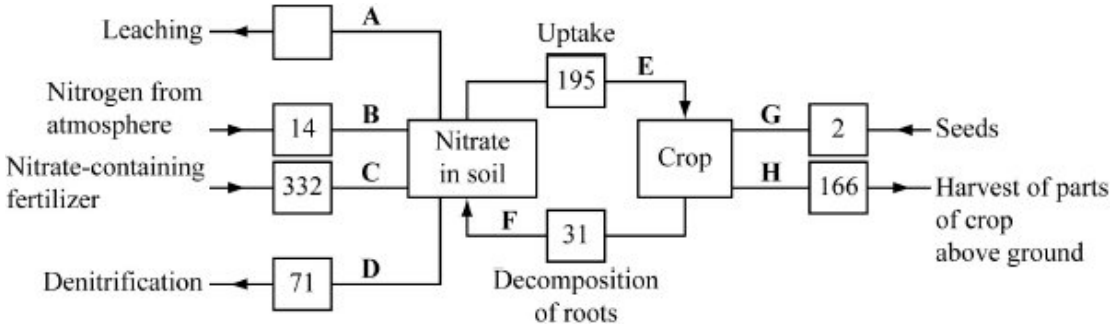
Q1. A wheat crop was grown in a field on a Dutch farm. When the wheat was harvested, all parts of the crop growing above ground were removed. The diagram shows the nitrogen cycle for this field. The figures are in kg of nitrogen per hectare per year.



(a) Give the letter of **one** pathway involving

(i) nitrifying bacteria

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(1)

(ii) nitrogen-fixing bacteria.

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(1)

(b) (i) Describe the part played by bacteria in pathway **D**.

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(2)

(ii) This wheat crop was growing on clay soil. Clay is easily waterlogged. The figure for pathway **D** would be lower on a farm with sandy soil that does not become waterlogged. Explain why.

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(2)

(c) (i) Calculate the maximum amount of nitrogen that could be leached from the soil where this crop was growing in a year.

Answer.....kg ha^{-1}

(1)

(ii) The information in the diagram could be useful to the farmer in reducing leaching. Explain **one** way in which it could be useful.

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(1)
(Total 8 marks)

Q2. (a) Name the type of bacteria which convert

(i) nitrogen in the air into ammonium compounds;

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(ii) nitrites into nitrates.

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(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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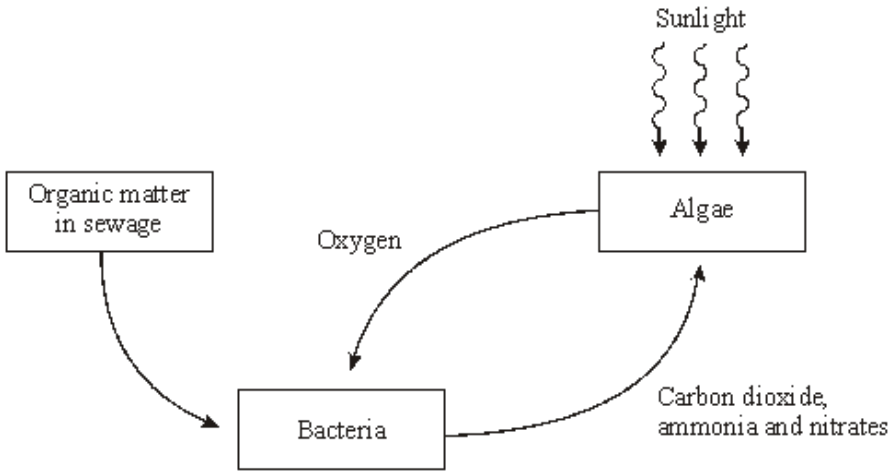
(2)
(Total 6 marks)

Q3. 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.

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(4)

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

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(4)
(Total 8 marks)

Q4. Detritivorous insects feed on the dead remains of plants. Some students estimated the numbers of detritivorous insects at two different sites in an ecosystem. They also obtained data about the net primary production of the sites to see if this influenced the numbers of insects present. Net primary production is a measure of plant biomass formed per year. The results are shown in the table.

Site	Number of insects per m^2	Net primary production / g m^{-2} y^{-1}
A	316	1440
B	90	550

(a) Explain how the students could use the mark-release-recapture technique to estimate the numbers of insects.

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(4)

(b) The students used the chi-squared (χ^2) test to test the hypothesis that there was no significant difference between the numbers of insects per square metre at sites **A** and **B**.

The value they obtained was 125.8. They checked this value in χ^2 tables.

(i) How many degrees of freedom should they check against?

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(1)

(ii) What level of probability is normally used to judge whether a difference is statistically significant?

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(1)

(iii) The value of χ^2 for the 0.001 level of probability for this number of degrees of freedom is 10.8. What does the value obtained by the students suggest about the difference in numbers of the insects per square metre between the two sites?

Explain your answer.

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(2)

(c) (i) Explain why the net primary production of an area does not represent the total amount of plant biomass formed per year by photosynthesis.

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(2)

(ii) Suggest how the difference in net primary production of sites **A** and **B** might explain the difference in the number of insects between the sites.

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(1)

(iii) Explain the role of bacteria in making carbon in dead plant remains available to plants.

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(4)
(Total 15 marks)

Q5. (a) Substances found in fallen leaves contain the elements carbon and nitrogen.
Explain how the activities of decomposers and nitrifying bacteria recycle the substances in fallen leaves for re-use by the trees.

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(7)

(b) Explain how the felling and burning of trees on a large scale could affect the concentration of carbon dioxide in the atmosphere.

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(2)

(c) Both rapidly-growing softwood trees and slow-growing hardwood trees grow in tropical rainforests. The seeds of both kinds of tree lie dormant on the floor of a mature forest and only germinate when exposed to light and warmth. However, the seedlings of many hardwood species grow more successfully beneath the protective canopy of the softwood trees.

When a small area of trees has been cut down, it can return naturally to tropical rainforest. Suggest and explain how re-establishment of the rainforest ecosystem may occur in such areas.

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(6)

(Total 15 marks)

Q6. 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.

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

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(5)

(b) Explain how the removal of hedges near the lake would increase the impact of fertilisers on the aquatic ecosystem.

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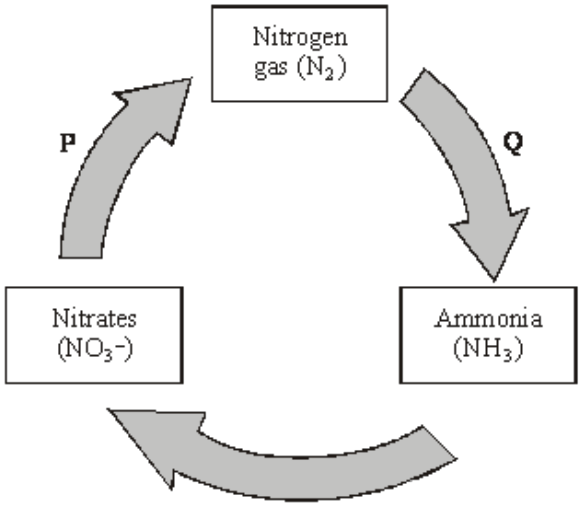
(2)
(Total 7 marks)

Q7. 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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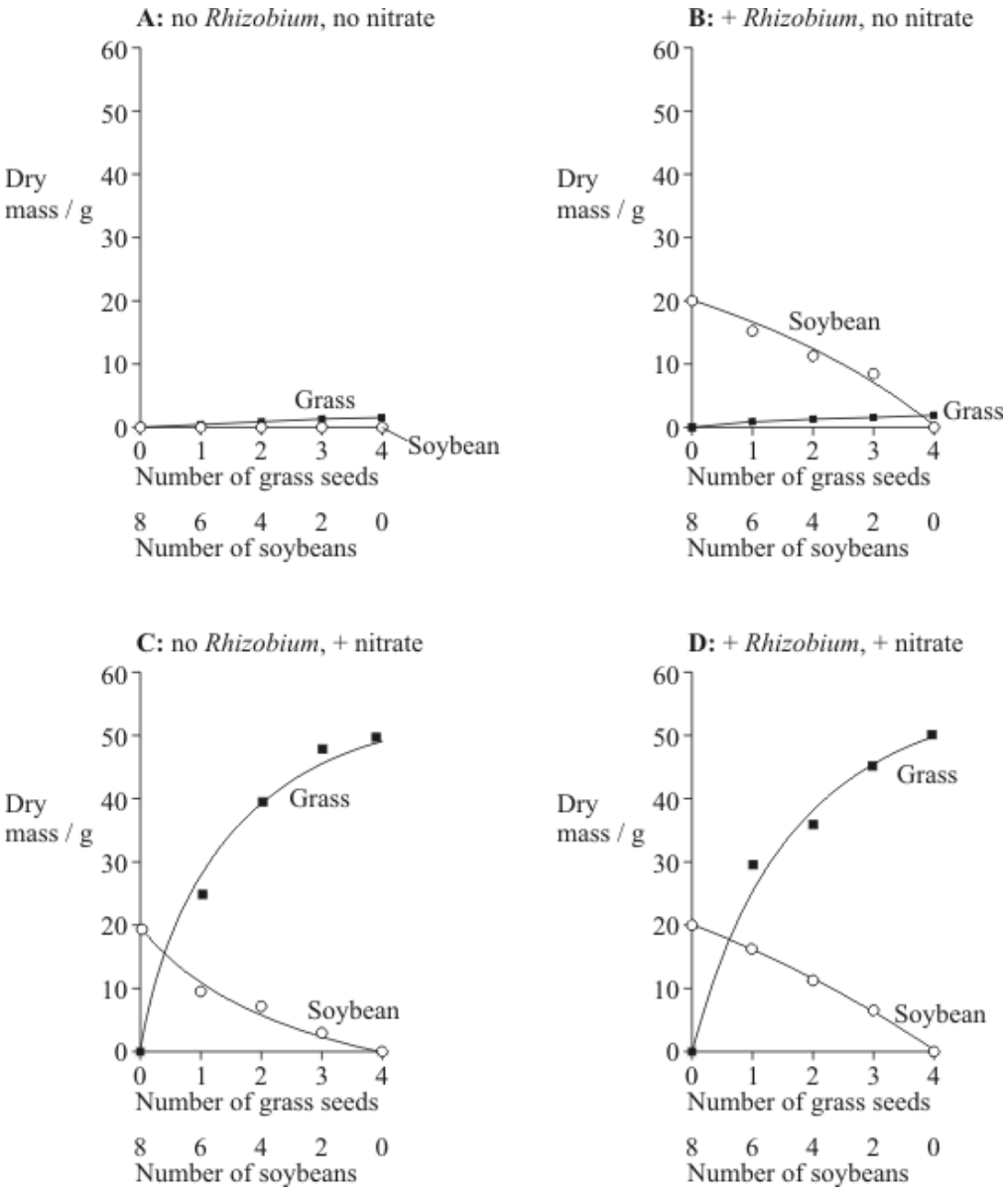
(1)
(Total 5 marks)

Q8. 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.

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(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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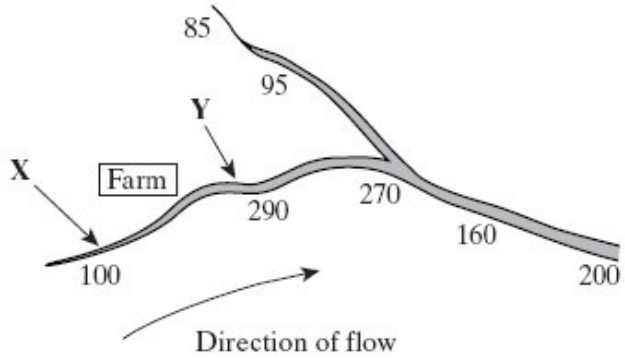
(3)
(Total 6 marks)

Q9. 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)

Q10. (a) Growing the same crop over a large area year after year is known as monoculture. Explain why an outbreak of pests is more of a problem in monoculture than where a mixture of crops is grown.

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(3)

(b) (i) Insect pests have developed resistance to pesticides. If the resistance is due to a single gene, explain how resistant insects could be produced when both parents are susceptible to the pesticide.

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(3)

(ii) Other than resistance, give **two** disadvantages of using pesticides.

1 .....

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2 .....

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(2)
(Total 8 marks)

Q11. (a) The concentrations of carbon dioxide in the air at different height_s 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)

(c) Microorganisms make the carbon in polymers in a dead worm available to cells in a leaf. Describe how.

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(5)
(Total 15 marks)

Q12. Deforestation often involves clearing large areas of forest for use as agricultural land.

(a) Deforestation reduces the diversity index of an area cleared in this way. Explain why.

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(2)

(b) Because the forest soil is often nutrient-poor, nitrogen-containing fertilisers may be applied to ensure good crop yields. Use your knowledge of the nitrogen cycle to explain the potential benefit of applying a fertiliser containing ammonium nitrate rather than one containing potassium nitrate.

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(3)
(Total 5 marks)

Q13. The flow chart shows how high nitrate concentration can affect a river.

High nitrate concentration

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Increased growth of algae

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Death and decay of submerged plants rooted in the mud

↓

Reduced oxygen concentration and increased nitrate production

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

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(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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(2)
(Total 12 marks)

Q14. (a) Insecticides are pesticides which kill insects. A low concentration of insecticide was sprayed on the leaves of rose plants to kill greenfly which were feeding on the plants. Ladybirds eat greenfly. One month after spraying, the concentration of insecticide in the tissues of ladybirds was found to be higher than the concentration sprayed on the rose plants. Explain why.

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(3)

(b) Spotted knapweed is a common weed in the USA. Two methods, chemical control and biological control, have been used to reduce the numbers of spotted knapweed plants.

The table shows the results of an investigation comparing the effectiveness of these two methods.

Month	**Mean number of spotted knapweed plants per m^2**	
	Chemical control	**Biological control**
February	2	2
March	15	3
April	3	3
May	20	5
June	3	4
July	16	3
August	2	2

(i) Describe the pattern of plant numbers resulting from the use of

chemical control; .....

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(1)

biological control. .....

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(1)

(ii) Explain how chemical control leads to the changes in the number of spotted knapweed plants from March to June.

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(1)

(c) Explain why the spotted knapweed plants were never completely eliminated when using

(i) chemical control;

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(2)

(ii) biological control.

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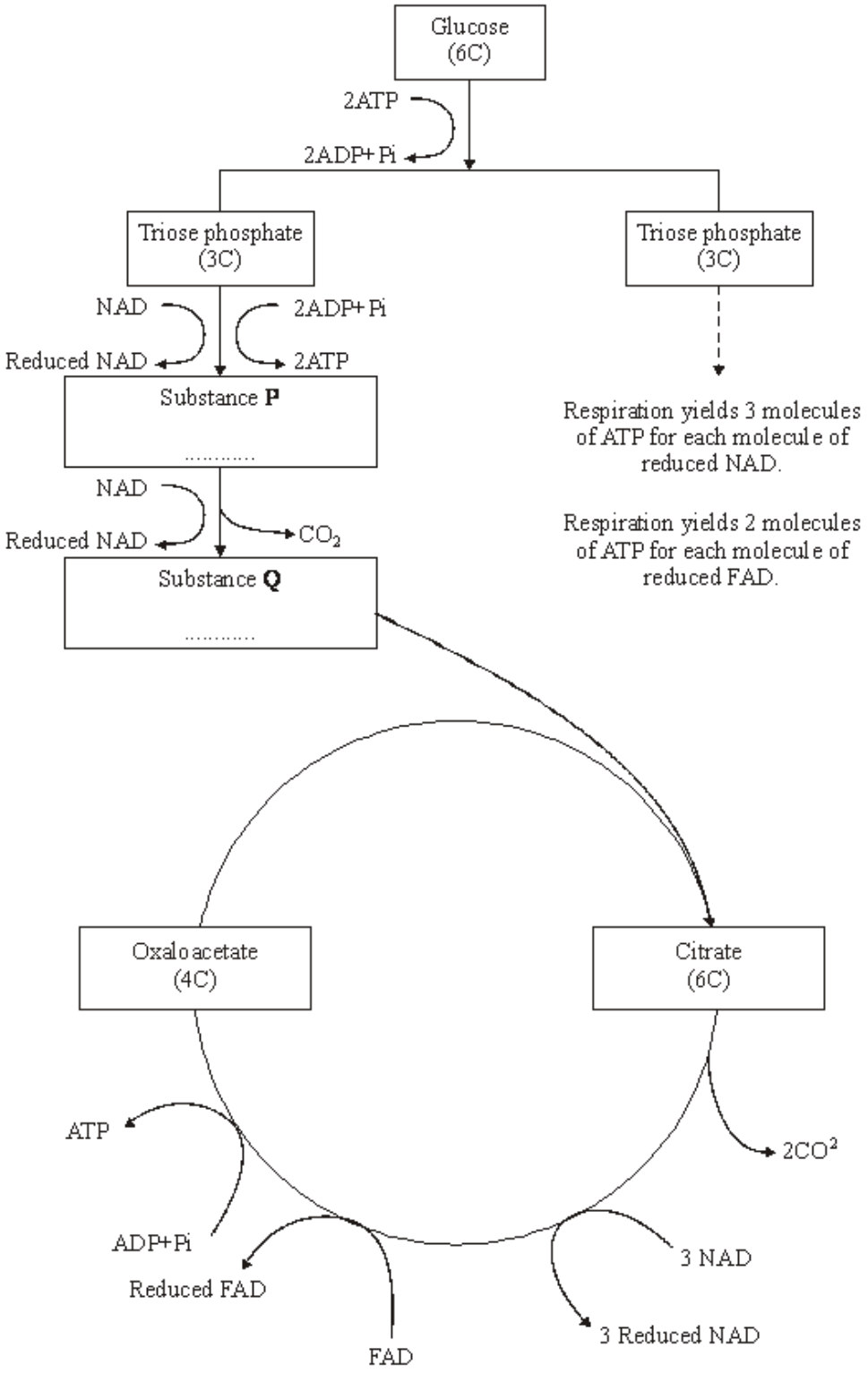
(2)
(Total 10 marks)

Q15. (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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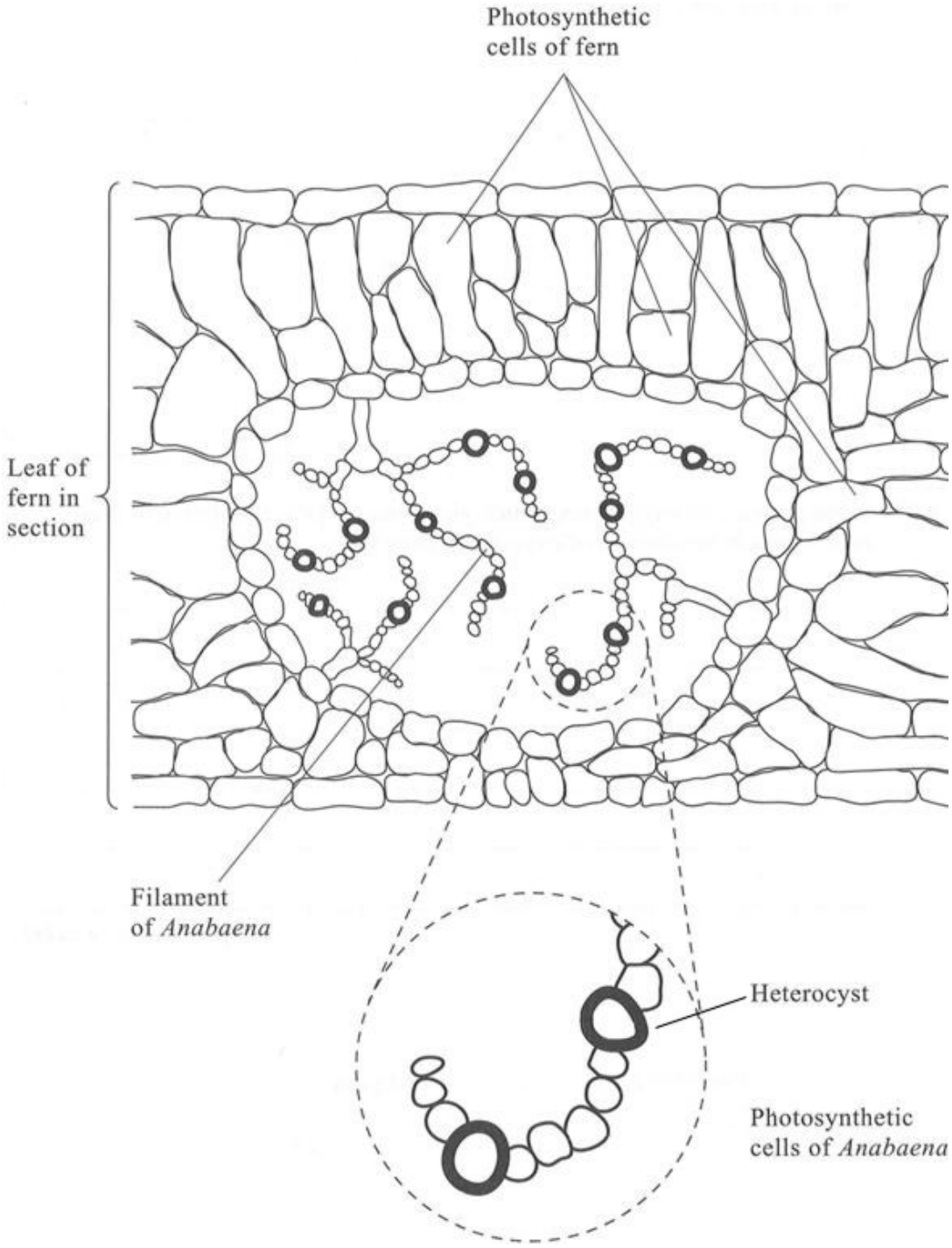
(3)

(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)

Q16. 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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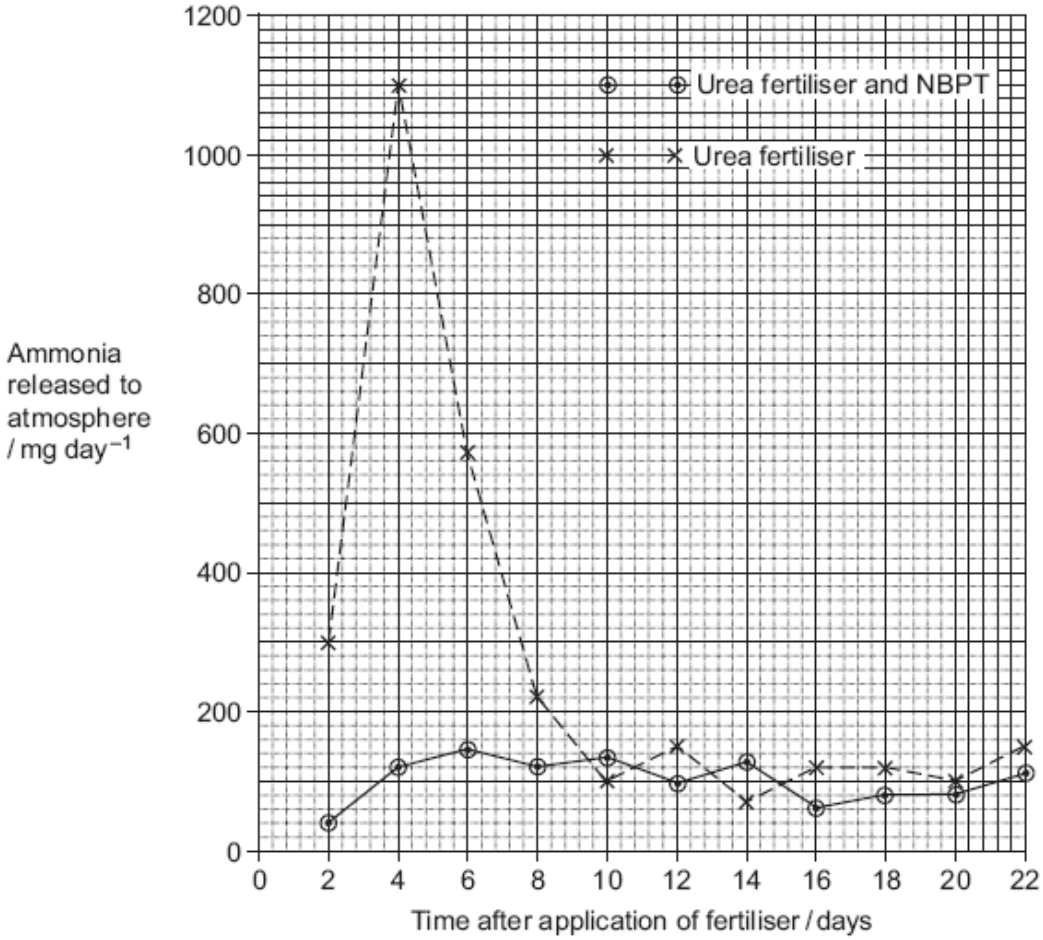
(2)

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)

Q17. 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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(Extra space) .....

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(5)

(b) Clearing the forests and burning the vegetation affects the carbon dioxide concentration in the atmosphere.
Describe how and explain why.

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(Extra space) .....

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(4)

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

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(Extra space) .....

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(6)
(Total 15 marks)

Q18. 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.

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(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)