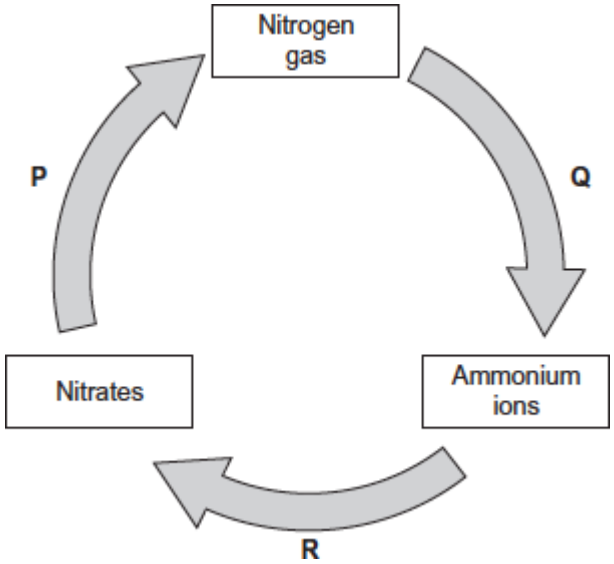
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(5)

(Total 10 marks)

Q8.

The diagram shows part of the nitrogen cycle.



(a) Which **one** of the processes **P**, **Q** or **R** involves nitrification?

☐

(1)

(b) The diagram above includes one process in which microorganisms add ammonium ions to soil.

Describe another process carried out by microorganisms which adds ammonium ions to soil.

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_____

_____

_____

_____

(2)

(c) Denitrification requires anaerobic conditions. Ploughing aerates the soil.
Explain how ploughing would affect the fertility of the soil.

_____

_____

_____

_____

_____

(2)

(d) One farming practice used to maintain high crop yields is crop rotation. This involves growing a different crop each year in the same field.

Suggest **two** ways in which crop rotation may lead to high crop yields.

1. _____

_____

_____

2. _____

_____

_____

(2)

(Total 7 marks)

Q9.

Upwelling is a process where water moves from deeper parts of the sea to the surface. This water contains a lot of nutrients from the remains of dead organisms.

(a) (i) Nitrates and phosphates are two of these nutrients. They provide a source of nitrogen and phosphorus for cells.

Give a biological molecule that contains:

1. nitrogen_____

2. phosphorus_____

(2)

(ii) Describe the role of microorganisms in producing nitrates from the remains of dead organisms.

_____

_____

_____

_____

_____

_____

(3)

(b) Upwelling often results in high primary productivity in coastal waters.
Explain why some of the most productive fishing areas are found in coastal waters.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q10.

During the light-independent reaction of photosynthesis, carbon dioxide is converted into organic substances. Describe how.

_____

_____

_____

_____

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_____

(Total 6 marks)

Q11.

Scientists measured the rate of respiration in **three** parts of an ecosystem.

They did this by measuring carbon dioxide released into the air by:

- leaves of plants
- stems and roots of plants
- non-photosynthetic soil organisms.

The table below shows the scientists' results for these three parts of the ecosystem.

Part of ecosystem	**Mean rate of carbon dioxide production / $cm^3\ m^{-2}\ s^{-1}$**	**Percentage of total carbon dioxide production measured**

		by the scientists
Leaves of plants	0.032	25.0
Stems and roots of plants	0.051	
Non-photosynthetic soil organisms	0.045	

(a) Complete the table to show the percentage of total carbon dioxide production by each part of the ecosystem.

Show your working.

(2)

(b) A student who looked at the data in the table concluded that plants carry out more respiration than non-photosynthetic organisms in the ecosystem.

Use the information provided to suggest why these data may **not** support the student's conclusion.

_____

_____

_____

_____

(2)

(c) What measurements would the scientists have made in order to calculate the rate of carbon dioxide production?

_____

_____

_____

_____

(2)

(d) The scientists calculated the mean rate of carbon dioxide production of the leaves using measurements of carbon dioxide release in the dark.

Explain why they did **not** use measurements taken in the light.

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_____

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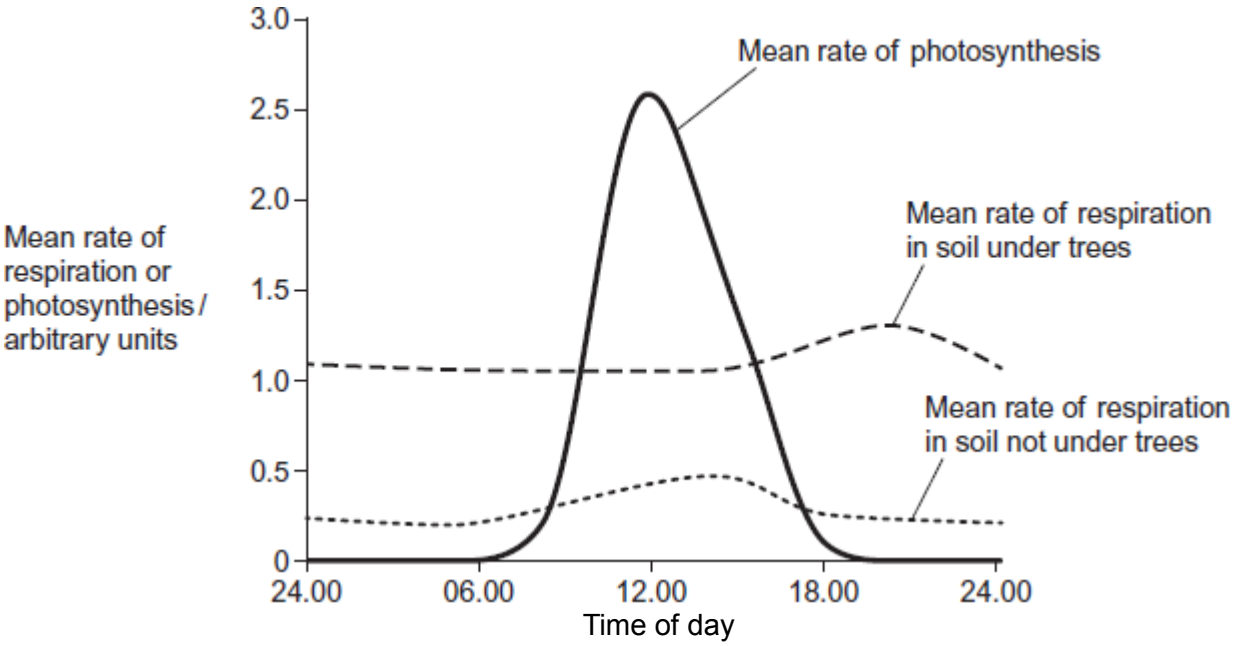
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(2)

Another group of scientists measured the mean rate of respiration in soil under trees and soil not under trees in the same wood. They also measured the mean rate of photosynthesis in the trees.

They took measurements at different times of day during the summer.

The figure below shows the scientists' results.



(e) (i) Describe **two** ways in which the mean rate of respiration in soil under trees is different from soil not under trees.

1. _____

_____

2. _____

_____

(2)

(ii) Suggest **one** explanation for the differences in the mean rate of respiration in soil under trees and soil not under trees between 06.00 and 12.00.

_____

_____

_____

_____

(2)

(f) The scientists suggested that the rise in the mean rate of photosynthesis was the cause of the rise in the mean rate of respiration in soil under trees.

(i) Suggest how the rise in the mean rate of photosynthesis could lead to the rise in the mean rate of respiration in soil under trees.

_____

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(2)

(ii) Suggest why there is a delay between the rise in the mean rate of photosynthesis and the rise in the mean rate of respiration.

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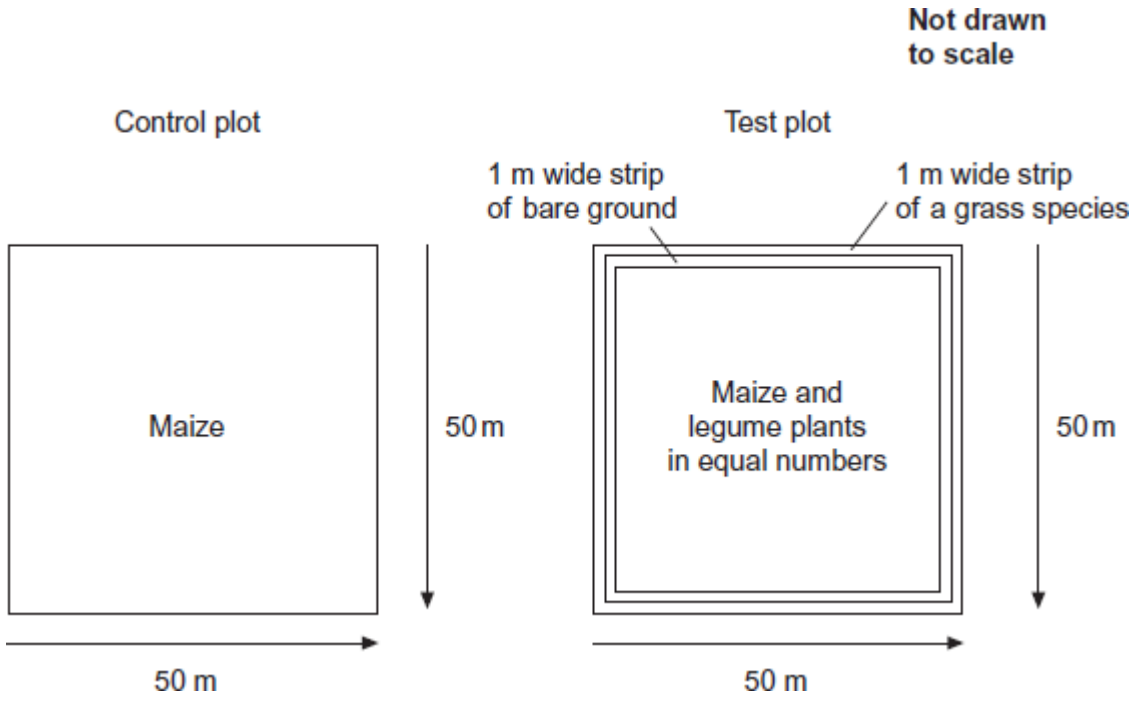
(1)

(Total 15 marks)

Q12.

Stemborers are insect pests that feed on maize plants. Scientists investigated the effect of **push-pull** stimuli on the control of these pests.

For this investigation, the scientists divided a large field into plots measuring 50 m × 50 m. They then designated each plot as a control plot or a test plot. The following figure shows what they planted in each type of plot.



The legumes planted with the maize drive stemborers away.
The grass species attracts stemborers.

The table below shows the scientists' results.

Plots	**Mean percentage damage to maize plants**	**Mean maize grain yield / tonnes per hectare (± standard deviation)**	**Mean production costs per farmer / $ per hectare (± standard deviation)**	**Mean total income for farmer / $ per hectare (± standard deviation)**
Control	29.6	1.5 (±0.2)	250 (±0.7)	329 (±5.9)
Test	6.7	3.7 (±0.3)	278 (±1.1)	679 (±10.2)

(a) In the test plot of land, identify the push stimulus and the pull stimulus.

Push stimulus _____

Pull stimulus _____

(1)

(b) When measuring the mean percentage damage to maize plants, 60 plants from each test plot were selected at random and examined.
Describe how the maize plants could be selected at random.

_____

_____

_____

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_____

_____

(3)

(c) In the test plot, bare ground was left between the maize and the grass species. Suggest an explanation why.

_____

_____

_____

_____

_____

(2)

(d) The legume plants have nodules containing nitrogen-fixing bacteria on their roots. Explain how nitrogen-fixing bacteria could increase the growth of the maize.

_____

_____

_____

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_____

(2)

(e) A year after this investigation, the government of one country decided that their farmers should use these **push-pull** stimuli.
How do these data support this decision?

_____

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_____

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(3)

(Total 11 marks)

Q13.

Nitrate from fertiliser applied to crops may enter ponds and lakes. Explain how nitrate may cause the death of fish in fresh water.

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(Total 5 marks)

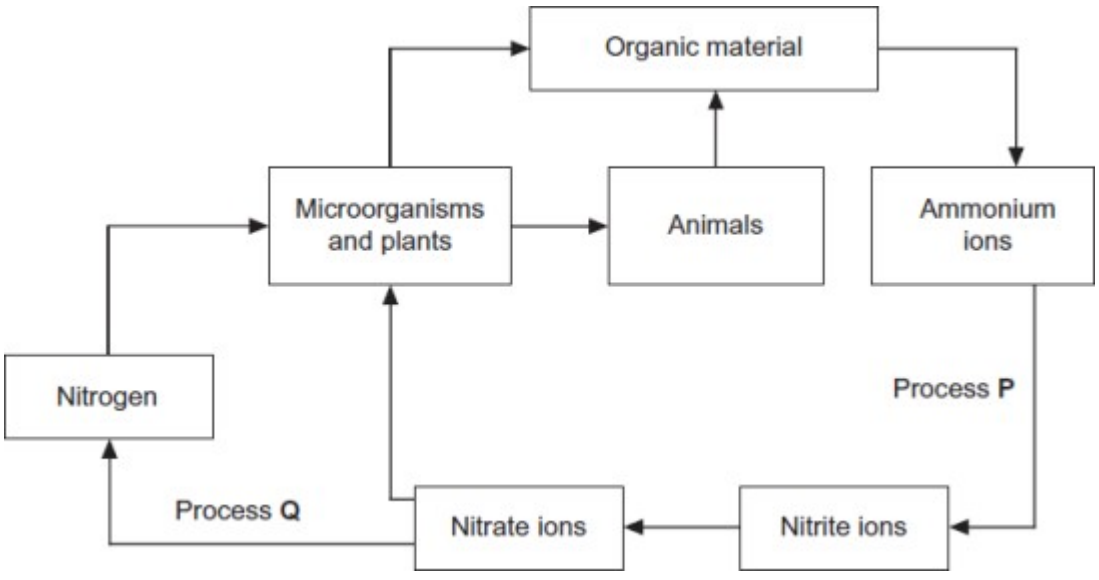
Q14.

Write an essay on the many different types of relationships and interactions between organisms.

(Total 25 marks)

Q15.

The diagram shows the nitrogen cycle.



(a) (i) Name process **P**.

_____

(1)

(ii) Name process **Q**.

_____

(1)

(b) Leguminous crop plants have nitrogen-fixing bacteria in nodules on their roots. On soils with a low concentration of nitrate ions, leguminous crops often grow better than other types of crop. Explain why.

_____

_____

_____

_____

_____

(2)

(c) Applying very high concentrations of fertiliser to the soil can reduce plant growth. Use your knowledge of water potential to explain why.

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(2)

(Total 6 marks)

Q16.

(a) Explain how farming practices increase the productivity of agricultural crops.

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(5)

(b) Describe how the action of microorganisms in the soil produces a source of nitrates

for crop plants.

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(5)

(Total 10 marks)

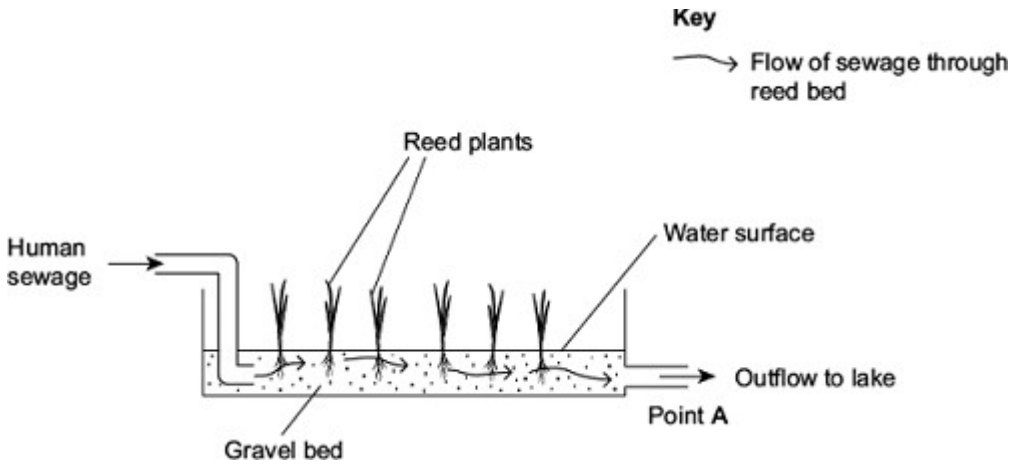
Q17.

(a) Name the process by which some bacteria oxidise ammonia to nitrate.

_____

(1)

Reeds are plants that grow with their roots under water. A reed bed contains a large number of growing reeds. Reed beds may be used to absorb nitrates produced when bacteria break down human sewage. The diagram shows a reed bed.



(b) Reeds have hollow, air-filled tissue in their stems which supplies oxygen to their roots.
Explain how this enables the roots to take up nitrogen-containing substances.

_____

_____

_____

_____

_____

(2)

(c) (i) There is an optimum rate at which human sewage should flow through the reed bed. If the flow of human sewage is too fast, the nitrate concentration at point **A** falls.
Explain why.

_____

_____

_____

_____

_____

(2)

(ii) An increase in nitrate concentration in the water entering the lake could affect algae and fish in the lake. Explain how.

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(3)

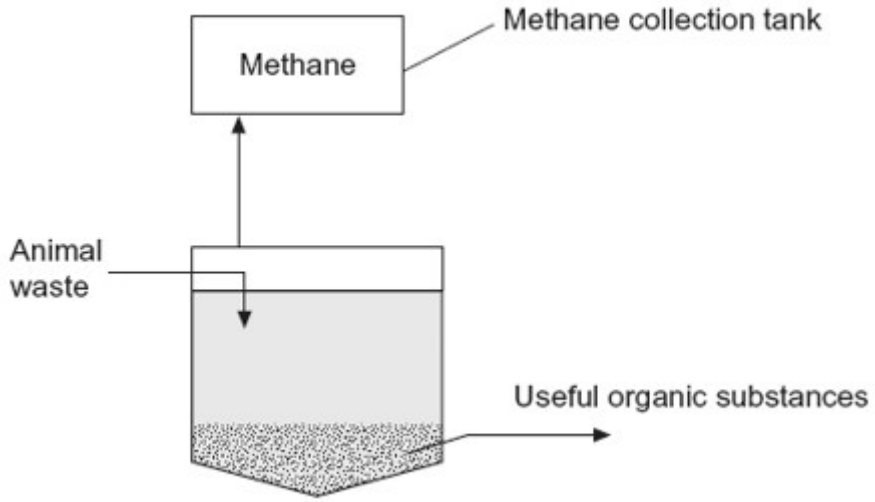
(Total 8 marks)

Q18.

Intensive rearing of livestock produces large quantities of waste. Some farmers use an anaerobic digester to get rid of the waste.

In an anaerobic digester, microorganisms break down the large, organic molecules in the waste. This produces methane, which is a useful fuel. It also produces organic substances that can be used as a natural fertiliser.

The diagram shows an anaerobic digester.



(a) (i) Suggest **two** advantages of processing waste in anaerobic digesters rather than in open ponds.

1. _____

_____

2. _____

_____

(2)

(ii) The anaerobic digester has a cooling system, which is not shown in the diagram.

Without this cooling system the digester would soon stop working. Explain why.

_____

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(2)

(b) (i) The over-application of fertiliser increases the rate of leaching. Explain the consequences of leaching of fertiliser into ponds and lakes.

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(3)

(ii) Give **one** advantage of using natural fertiliser produced in the digester rather than an artificial fertiliser.

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(1)

(Total 8 marks)

Q19.

Much of Indonesia is covered with forest. Large areas of forest have been cleared and planted with oil-palm trees to be used in the production of fuel.

(a) In these forests, nitrogen in dead leaves is made available to growing plants by the action of bacteria. Describe the role of bacteria in making the nitrogen in dead leaves available to growing plants.

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(5)

(b) During photosynthesis, oil-palm trees convert carbon dioxide into organic substances. Describe how.

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(6)

(Total 11 marks)

Q20.

Urea from animal waste can be used as a fertiliser. Some bacteria in the soil secrete the enzyme urease which hydrolyses urea into ammonia. Some of this ammonia is released into the atmosphere. NBPT is an inhibitor of urease and can be added to urea fertiliser to reduce the loss of ammonia to the atmosphere.

(a) A molecule of NBPT has a similar structure to a molecule of urea. Use this information to suggest how NBPT inhibits the enzyme urease.

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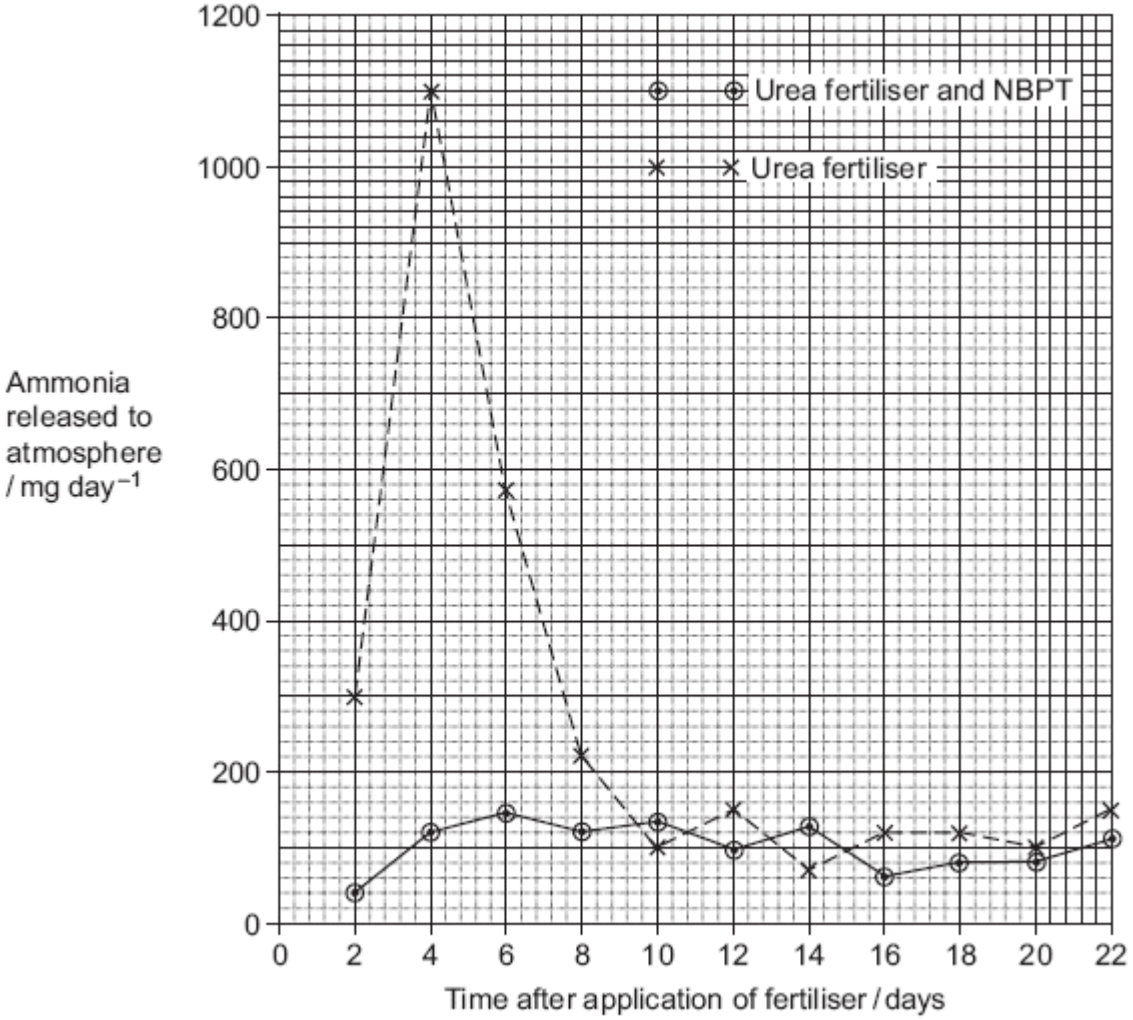
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(2)

Scientists investigated the effect of NBPT on the release of ammonia from urea fertiliser added to the soil. A control experiment was carried out. This involved adding urea fertiliser only. The graph shows their results.



(b) (i) Describe how NBPT affected the loss of ammonia from urea fertiliser.

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(1)

(ii) Suggest an explanation for the increase in mass of ammonia released over the first four days in the control experiment.

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(2)

(c) Suggest how the addition of NBPT to urea fertiliser could result in increased growth of crop plants.

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(3)

(Total 8 marks)

Q21.

Nitrogenase catalyses the reduction of nitrogen during nitrogen fixation. The reaction requires 16 molecules of ATP for each molecule of nitrogen that is reduced.

(a) Nitrogen gas is the usual substrate for this enzyme. Name the product.

_____

(1)

(b) Nitrogenase also catalyses reactions involving other substances. Explain what this suggests about the shapes of the molecules of these other substances.

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(2)

(c) (i) *Azotobacter* is a nitrogen-fixing bacterium. It produces the enzyme nitrogenase. The enzyme only works in the absence of oxygen.

Azotobacter has a very high rate of aerobic respiration compared with bacteria that do not fix nitrogen. Suggest **two** advantages of the very high rate of aerobic respiration.

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(2)

(ii) If scientists could transfer the gene that codes for nitrogenase to cereal plants, these cereal plants would be able to fix nitrogen. However, the scientists would expect these genetically engineered cereal plants to grow more slowly than cereal plants that get their nitrogen from fertiliser. Explain why they would grow more slowly.

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(2)

(Total 7 marks)

Q22.

(a) The concentrations of carbon dioxide in the air at different heights above ground in a forest changes over a period of 24 hours. Use your knowledge of photosynthesis to describe these changes and explain why they occur.

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(5)

(b) In the light-independent reaction of photosynthesis, the carbon in carbon dioxide becomes carbon in triose phosphate. Describe how.

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(5)

(Total 10 marks)

Q23.

When fertilisers are applied to fields next to a lake, nitrogen-containing substances from the fertilisers get into the lake.

(a) (i) Describe how the nitrogen-containing substances get into the lake.

_____

_____

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(1)

(ii) It takes longer for the nitrogen-containing substances to get into the lake when an organic fertiliser is used than when an inorganic fertiliser is used. Explain why it takes longer when an organic fertiliser is used.

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(2)

(b) Describe how the presence of nitrates in a lake may eventually lead to the death of fish.

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(4)

(Total 7 marks)

Q24.

In the activated sludge method of sewage treatment, organic matter in untreated sewage supplies nutrients to bacteria in the treatment tank. These bacteria include decomposers and nitrifying bacteria. The bacteria are eaten by ciliated protoctistans, which are, in turn, eaten by carnivorous protoctistans.

(a) (i) Explain the roles of the decomposers and the nitrifying bacteria in converting nitrogen in organic compounds in the sewage into a soluble, inorganic form.

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(3)

(ii) Nitrifying bacteria are one kind of bacteria that are important in the nitrogen cycle; nitrogen-fixing bacteria are another kind. Describe the part played by nitrogen-fixing bacteria in the nitrogen cycle.

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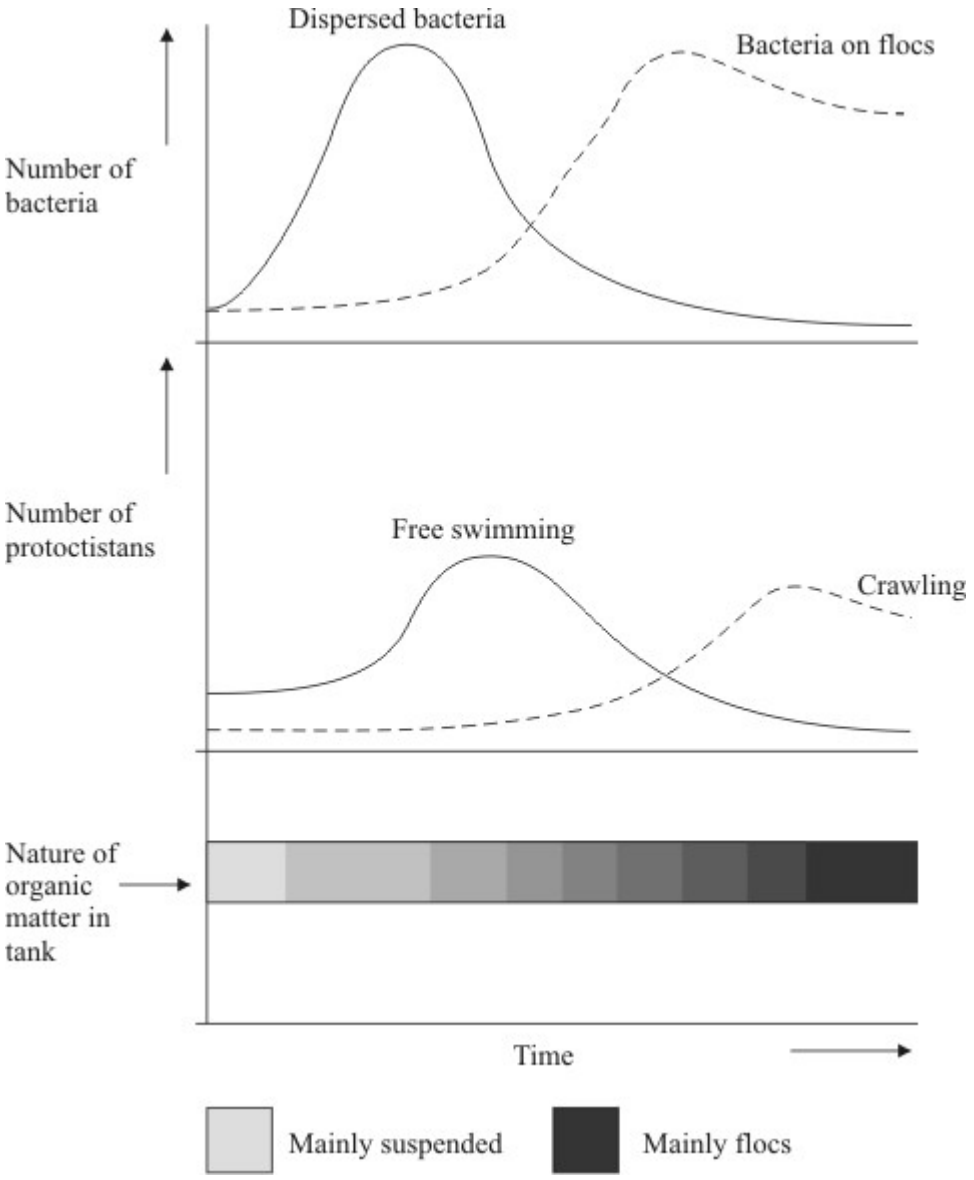
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(2)

(b) The organic matter in untreated sewage consists of small particles, which are suspended in water. Activated sludge consists of solid lumps (flocs) of organic matter and bacteria. When the two are mixed in the treatment tank, bacteria from the flocs become dispersed in the water and feed on the suspended organic matter, converting it to flocs. Different types of ciliated protoctistans feed on the bacteria.

- Free-swimming protoctistans are able to move throughout the tank.
- Crawling protoctistans can only move over the surface of the flocs.

The diagram shows the change in the nature of the organic matter in the treatment tank and the changes in the numbers of the different types of organisms present.



(i) Explain the changes in the numbers of dispersed bacteria and the numbers of free-swimming protoctistans.

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(3)

(ii) Explain how the changes that occur in the treatment tank illustrate the process of succession.

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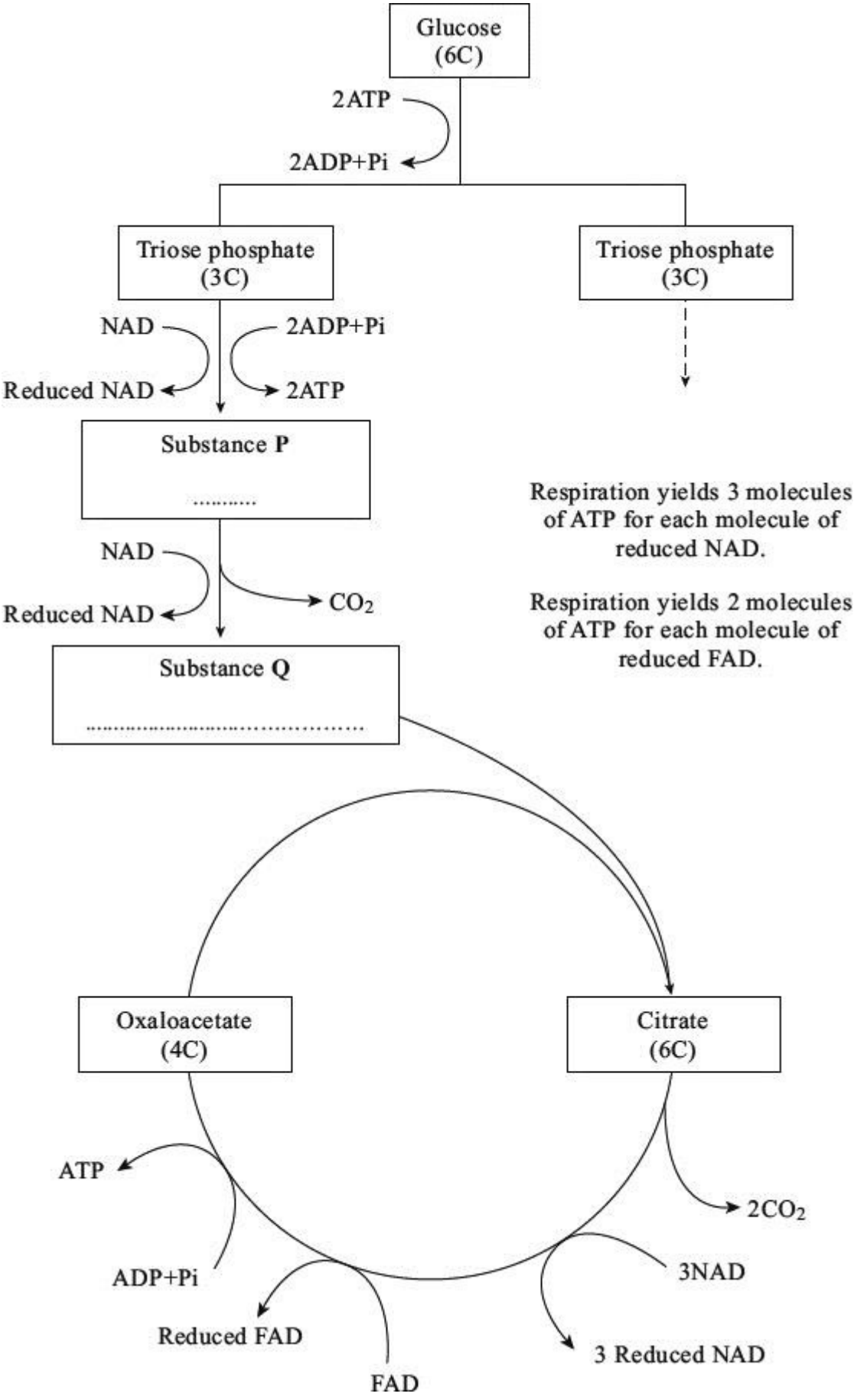
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(4)

(Total 12 marks)

Q25.

(a) The flow chart shows the main stages in aerobic respiration.



(i) Complete the flow chart by writing, in the appropriate boxes, the number of carbon atoms in substance **P** and the name of substance **Q**.

(2)

(ii) Some ATP is formed in the cytoplasm and some in the mitochondria. Use the information given to calculate the number of molecules of ATP formed in a mitochondrion from one molecule of glucose in aerobic respiration. Show how you arrived at your answer.

Answer_____

(2)

(iii) In the presence of oxygen, respiration yields more ATP per molecule of glucose than it does in the absence of oxygen. Explain why.

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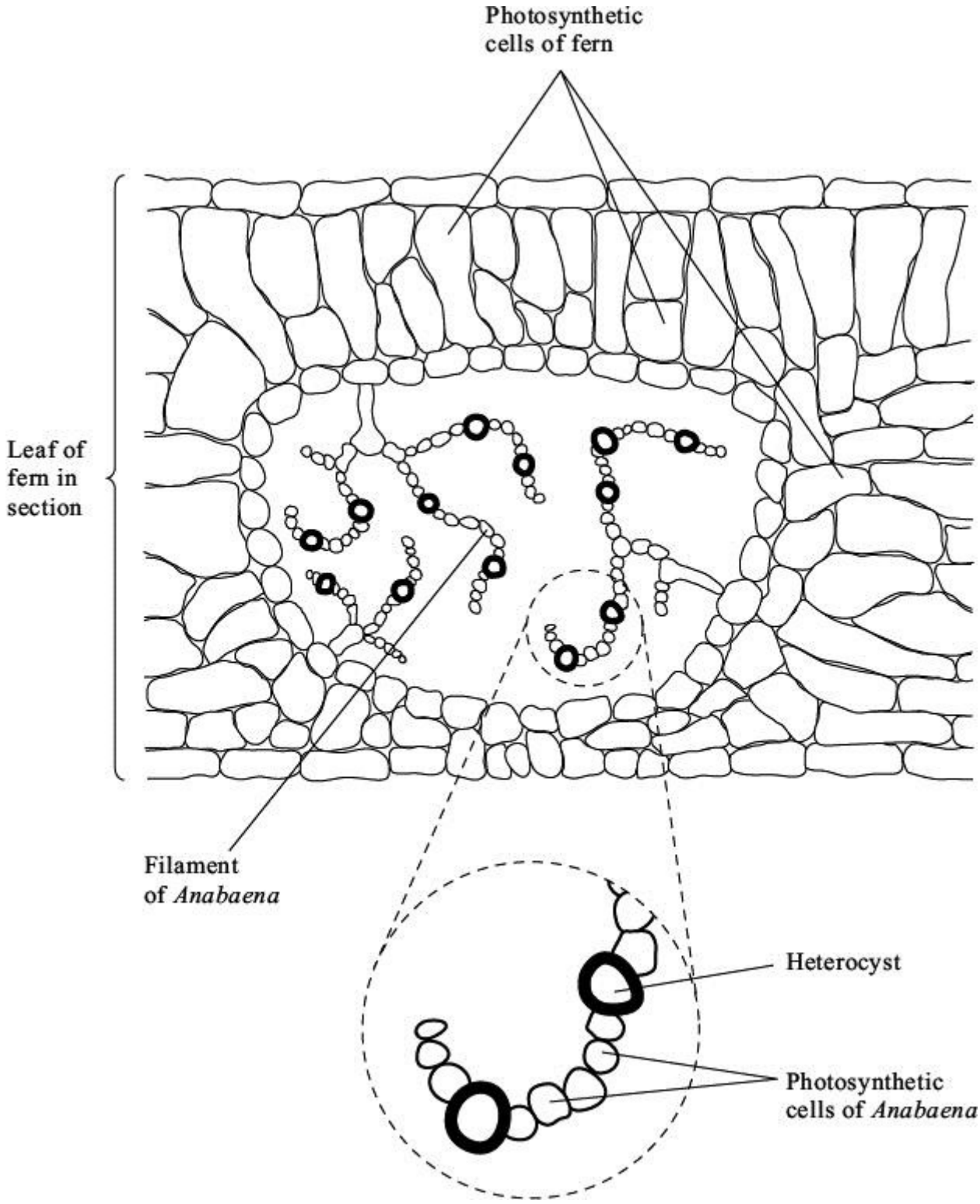
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(3)

(b) Anabaena is a prokaryote found inside the leaves of a small fern. Anabaena can produce ammonia from nitrogen (nitrogen fixation). This reaction only takes place in the anaerobic conditions found in cells called heterocysts. Heterocysts are thick-walled cells that do not contain chlorophyll. The drawing shows the relationship between *Anabaena* and the fern.



(i) Suggest how the features of the heterocysts improve the efficiency of the process of nitrogen fixation.

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(3)

(ii) In China, the fern is cultivated and ploughed into fields to act as an organic fertiliser. Explain how ploughing the fern plants into the soil results in an improvement in the growth of the rice crop grown in these fields.

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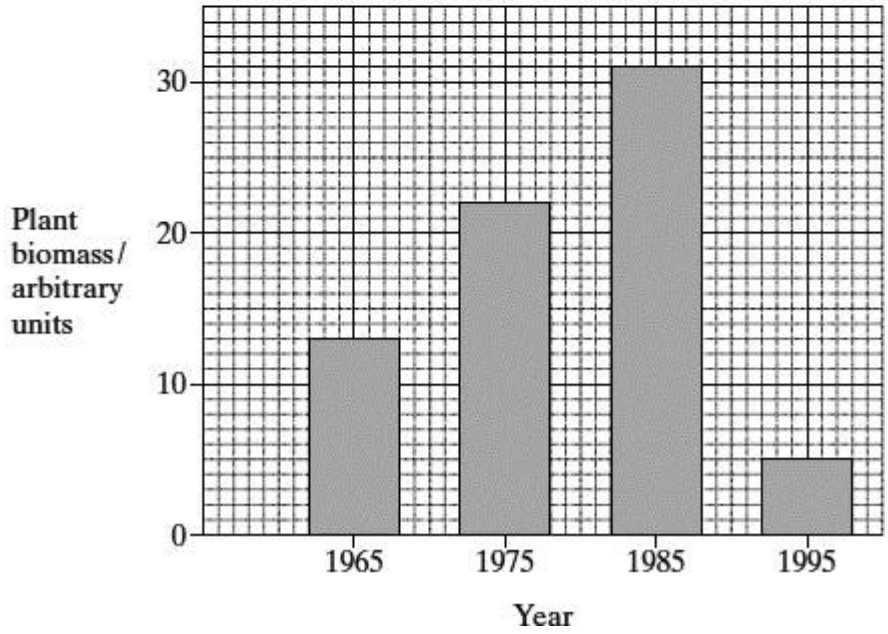
(5)

(Total 15 marks)

Q26.

Since 1965 there has been a steady rise in the phosphate concentration in the water of Lake Windermere. Scientists have monitored the phosphate concentration and plant biomass over a period of time. The results are shown in the graphs.





(a) Suggest **one** source of the phosphate in the lake.

_____

_____

(1)

(b) Calculate the percentage decrease in plant biomass between 1985 and 1995. Show your working.

Answer _____

(2)

(c) From these graphs, a student concluded that changes in phosphate concentration

caused changes in plant biomass. Explain why this conclusion may not be valid.

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(2)

(d) Between 1982 and 1992 the number of fish in the lake decreased. Explain how the change in phosphate concentration may have resulted in this decrease in the fish population.

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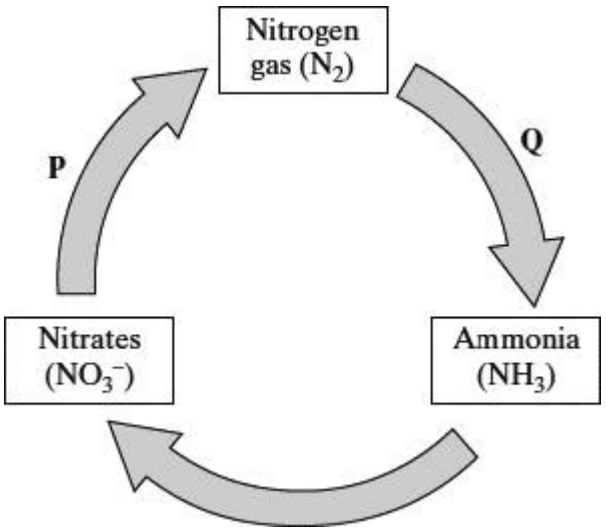
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(6)

(Total 11 marks)

Q27.

The diagram shows part of the nitrogen cycle.



(a) Name processes **P** and **Q**.

P _____

Q _____

(2)

(b) It is estimated that, each year, a total of 3×10^9 tonnes of ammonia are converted to nitrate. Only 2×10^8 tonnes of ammonia are produced from nitrogen gas. Explain the difference in these figures.

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_____

(2)

(c) The conversion of ammonia to nitrate involves oxidation. What evidence in the diagram supports this?

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(1)

(Total 5 marks)

Q28.

Two fields, **A** and **B**, were used to grow the same crop. The fields were divided into plots. Different masses of fertiliser containing sodium nitrate were applied to these plots. After six weeks, samples of crop plants from each plot were collected and their mass determined. The results are shown in the table.

Mass of fertiliser	**Mass of crop/kg m^{-2}**

added/kg ha^{-1}	Field **A** - used for grazing cattle in previous year	Field **B** - used for same crop in previous year
0	14.5	6.4
10	16.7	9.8
20	17.4	12.9
30	17.5	16.2
40	17.5	17.1
50	17.5	17.1
60	17.5	17.1

(a) (i) Describe the pattern shown by the data for field **B**.

_____

_____

(1)

(ii) Explain the change in the mass of crop produced from field **B** when the mass of fertiliser added increases from 0 to 20 kg ha^{-1}.

_____

_____

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(2)

(iii) Explain why the mass of crop produced stays the same in both fields when more than 40 kg of fertiliser is added.

_____

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(2)

(b) In the previous year, field **A** had been used for grazing cattle. Field **B** had been used to grow the same crop as this year. When no fertiliser was added, the mass of crop from field **A** was higher than from field **B**. Explain this difference.

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(2)

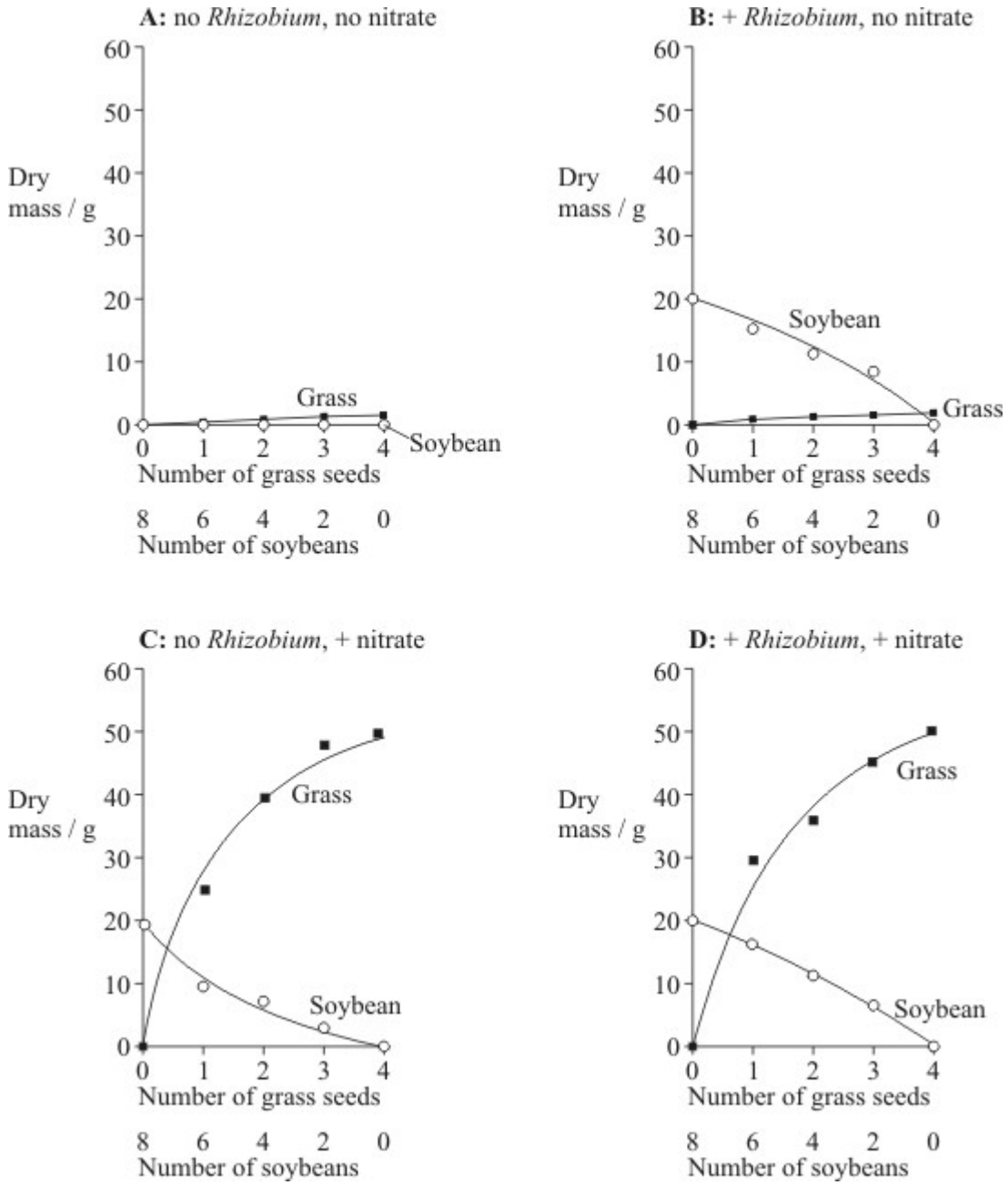
(Total 7 marks)

Q29.

The soybean is a leguminous plant. The effect of nitrate fertiliser and of the nitrogen-fixing bacterium, *Rhizobium*, on the growth of soybeans and on the growth of one species of grass was investigated. The soybeans and grass seeds were sown together in pots of soil in five different proportions. They were then treated with different combinations of nitrate fertiliser and *Rhizobium* bacteria, as follows:

Batch **A**: no *Rhizobium*, no nitrate fertiliser
Batch **B**: *Rhizobium* added, no nitrate fertiliser
Batch **C**: no *Rhizobium*, nitrate fertiliser added
Batch **D**: *Rhizobium* added, nitrate fertiliser added

The dry masses of the soybean plants and of the grass were determined after 6 months of growth. The results are shown in the graphs.



(a) Did *Rhizobium* bacteria have any effect on the growth of the grass? Give evidence from graphs **C** and **D** for your answer.

_____

_____

(1)

(b) Can the soybean make use of nitrogen supplied in the form of nitrate fertiliser? Give evidence from the graphs for your answer.

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(2)

(c) Describe and explain the effect of *Rhizobium* bacteria on the growth of soybeans.

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(3)

(Total 6 marks)

Q30.

(a) Name the type of bacteria which convert

(i) nitrogen in the air into ammonium compounds;

_____

(ii) nitrites into nitrates.

_____

(2)

(b) (i) Other than spreading fertilisers, describe and explain how **one** farming practice results in addition of nitrogen-containing compounds to a field.

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(2)

(ii) Describe and explain how **one** farming practice results in the removal of nitrogen-containing compounds from a field.

_____

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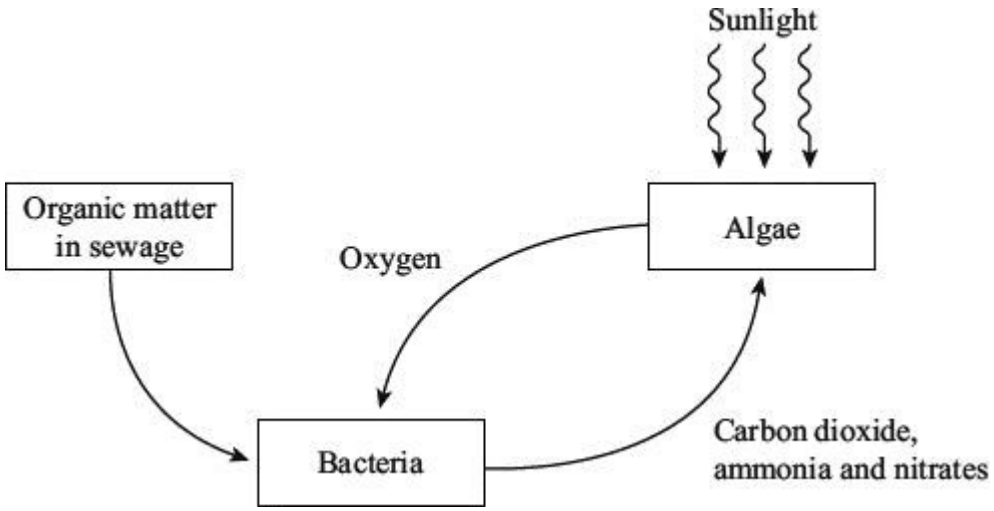
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(2)
(Total 6 marks)

Q31.

Purification ponds can be used in warm climates to break down sewage. The ponds are about 1m deep and contain bacteria and green algae. The diagram summarises the processes involved in the breakdown of sewage in a purification pond.



(a) Explain the advantage of having both algae and bacteria in a purification pond.

(4)

(b) Purification ponds only work efficiently when they are shallow and warm. Explain why.

_____

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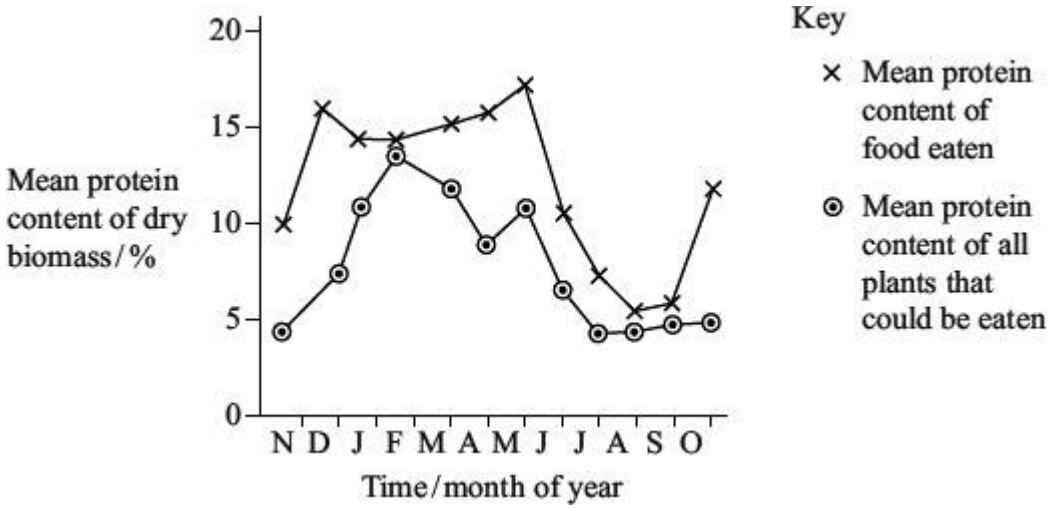
(4)

(Total 8 marks)

Q32.

The wildebeest is a large mammal that lives on grasslands in Africa and feeds on a number of species of plant. A lot of rain falls from April to May and also in November. In the dry season between July and October very little rain falls.

The graph shows changes in the mean protein content of all the plants that could be eaten at different times of year. It also shows the mean protein content of the food the wildebeest actually eat.



(a) During the dry season the protein content of the plants decreases. Suggest **one** way in which a lack of rain could account for this change.

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(2)

(b) Throughout the year the mean protein content of all the plants which could be eaten and the mean protein content of the food actually eaten differs. Suggest **one** explanation for this difference.

_____

_____

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(2)

(c) When wildebeest eat food containing less than 6% protein, they start to lose protein from their body tissues. Suggest and explain how a deficiency of **one** named protein makes the wildebeest more susceptible to being caught by predators.

_____

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_____

(2)

(Total 6 marks)

Q33.

(a) Explain how including leguminous plants in a crop rotation reduces the need to use artificial fertilisers.

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(2)

(b) Application of very high concentrations of fertiliser to the soil causes plants to wilt. Explain why.

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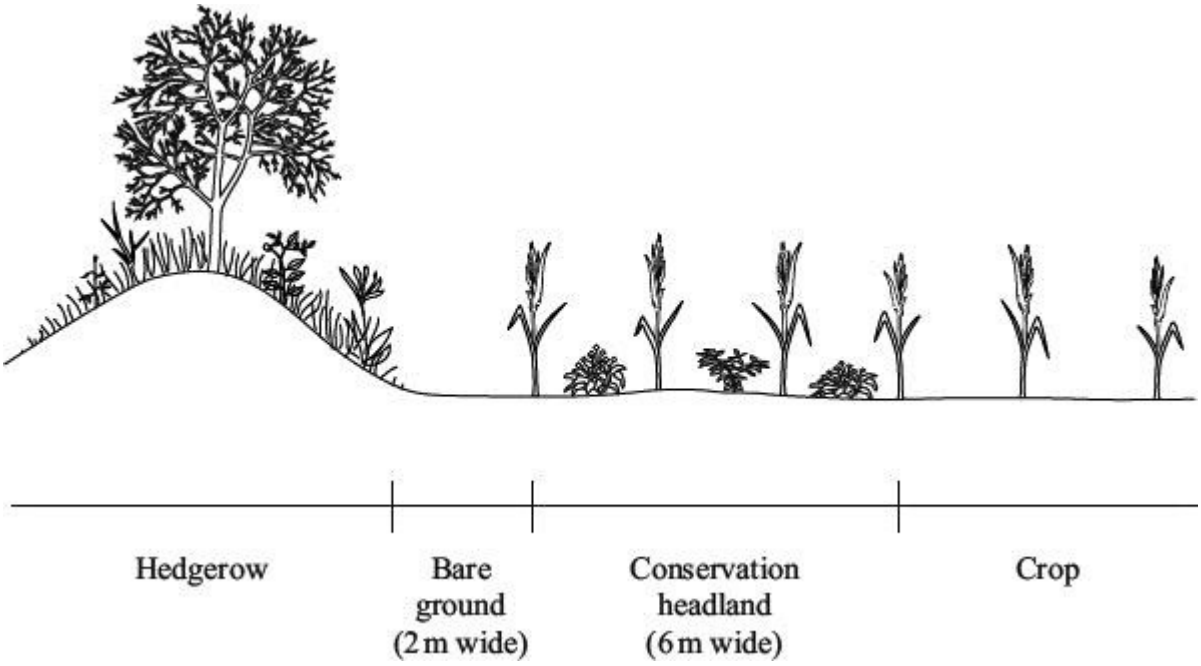
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(2)

(Total 4 marks)

Q34.

The diagram shows a hedgerow and part of a field with a crop. The land is farmed in a way that conserves wildlife. The strip of bare ground next to the hedgerow is ploughed frequently to prevent any plants from growing. The first 6 m of the field, called the conservation headland, is sprayed with a selective herbicide to control some kinds of weeds. The rest of the field is sprayed with herbicide to kill all weeds.



(a) Suggest **one** advantage of leaving a strip of bare ground between the hedgerow and the field.

_____

_____

(1)

(b) Suggest the benefit of allowing some weeds to grow in the conservation headland.

_____

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(2)

(c) After harvesting the crop, the farmer digs the unwanted stems and roots into the soil. Explain how the nutrients contained in these plant parts become available for use by other organisms.

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(4)

(Total 7 marks)

Q35.

The flow chart shows how high nitrate concentration can affect a river.

High nitrate concentration

↓

Increased growth of algae

↓

Death and decay of submerged plants rooted in the mud

↓

Reduced oxygen concentration and increased nitrate production

(a) Explain how a high nitrate concentration increases the growth of algae.

_____

_____

_____

(2)

(b) Suggest how increased growth of algae could lead to the death of the submerged plants.

_____

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(2)

(c) Explain how the decay of dead plants results in reduced oxygen concentration and increased nitrate production.

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(6)

(d) Describe how the reduced oxygen concentration of the water will change the composition of the communities in the river.

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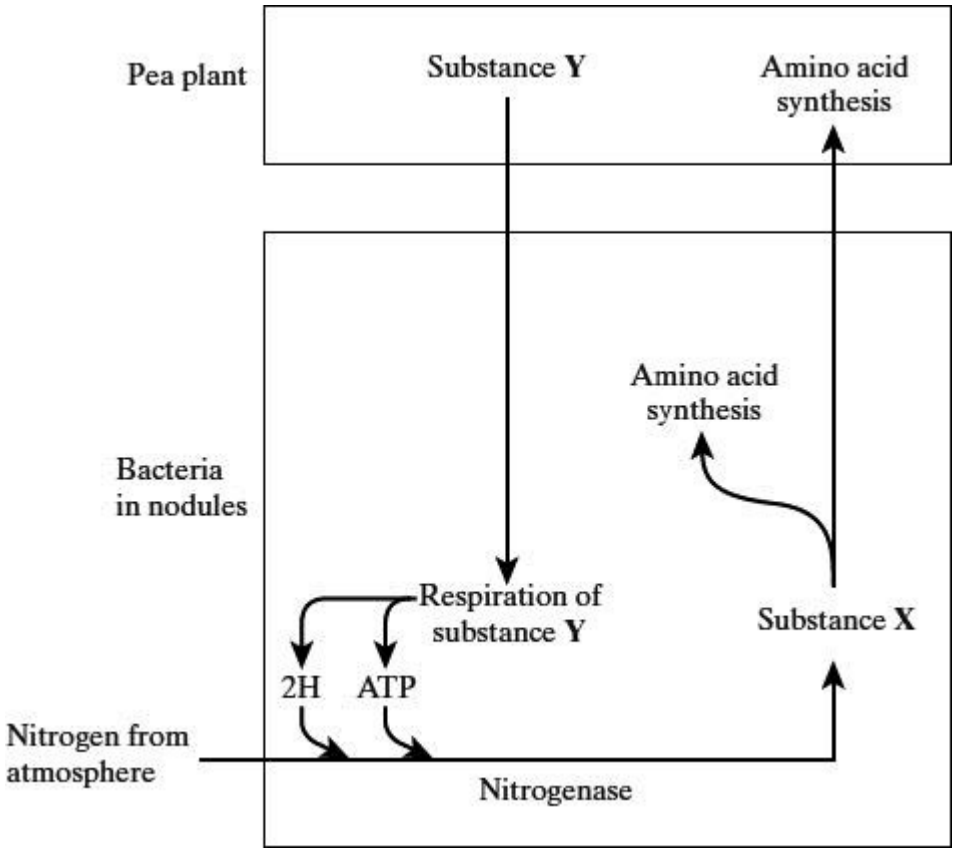
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(2)

(Total 12 marks)

Q36.

Pea plants are leguminous and have nodules on their roots which contain bacteria that are able to fix nitrogen. The diagram shows some of the processes involved in nitrogen fixation by these bacteria.



(a) Name

(i) substance **X**;

_____

(1)

(ii) substance **Y**.

_____

(1)

(b) Pea plants respire aerobically, producing ATP which can be used for amino acid synthesis. Describe the role of oxygen in aerobic respiration.

_____

_____

_____

_____

(2)

(c) The bacteria respire anaerobically. This produces hydrogen and ATP used in nitrogen fixation. The hydrogen comes from reduced NAD. Explain how the regeneration of NAD in this way allows ATP production to continue.

_____

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(2)

(d) The enzyme nitrogenase is specific to the reaction shown. Explain how **one** feature of the enzyme would contribute to this specificity.

Feature

_____

Explanation

_____

_____

_____

(2)

(e) Sodium ions act as a non-competitive inhibitor of the enzyme nitrogenase. Explain how the presence of a non-competitive inhibitor can alter the rate of the reaction catalysed by nitrogenase.

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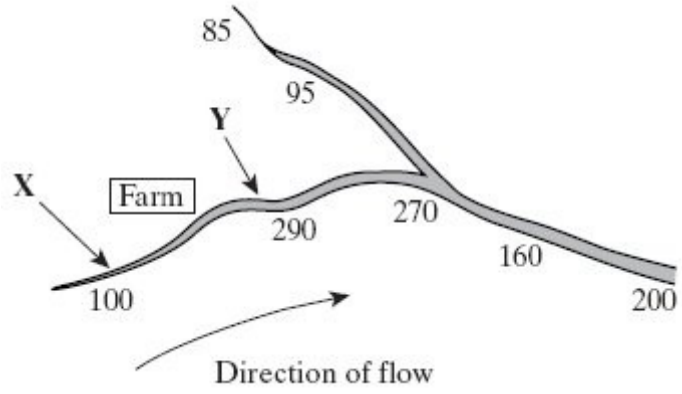
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(3)

(Total 11 marks)

Q37.

The diagram shows a river system in an area of farmland. The numbers show the nitrate concentration in parts per million (ppm) in water samples taken at various locations along the river. Concentrations above 250 ppm encourage eutrophication in the river.



(i) Explain how farming practices might be responsible for the change in nitrate concentration in the water between point **X** and point **Y**.

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(2)

(ii) Describe the effect the nitrate concentration may have in the river at point **Y**.

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(5)

(Total 7 marks)

Q38.

The mesquite tree grows in dry areas which have soils with low concentrations of ions. Its roots grow down to 25 metres and contain nitrogen-fixing bacteria. It is considered a pest in areas where farm animals graze because it out-competes grass. In some areas, young mesquite trees are cut down and then ploughed into the ground. This is expensive but makes the soil slightly more fertile for a few years.

(a) Using the information given, explain **one** way in which mesquite trees are adapted for survival.

_____

_____

(1)

(b) Name the type of competition occurring between mesquite and grass.

_____

(1)

(c) Explain how ploughing the mesquite into the soil makes it more fertile.

_____

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(3)

(Total 5 marks)

Q39.

In autumn when there is no crop, farm land may be used to grow mustard. The mustard absorbs nitrates which otherwise can leach out of the soil at this time of the year. The mustard is ploughed back into the soil just before sowing of the main crop in the spring.

(a) Nitrogen compounds in the mustard plants are made available for the main crop after ploughing in spring. Describe the role of microorganisms in this process.

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(5)

(b) Explain why it is important for the farmer to reduce the leaching of nitrates.

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_____

_____

(2)

(c) Plants absorb a number of other nutrients from the soil including phosphates. Describe why phosphates are needed by a growing plant.

_____

_____

_____

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_____

(4)

(Total 11 marks)

Q40.

(a) Farmers who grow wheat sometimes leave a field fallow for a year by not growing a crop in it. The concentration of nitrate ions in the soil decreases when a field is left fallow.

(i) When grass is grown in the field, fewer nitrate ions are lost than when the field is left with bare soil. Explain why.

_____

_____

(1)

(ii) A crop of leguminous plants such as clover may be grown in the field and then ploughed in. Explain why less fertiliser would be needed for the wheat crop in

the following year.

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_____

(2)

(b) The table gives information about the yield and profitability of a wheat crop grown using different amounts of fertiliser.

Nitrogen fertiliser applied / kg ha^{-1}	Grain yield / tonnes ha^{-1}	Grain protein / %	Value added by using fertiliser / £ha^{-1}	Cost of using fertiliser / £ha^{-1}	Benefit : cost ratio
0	2.4	11.7	–	–	–
25	2.5	12.5	19	11	1.7 : 1.0
50	2.5	12.9	25	22	1.1 : 1.0
75	2.5	13.3	31	33	0.9 : 1.0
100	2.5	13.5	37		

(i) Describe the effects of increasing fertiliser application on the yield and protein content of the grain produced.

_____

_____

_____

_____

(2)

(ii) Use the data in the table to estimate the benefit: cost ratio for a fertiliser application of 100 kg ha^{-1}. Write your answer in the table.

(1)

(Total 6 marks)

Q41.

Answers should be written in continuous prose, where appropriate.

A large lake is surrounded by fields. These fields are separated from each other by hedges. One hundred years ago the lake was a habitat for many plants, invertebrates and fish. Today the lake has no fish and few plants or invertebrates.

Explain how increased use of inorganic fertilisers on the fields may have led to these changes.

_____

_____

_____

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_____

(Total 5 marks)