5.3 Energy transfers in and between organisms (A-Level Only) – Energy and Ecosystem – Questions

Q1.

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.

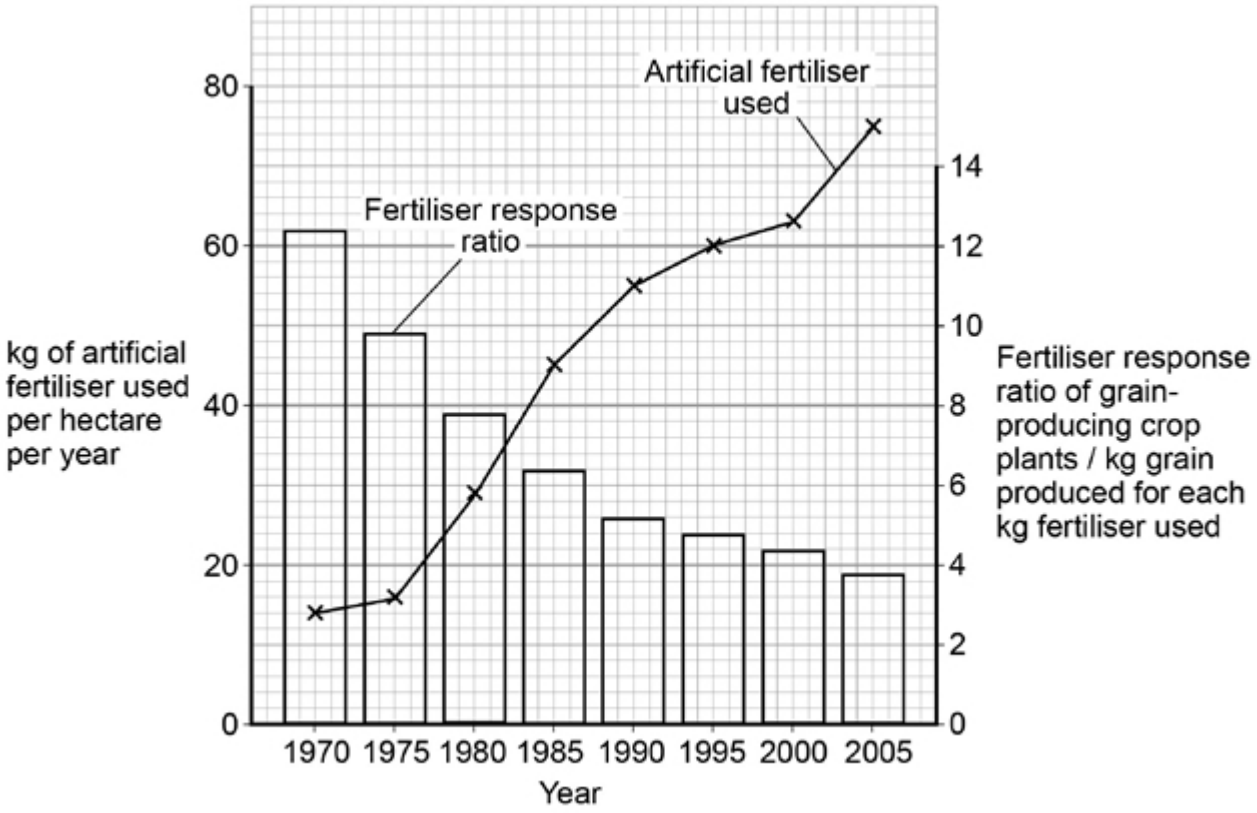
1. _____

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)

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.

_____

_____

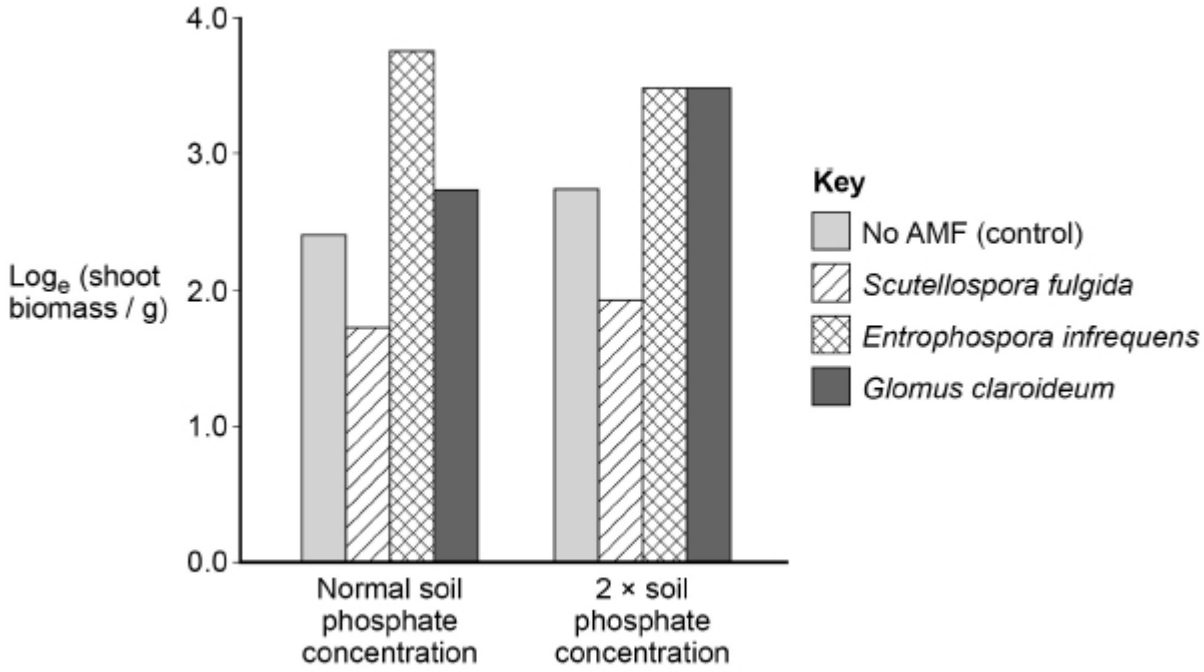
(1)

(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.

Ecologists developed a method for estimating the biomass of trees in a plantation. The plantation consisted of trees of the same species.

They collected samples of wood from trees. For each sample they:

- determined the density of the freshly cut wood
- dried the wood in an oven at 103 °C for 24 hours
- determined the volume of the dried wood sample
- determined the density of the dried wood.

The table below shows data about one wood sample.

Volume of freshly cut wood sample / dm^3	**Density of freshly cut wood / g per dm^3**	**Volume of dried wood sample / dm^3**	**Density of dried wood sample / g per dm^3**
1.345	993.0	1.125	769.0

(a) The loss of mass of the wood sample was due to loss of water. Water has a density of 1 g per cm^3.

Use the data in the table to calculate the percentage of water in the freshly cut wood sample. Show your working.

Percentage of water = _____

(2)

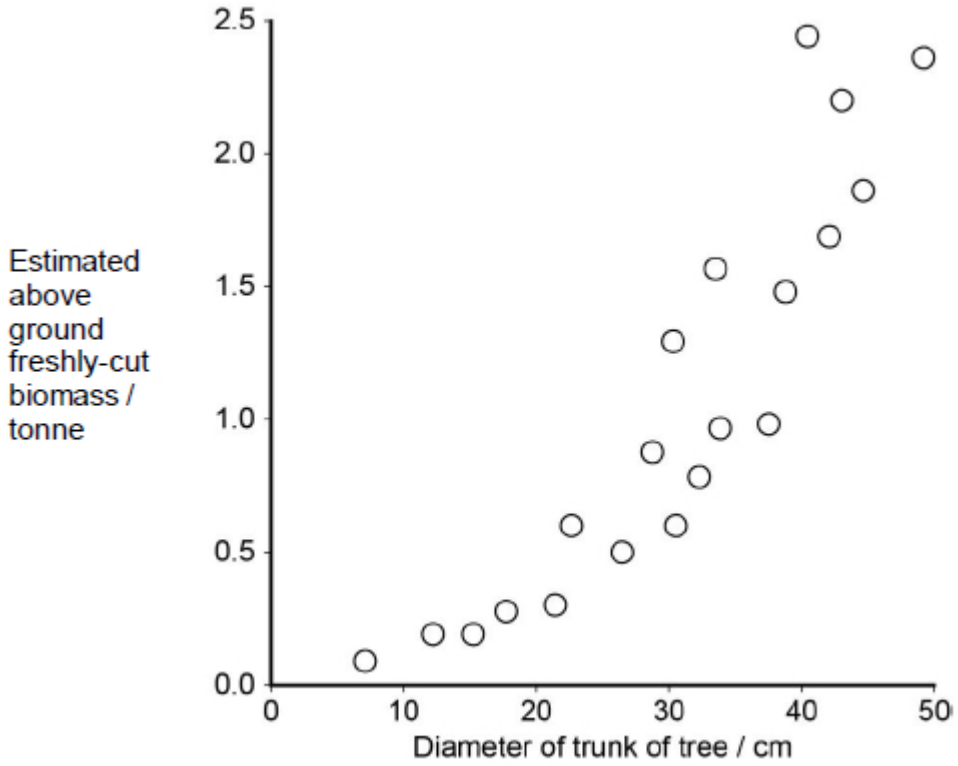
(b) The ecologists dried the samples in an oven at 103 °C for 24 hours. Describe how the ecologists could have determined whether or not this drying removed all the water from a sample of wood.

_____

(2)

(c) Ecologists then investigated the relationship between the diameter of the trunk of the trees and their biomass.

The graph below shows their results. Each point is the result for **one** tree.



What does the graph show about the relationship between the diameter of the trunk of the trees and their biomass?

(2)

(d) Plantations of trees are often created to remove carbon dioxide from the atmosphere, to help to balance the carbon dioxide released by burning fossil fuels.

For different species of tree, information is available for:

- the relationship between diameter of trunk and freshly cut biomass

- the percentage of water in fresh-cut wood
- the mean dried density of wood.

Using only the information provided in part **(c)**, suggest how the mass of carbon in the wood of a plantation of trees of a particular species could be estimated.

Start with measuring the diameter of a large number of trees.

Assume that the dry biomass of a tree consists of biological molecules that contain carbon.

(4)

(Total 10 marks)

Q4.

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.

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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.

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(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	0.34	0.96

ammonium fertiliser	(±0.03)	(±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)

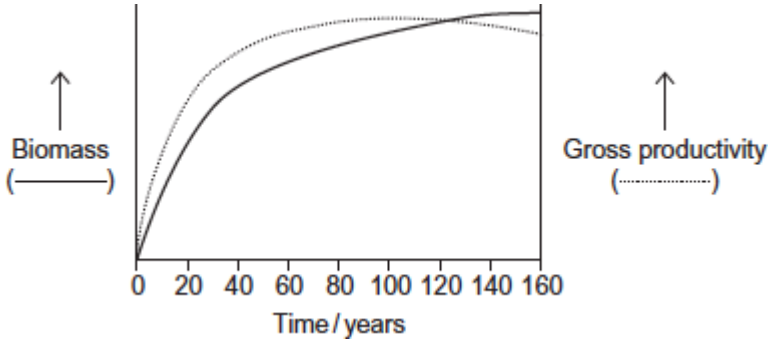
(g) Which treatment gave the best result in commercial terms? Justify your answer.

(2)

(Total 15 marks)

Q5.

The graph shows how gross productivity and biomass in an area changed with time in the succession from bare soil to mature woodland.



(a) (i) Suggest appropriate units for gross productivity.

_____

(1)

(ii) Explain the decrease in gross productivity as the woodland matures.

_____

_____

_____

_____

_____

(2)

(b) Use your knowledge of succession to explain the increase in biomass during the first 20 years.

_____

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[Extra space] _____

_____

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(3)

(c) Use the information in the graph and your knowledge of net productivity to explain why biomass shows little increase after 100 years.

_____

_____

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(2)

(d) Suggest **one** reason for conserving woodlands.

_____

_____

_____

(1)

(Total 9 marks)

Q6.

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.

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(Extra space) _____

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(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.

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(2)

(Total 7 marks)

Q7.

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

(Total 5 marks)

Q8.

(a) Energy enters most ecosystems through the light-dependent reaction of photosynthesis. Describe what happens during the light-dependent reaction.

(5)

(b) Changes in ecosystems can lead to speciation. A high concentration of copper in soil is toxic to most plants. In some areas where the soil is polluted with copper, populations of grasses are found to be growing. These populations of grass belong to a species also found growing on unpolluted soils.

It has been suggested that a new species of grass may evolve on soil that has been polluted with copper. Explain how this new species might evolve.

(5)

(Total 10 marks)

Q9.

Biofuels are fuels which can be produced from plants. Scientists have developed a standard method called net life-cycle carbon dioxide production (NLP) to find the overall effect of producing and using particular biofuels on carbon dioxide production.

(a) Petroleum is used as a comparison when evaluating NLPs of biofuels. Suggest **two** reasons why.

1. _____

_____

2. _____

_____

(2)

(b) Biofuels are produced by a variety of different companies. The scientists who developed the method of calculating NLPs are funded by the government's environmental agency.

Suggest **two** advantages of this method being developed by these scientists.

1. _____

_____

2. _____

_____

(2)

Scientists compared the percentage change in carbon dioxide production if different biofuels replaced petroleum. Their results are shown in the table.

Biofuel	**Percentage change in carbon dioxide production if this fuel replaced petroleum**
Corn ethanol	–18
Soy-based biodiesel	+4
Switch-grass ethanol	–124
Sugar-cane ethanol	–26

(c) Producing and using biofuels from corn ethanol results in a negative percentage change in carbon dioxide production. Explain why.

_____

_____

_____

_____

(2)

(d) Ethanol can be produced from cellulose. It is produced by anaerobic respiration of cellulose-based biomass by microorganisms. The cellulose is pre-treated by adding cellulose-digesting enzymes before it is used in anaerobic respiration. Suggest why pre-treatment is necessary.

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*(Extra space)*_____

(3)

(e) Large areas of land have to be used to grow the plants to make biofuels. Ecologists have suggested that changes in land use could lead to a decrease in biodiversity. Suggest how changes in land use could lead to a decrease in biodiversity.

(2)

(Total 11 marks)

Q10.

In some countries, pigs are reared in intensive units in which the temperature is controlled. Agricultural scientists investigated the effect of temperature on pig growth and on the efficiency with which the pigs converted food to biomass.

(a) (i) In the investigation, the scientists used pigs of the same breed, with similar genotypes.
Explain why.

(2)

(ii) The pigs were allowed to eat as much food as they wanted.
How could this have decreased the reliability of any conclusions drawn from the
investigation?

(2)

The table shows the results of this investigation.

Temperature / °C	Mean growth rate / kg per day	Efficiency of conversion of food to biomass /%
0	0.54	19
10	0.80	42
20	0.85	48
30	0.45	37
35	0.31	37

(b) (i) Describe the effect of temperature on mean growth rate.

(1)

(ii) A student concluded from these data that the mean growth rate of the pigs was fastest at 20 °C.
Do you agree with this conclusion? Explain your answer.

(2)

(c) (i) Pigs can survive at temperatures above 35 °C. Use the data to suggest why scientists did **not** carry out any investigations at temperatures higher than 35 °C.

(2)

(ii) The efficiency of conversion of food to biomass is lower at 0 °C than it is at 20 °C.
Suggest an explanation for the lower efficiency.

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_____

_____

_____

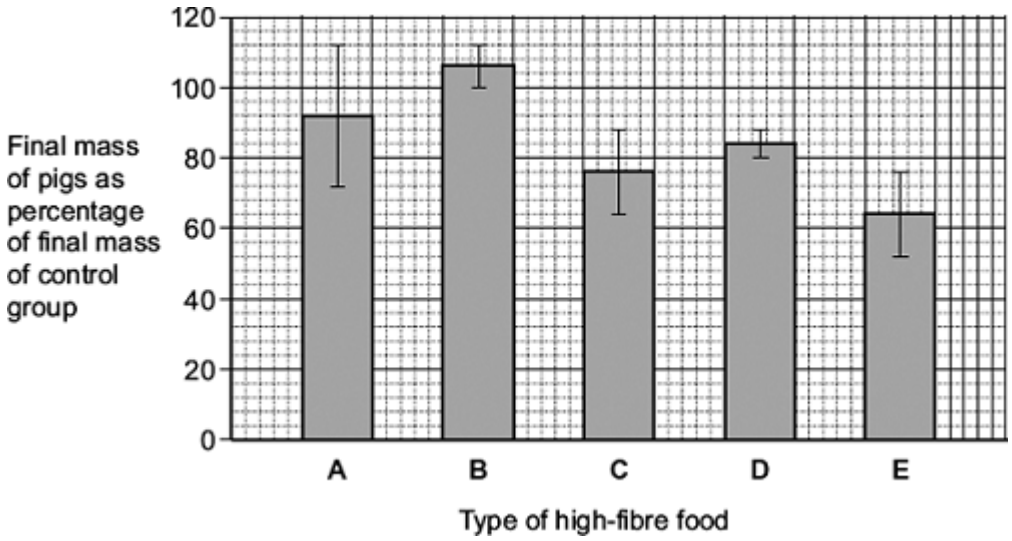
_____

(2)

(d) Pigs require a mixture of fibre and protein in their food. The greater the ratio of fibre to protein, the less the food costs.

Scientists took five large groups of pigs. They fed each group a different high-fibre food. Each of the foods contained fibre from different plant species, but they all had the same energy content. The scientists fed a control group of pigs a low-fibre food with the same energy content. After 10 days, the scientists compared the masses of the pigs fed on high-fibre food to those fed on low-fibre food.

The graph shows the results of the investigation. The bars represent ±2 standard errors of the mean.



A farmer saw these results and concluded that he should replace his pigs' usual food with food **B**.
Evaluate this conclusion.

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(Extra space)

(4)

(Total 15 marks)

Q11.

Residual food intake (RFI) is the difference between the amount of food an animal actually eats and its expected food intake based on its size and growth rate. Scientists have selectively bred cattle for low RFI.

(a) (i) Explain the advantage to farmers of having cattle with a low RFI.

(2)

(ii) When RFI is calculated, low values are negative. Explain why they are negative.

(1)

(b) Scientists have developed a standard procedure for comparing RFI in cattle. They control **two** factors. These are type of food and environmental temperature. Explain why each of these factors needs to be controlled.

Type of food

Environmental temperature

(4)

(c) Bacteria in the digestive systems of cattle break down food and produce methane. Scientists investigated the relationship between RFI and methane production. They measured the rate of methane production of 76 cattle over a fifteen-day period. Some of the results are shown in **Table 1**.

Table 1

	Low RFI	**High RFI**
Mean rate of methane production / g day^{-1}	142.3	190.2

Suggest a null hypothesis for this investigation.

(1)

(d) Other scientists investigated the release of methane from rice fields. They investigated the effect of adding organic material (straw) and inorganic substances on the release of methane from rice fields. The results are shown in **Table 2**.

Table 2

Inorganic substance added to soil	**Total methane released over 30 days / µmol kg^{-1} soil**	
	Without straw	**With straw**
None	1179	25 492
Nitrate	63	764
Sulfate	19	144
Iron oxide	39	313
Manganese oxide	53	475

(i) Which treatment is most effective in reducing release of methane from rice fields?

_____

_____

(1)

(ii) Research findings are not always of direct use to farmers. What else would rice farmers need to know before acting on the results of this investigation?

_____

_____

_____

_____

(2)

(iii) Methane is produced by anaerobic microorganisms in the soil. The scientists found that rice fields that are not flooded do not produce large amounts of methane.

Suggest why.

_____

_____

_____

_____

_____

(2)

(Total 13 marks)

Q12.

Scientists measured the mean temperature in a field each month between March and October. The table shows their results.

Month	Mean temperature /°C
March	9
April	11
May	14
June	17
July	20
August	18
September	16

October	14

(a) The gross productivity of the plants in the field was highest in July.

Use the data in the table to explain why.

(2)

(b) (i) Give the equation that links gross productivity and net productivity.

(1)

(ii) The net productivity of the plants in the field was higher in August than in July. Use the equation in part (b)(i) and your knowledge of photosynthesis and respiration to suggest why.

(2)

(c) A horse was kept in the field from March to October. During the summer months, the horse was able to eat more than it needed to meet its minimum daily requirements.

Suggest how the horse used the extra nutrients absorbed.

(1)

(d) The horse's mean energy expenditure was higher in March than it was in August. Use information in the table to suggest why.

_____

_____

_____

(2)

(Total 8 marks)

Q13.

Yield can be determined by measuring the dry mass of plants.

(a) Suggest how you could determine the dry mass of a sample of plant material.

_____

_____

_____

_____

(2)

(b) What is the advantage of using dry mass and not fresh mass to compare the yield of plants?

_____

_____

_____

_____

(2)

(Total 4 marks)

Q14.

Tomato plants were grown in two glasshouses, each with an area of 2000 m^2. The table shows the mean number of hours of sunshine per month during fruit production.

	1995 – 1997 (no extra carbon dioxide	**1998 – 2000 (extra carbon dioxide)**
Mean number of hours of sunshine per month	148.91	147.00

- The scientists used heating to maintain the temperature inside the glasshouses above 18 °C. They opened the windows to keep the temperature below 30 °C.
- From 1998 to 2000 they maintained the carbon dioxide concentration between 0.06 % and 0.08 % when the windows were closed and between 0.04 % and 0.05 % when the windows were open.

- The carbon dioxide concentration in the air outside the glasshouse was 0.04 %.

(a) The scientists monitored the number of hours of sunshine per month. Explain why they monitored the number of hours of sunshine.

_____

_____

_____

_____

_____

_____

(2)

(b) The temperature, the use of fertiliser and the number of insect pests were controlled during this investigation. Name one other factor which should have been controlled during the investigation. Explain why variation in this factor would affect yield.

Factor _____

Explanation _____

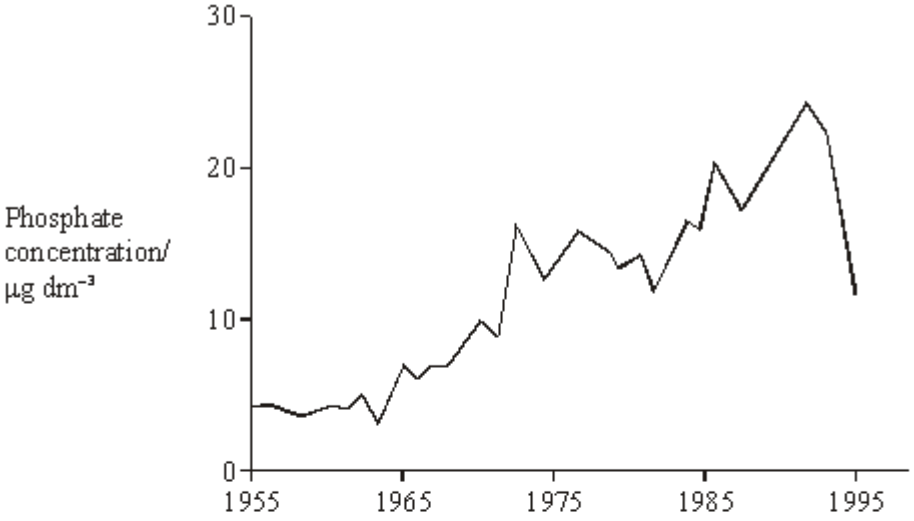
_____

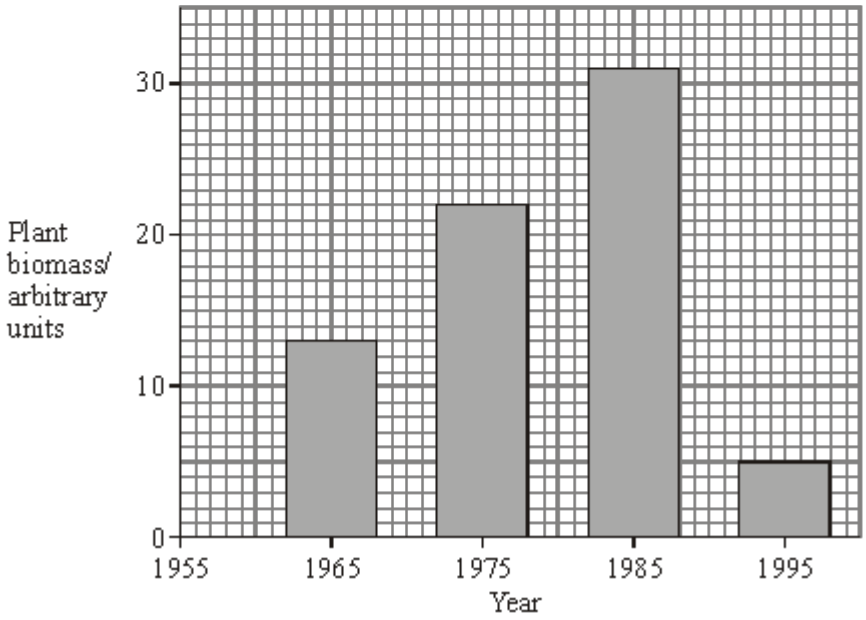
(2)

(Total 4 marks)

Q15.

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.

(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.

(6)

(Total 11 marks)

Q16.

During the last 50 years, there have been changes in the climate of the UK. One of the main changes is temperature. The data in the following resources all relate to southern England.

Figure 1 shows the mean temperatures for January and February combined.

Figure 1

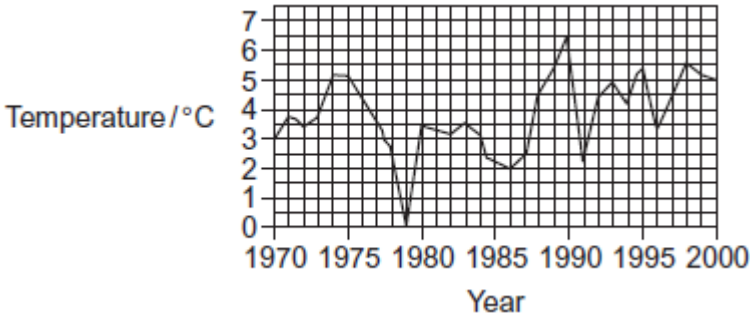
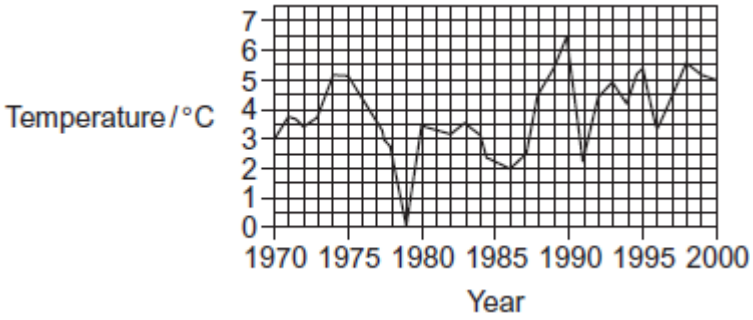


Figure 2 shows the mean temperatures for March.

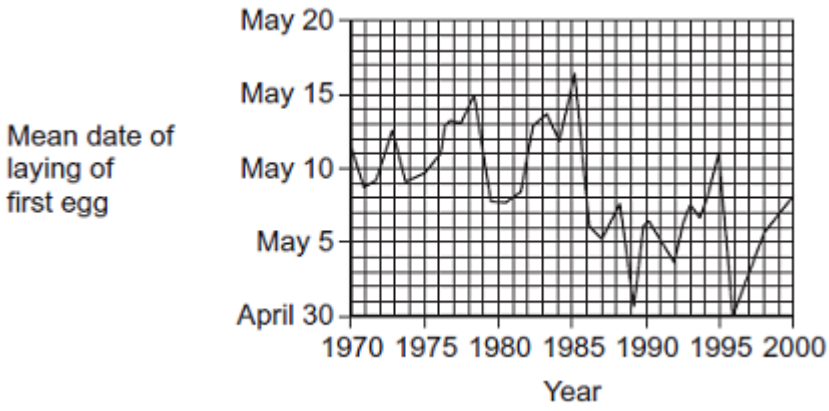
Figure 2



Birds, such as chaffinches, have been recorded as breeding earlier. Chaffinches build nests. When the nest is complete, the female lays eggs until she has produced a full clutch of 4 to 6 eggs. After the eggs hatch, the parent birds feed the young on insects.

Figure 3 shows the mean date on which chaffinches laid their first egg.

Figure 3



The data from which this graph was drawn were collected by volunteers. They used standard record cards. The volunteers used one record card for each nest they found. Each card was used to record

- the geographical location
- the habitat in which the nest site was situated
- the date of each visit to the nest by the volunteer
- the number of eggs present in the nest at each visit.

Visits were made to the nests at least once every 5 days.

(a) Do the data in **Figure 1** and **Figure 2** support the idea that there has been a rise in

the mean temperatures in southern England between 1970 and 2000? Explain your answer.

(2)

(b) Describe briefly how you would use a statistical test to find whether there is a significant correlation between mean March temperature and the date when chaffinches laid their first egg.

(Extra space)

(3)

(c) In chaffinches, the date of laying the first egg is determined by a number of factors. These include day length and temperature. What is the advantage to the bird of egglaying being determined by

(i) daylength

(2)

(ii) temperature?

(2)

(d) Scientists found that there was a correlation between mean annual temperature and the date when chaffinches laid the first egg. Can you conclude that higher temperatures cause earlier laying of the first egg?
Explain your answer.

(2)

(e) How does the way in which the data were collected affect the conclusions which can be drawn from **Figure 3**?

(2)

(Total 13 marks)

Q17.

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.

(3)

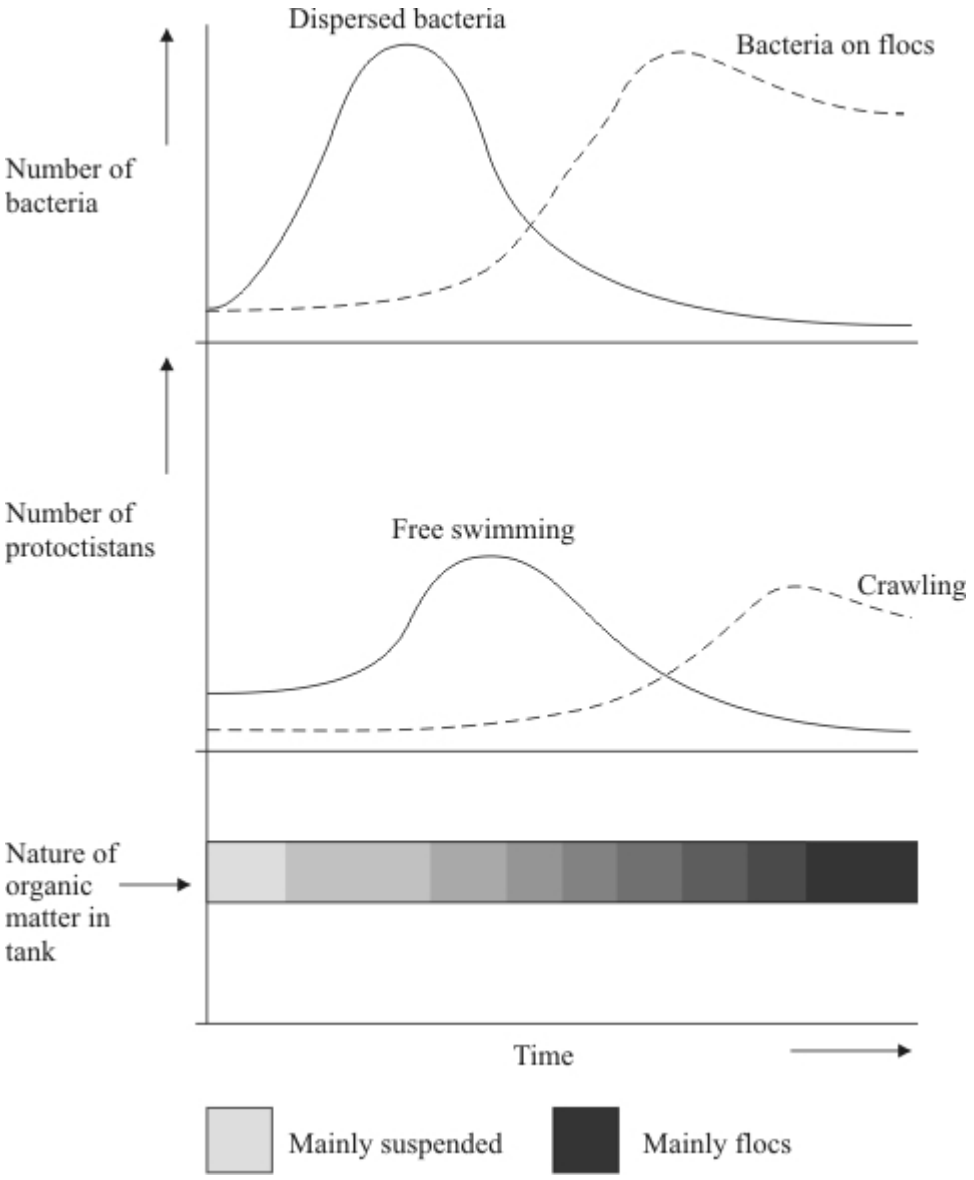
(ii) Nitrifying bacteria are one kind of bacteria that are important in the nitrogen cycle; nitrogen-fixing bacteria are another kind. Describe the part played by nitrogen-fixing bacteria in the nitrogen cycle.

(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.

(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)

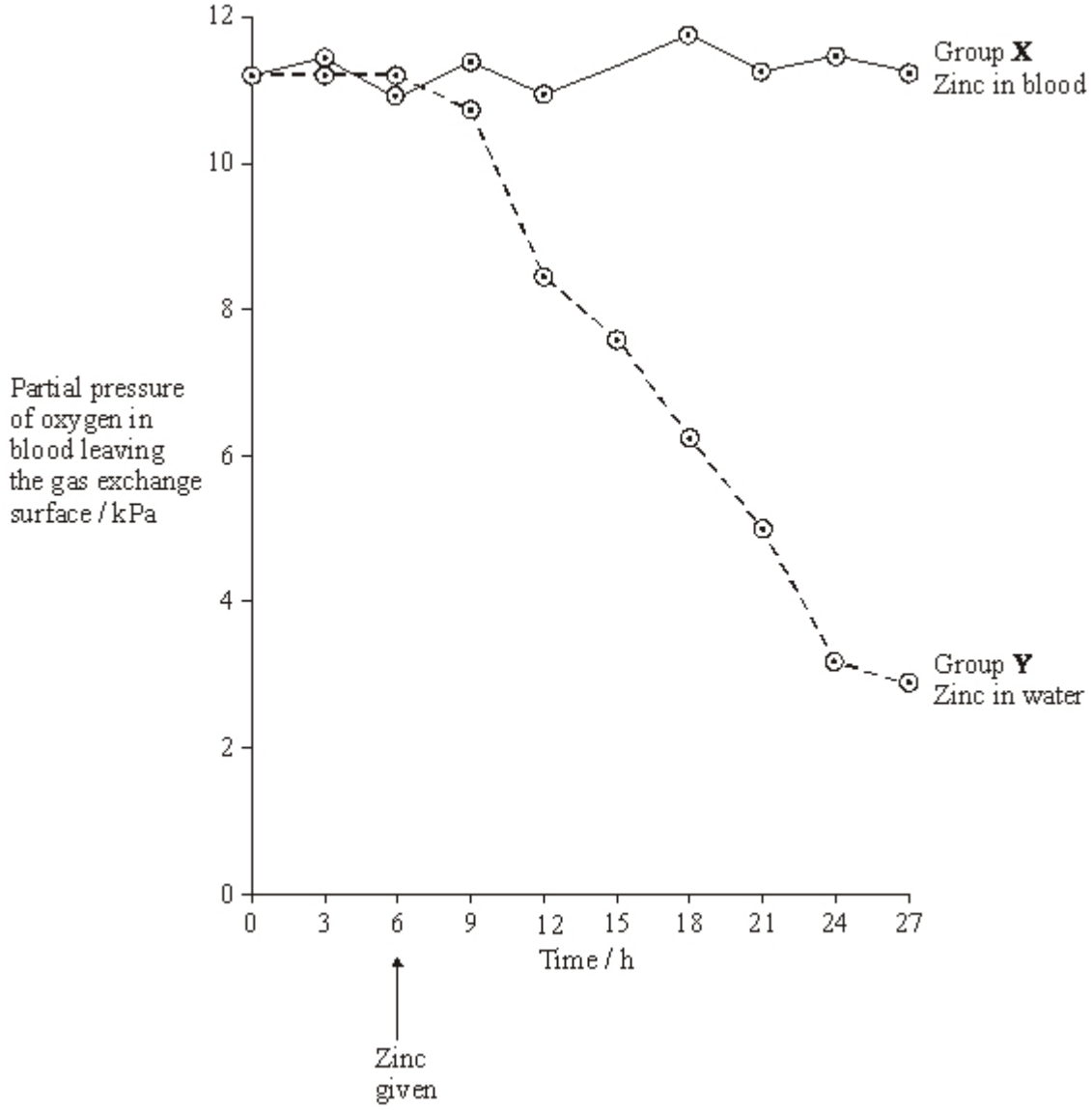
(Total 12 marks)

Q18.

Ions of metals such as zinc often pollute rivers. The effect of zinc ions on gas exchange and respiration in fish was investigated. Fish were kept in tanks of water in a laboratory.

The fish in one group (**X**) had a solution of a zinc compound injected directly into their blood and were then put in a tank of zinc-free water. A second group (**Y**) was not injected but had the solution of the zinc compound added to the water in the tank.

The partial pressure of oxygen in the blood of both groups of fish was then monitored. The results are shown in the graph.



(a) During this investigation, the water temperature in the tanks was kept constant. Explain why changes in the water temperature might lead to the results of the investigation being unreliable.

_____

_____

(1)

(b) The results from the two groups were compared using a statistical test.

(i) Suggest a null hypothesis that could be tested.

_____

(1)

(ii) Explain why it is important to use a statistical test in analysing the results of this investigation.

_____

_____

_____

_____

(2)

(c) Two suggestions were made to explain the results shown in the graph.

A Zinc ions reduce the rate at which oxygen is taken up from the water and passes into the blood.

B Zinc ions reduce the ability of haemoglobin to transport oxygen.

Which of these suggestions is the more likely? Explain the evidence from the graph that supports your answer.

_____

_____

_____

_____

(2)

(d) During the investigation, the pH of the blood was also monitored. It decreased in group **Y**. Suggest an explanation for this decrease in pH.

_____

_____

_____

_____

_____

_____

(3)

(e) Leaves were collected from sycamore trees growing in a polluted wood and the concentration of some metal ions in samples of these leaves was measured. Woodlice were then fed with the leaves. After 20 weeks, the concentration of the ions in the bodies of the woodlice was measured. Some of the results are shown in the table.

	Concentration of ions / µg g^{-1}			
	Copper	Cadmium	Zinc	Lead
Leaves	52	26	1430	908
Woodlice	1130	525	1370	132

(i) Which of the elements shown in the table is concentrated most by the woodlice? Use suitable calculations to support your answer.

(2)

(ii) Suggest what happens to most of the lead ions in the leaves eaten by the woodlice.

_____

_____

(1)

(iii) Explain the difference in the copper ion concentration between the leaves and the woodlice.

_____

_____

_____

_____

(2)

(f) Yorkshire fog is a species of grass. Two varieties of Yorkshire fog were studied. One variety was tolerant to arsenic, while the other variety was not. In a series of investigations, it was found that

- Arsenic-tolerant plants grow in soil which contains a high concentration of arsenic.
- Arsenic-tolerant plants growing in soil containing high concentrations of arsenic and phosphorus-containing compounds have very low concentrations of arsenic in their cells. They also have low concentrations of phosphates in their cells. Arsenic and phosphorus are chemically similar.
- Plants that are not tolerant to arsenic grow poorly on soil which has a high concentration of both arsenic and phosphorus-containing compounds.
- Tolerance to arsenic in Yorkshire fog is caused by a single gene with the allele, **a**, for tolerance recessive to the allele, **A**, for non-tolerance.

(i) What caused the allele for tolerance to first arise?

_____

_____

(1)

(ii) Give **two** functions of phosphates in plant cells.

1. _____

_____

2. _____

_____

(2)

(iii) Arsenic-tolerant Yorkshire fog plants are very rare in areas with low concentrations of arsenic in the soil, even where the soil has a high concentration of phosphate. Explain why they are unable to compete in these conditions with plants that are not tolerant to arsenic.

_____

_____

_____

_____

_____

_____

(3)

(Total 20 marks)

Q19.

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.

_____

_____

_____

_____

_____

_____

_____

_____

(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?

_____

(1)

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

_____

(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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

(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.

_____

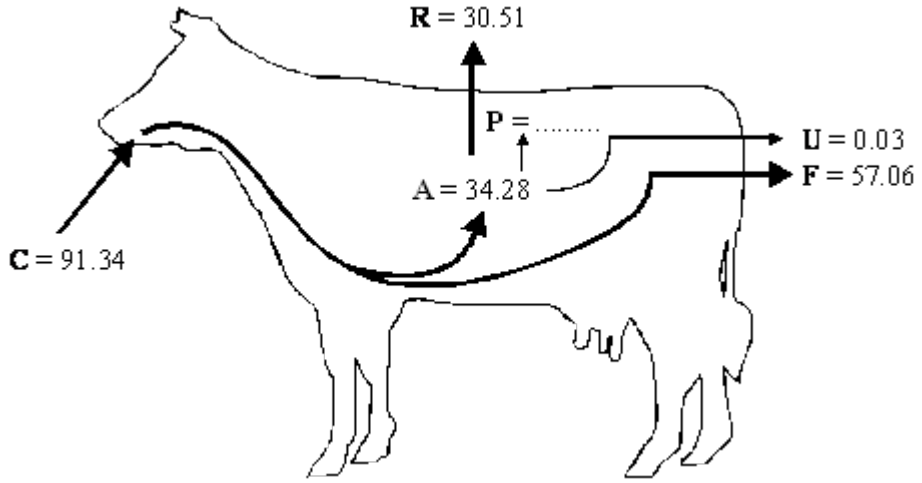
_____

(1)

(Total 11 marks)

Q20.

The diagram shows the transfer of energy through a cow. The figures are in kJ × 10^6 $year^{-1}$.



Key: **A** = energy absorbed from the gut
C = energy consumed in food
F = energy lost in faeces
P = energy used in production of new tissue
R = energy lost by respiration
U = energy lost in urine

(a) (i) Complete the following equation for the energy used in the production of new tissue. Use only the letters **C**, **F**, **R** and **U**.

P = _____

(1)

(ii) Calculate the value of **P**.

P = _____ kJ × 10^6 $year^{-1}$

(1)

(b) It has been estimated that an area of 8100 m^2 of grassland is needed to keep one cow. The productivity of grass is 21 135 kJ m^{-2} $year^{-1}$. What percentage of the energy in the grass is used in the production of new tissue in one cow? Show your working.

Answer _____ %

(2)

(c) Keeping cattle indoors, in barns, leads to a higher efficiency of energy transfer.

Explain why.

_____

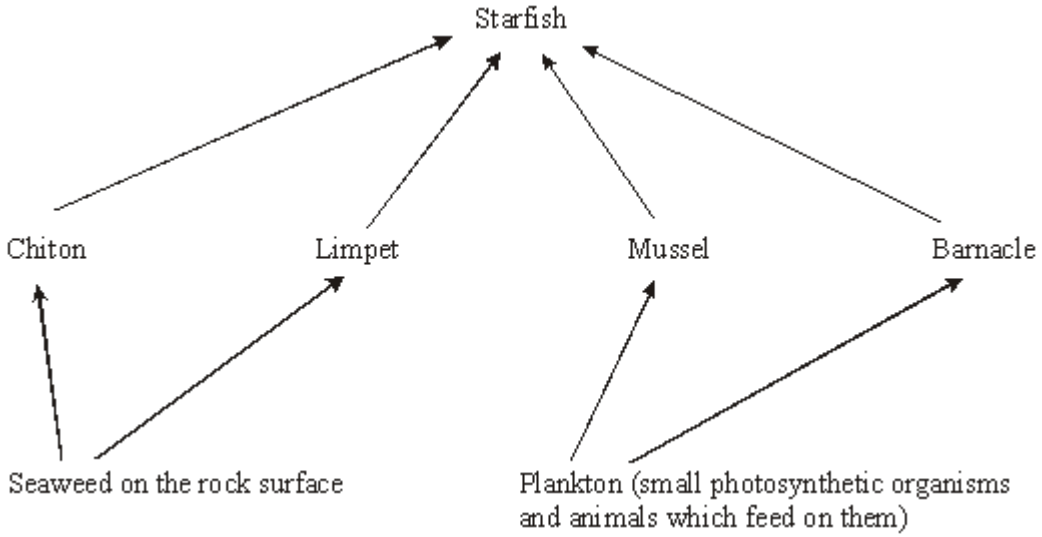
_____

(1)

(Total 5 marks)

Q21.

Starfish feed on a variety of invertebrate animals that are attached to rocks on the seashore. The diagram shows part of a food web involving a species of starfish.



(a) When starfish feed on mussels they leave behind the empty shell. Explain how quadrats could be used to determine the percentage of mussels that had been eaten by starfish on a rocky shore.

_____

_____

_____

_____

_____

(3)

(b) The table shows the composition of the diet of starfish.

	Prey species			
	Chitons	Limpets	Mussels	Barnacles
Percentage of total number of animals eaten	3	5	27	65

Energy provided by each species as a percentage of total energy intake	42	5	38	15

(i) The percentage of barnacles in the diet is much higher than the percentage of energy they provide. Suggest **one** explanation for this difference.

_____

(1)

(ii) The table shows that the amount of energy provided by chitons is greater than the amount of energy provided by limpets. Calculate the number of limpets a starfish would need to eat in order to obtain the same amount of energy as it would obtain from one chiton.

Number of limpets _____

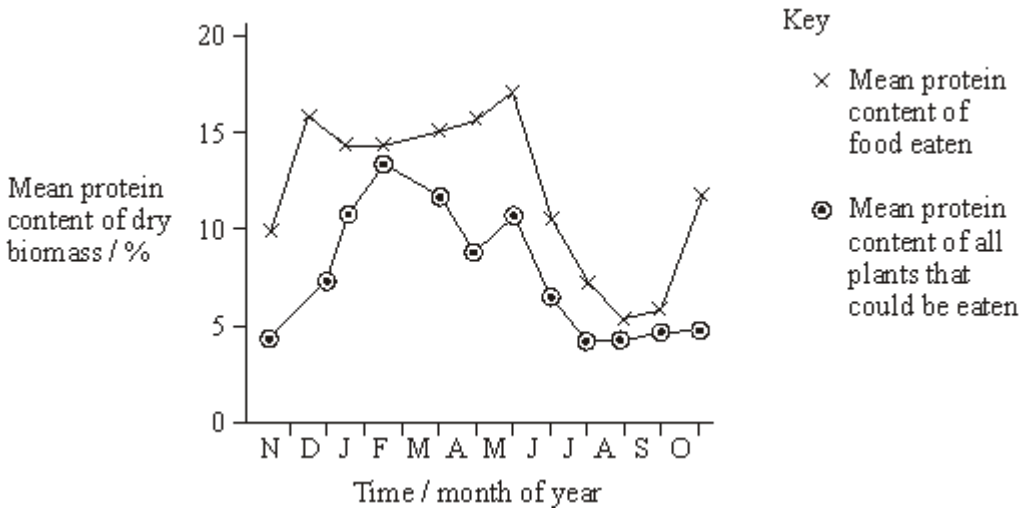
(1)

(Total 5 marks)

Q22.

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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

(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.

_____

_____

_____

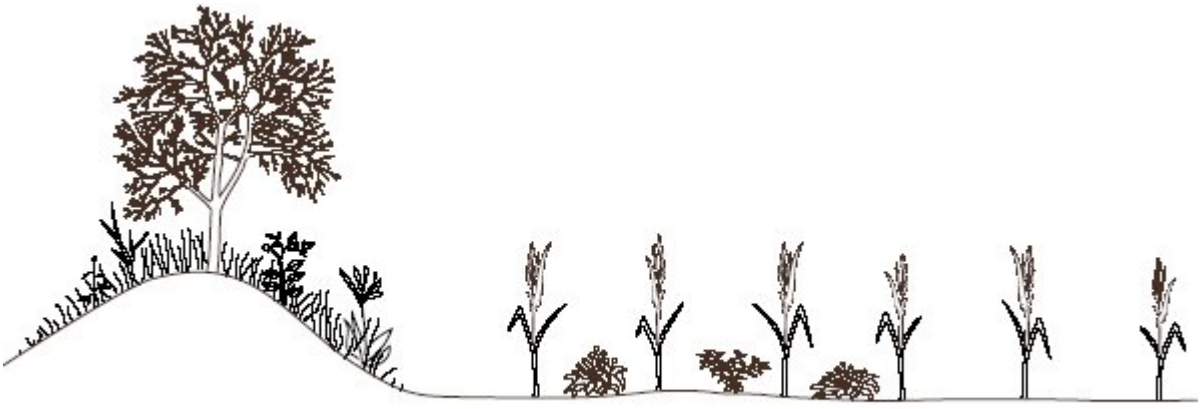
_____

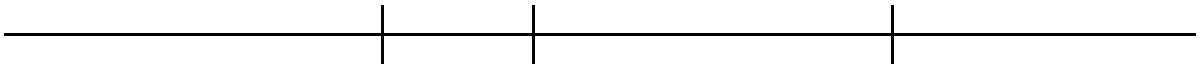
(2)

(Total 6 marks)

Q23.

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.





Hedgerow	Bare ground (2 m wide)	Conservation headland (6 m wide)	Crop

(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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

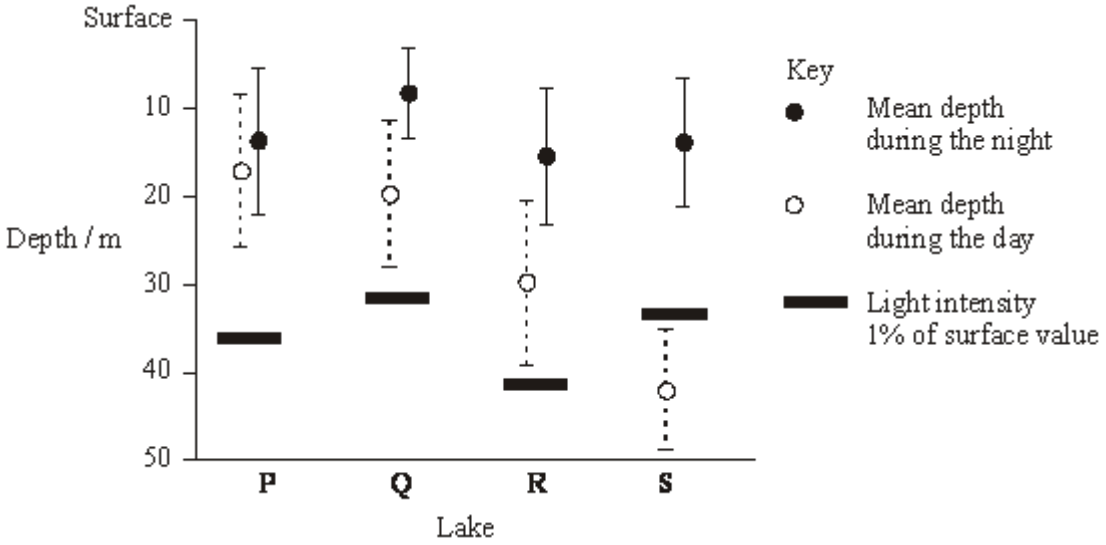
_____

(4)

(Total 7 marks)

Q24.

Zooplankton are very small animals which feed on algae (green protoctists) found in lakes. The chart shows the mean depth of zooplankton populations in four lakes, **P** to **S**, during the day and the night. It also shows the standard deviations of the means. The depth at which the light intensity is 1% of the surface light intensity is also shown.



(a) Explain the evidence that the zooplankton feed at night.

(3)

(b) Predatory fish, which hunt by sight, are present in some of the lakes. These fish have been present in the lakes for different lengths of time.

Lake	Estimated length of time predatory fish have been present / years
P	0
Q	5
R	25
S	Over 1000

(i) Describe the relationship between the depth of the zooplankton during the day and the length of time predators have been present in the lake.

_____

_____

(1)

(ii) Suggest how the differences in behaviour of the zooplankton populations in the four lakes might have evolved.

_____

_____

_____

_____

_____

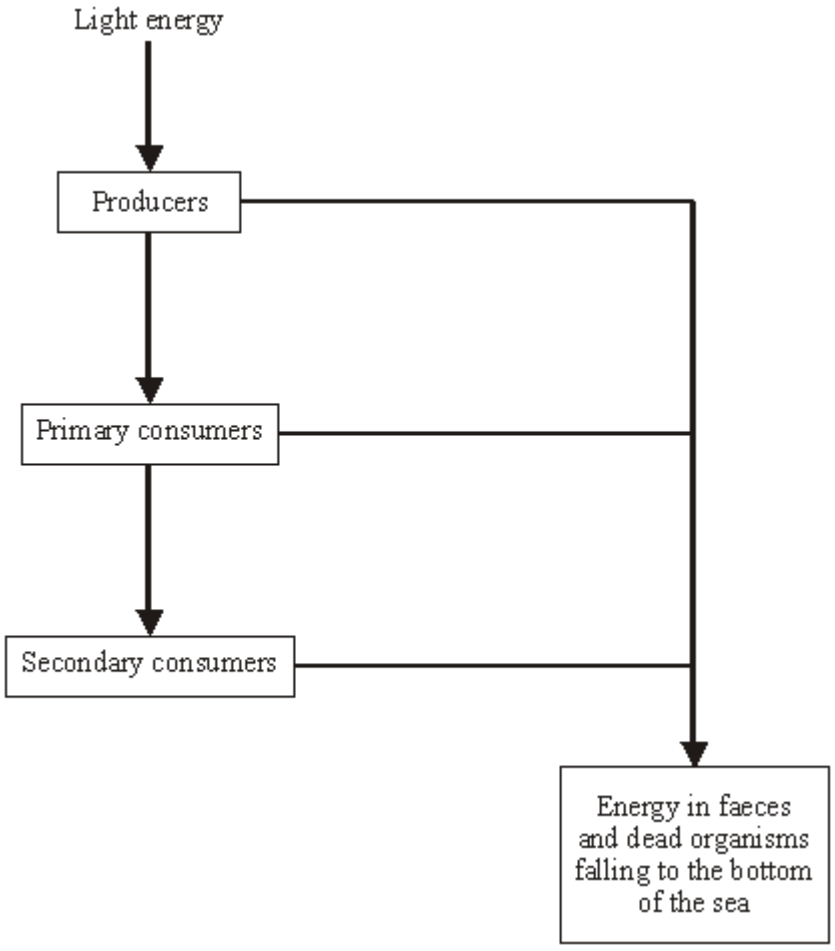
_____

(3)

(Total 7 marks)

Q25.

The diagram shows the flow of energy through a marine ecosystem.



(a) Give **one** reason why not all the light energy falling on the producers is used in photosynthesis.

_____

_____

(1)

(b) The producers in this ecosystem are seaweeds, which have a large surface area to volume ratio. Give **two** advantages to seaweeds of having a large surface area to volume ratio.

1. _____

_____

2. _____

_____

(2)

(c) Some species of seaweed are submerged in water for most of the time. Explain how being under water might affect the rate of photosynthesis.

_____

_____

_____

_____

_____

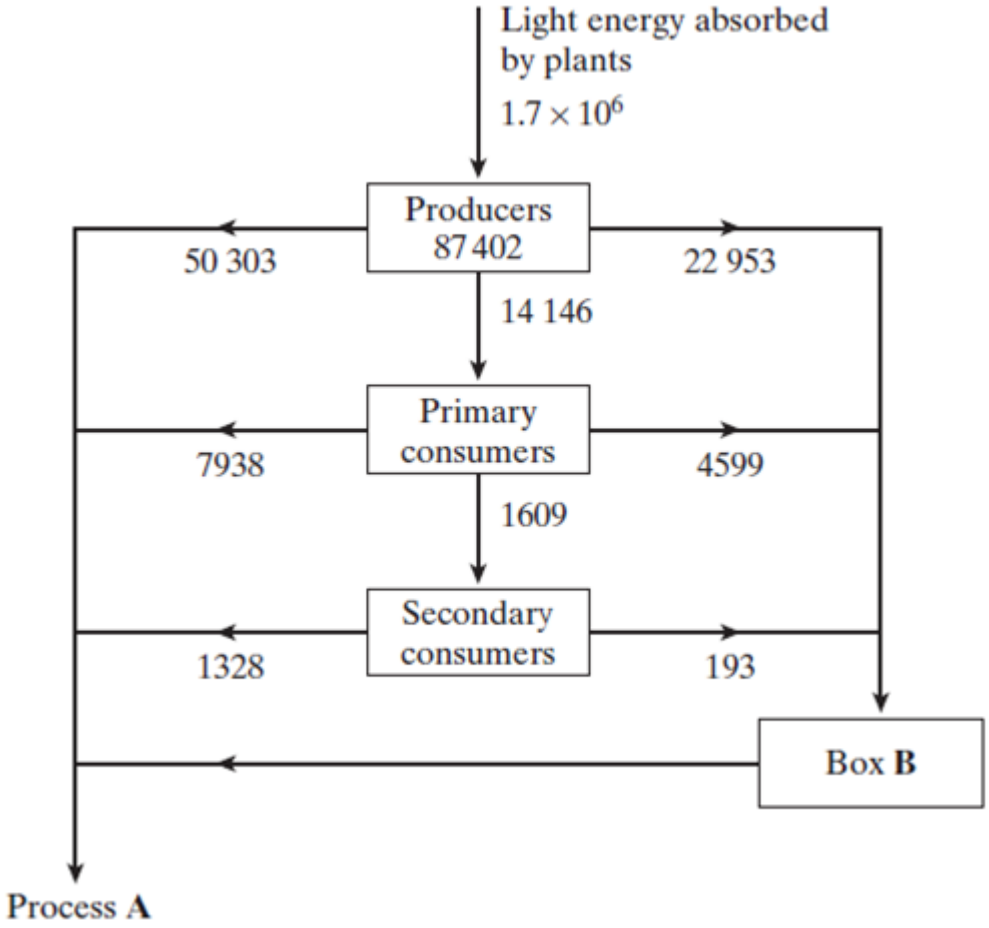
_____

(3)

(Total 6 marks)

Q26.

The diagram shows the energy flow through a freshwater ecosystem.
All units are kJ $m^{-2}year^{-1}$.



(a) Name

(i) process **A**;

_____

(1)

(ii) the group of organisms represented by box **B**.

_____

(1)

(b) Calculate the percentage efficiency with which light energy is transferred to energy in producers. Show your working.

Answer _____

(2)

(c) Describe the effect of light energy in the light-dependent reaction of photosynthesis.

_____

_____

_____

_____

(2)

(d) If a plant is kept in the dark it is still able to produce carbohydrates, as long as it is provided with two products of the light-dependent reaction of photosynthesis. Give the name of these products and explain their function in the light-independent reaction of photosynthesis.

Name _____

Function _____

_____

Name _____

Function _____

_____

(4)

(Total 10 marks)

Q27.

A hormone has been shown to switch on a gene in fish, leading to the increased production of an enzyme. Experiments were carried out to investigate the effects of heavy metal ions on the production of this enzyme, with and without the hormone. The table shows the results.

	Amount of enzyme produced / percentage of maximum	
Heavy metal ion present	**Without hormone**	**With hormone**
None	16	100
Cadmium	15	55
Zinc	17	94
Copper	16	100

Explain how the results suggest that cadmium affects the action of the hormone.

_____

_____

_____

_____

(Total 2 marks)

Q28.

(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.

_____

_____

_____

_____

(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)

Q29.

The Solomon Islands are situated in the Pacific Ocean. The nearest large land mass is Australia, which is about 1500 km away. The biggest islands are mountainous, with large areas of tropical forest and a wide range of habitats. Some islands have a very high species diversity, and many species are endemic, that is they occur only in the Solomon Islands.

The table shows the total number of species on the islands in four vertebrate classes and the percentage which are endemic.

Vertebrate class	Total number of species	Endemic species / %
Mammals	53	36
Birds	223	20
Reptiles	61	16
Amphibians	17	53

(a) How many reptile species are endemic?

_____

(1)

(b) Suggest an explanation for the high proportion of endemic species on the Solomon Islands.

_____

_____

_____

_____

_____

_____

(3)

(Total 4 marks)

Q30.

A hedgerow is a line of shrubs and trees bordering a field, together with the herbaceous plants at their base. In the last 50 years farmers have removed many hedgerows.

(a) Explain **two** advantages for a farmer of removing hedgerows.

1. _____

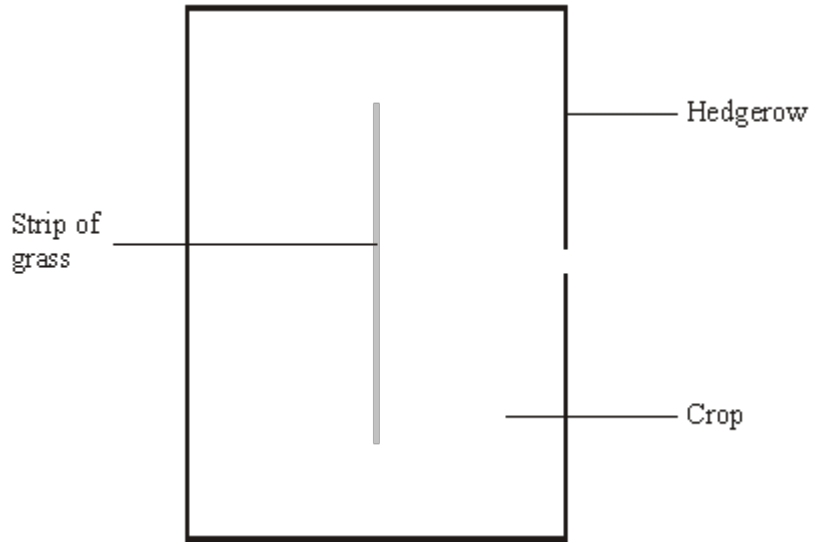
_____

2. _____

_____

(2)

(b) In recent years some hedgerows have been replanted. Ground beetles, which are unable to fly, are predators of crop pests. The beetles overwinter in the shelter of grasses at the base of the hedgerow. In some large fields, a permanent strip of grass is left as shown in the diagram.



Suggest and explain the advantage of leaving the strip of grass in the middle of the field.

_____

_____

_____

_____

(2)

(c) Apart from providing a habitat for predators of crop pests, give **two** biological benefits of replanting hedgerows.

1. _____

_____

2. _____

_____

(2)

(Total 6 marks)

Q31.

(a) Explain what is meant by

(i) succession;

_____

_____

_____

_____

(2)

(ii) a climax community.

_____

_____

(1)

Heather plants are small shrubs. Heather plants are the dominant species in the climax community of some moorlands. The structure and shape of a heather plant changes as it ages. This results in changes in the species composition of the community. A large area of moorland was burnt leaving bare ground. The table shows four stages of succession in this area.

Time after burning / years	Appearance of heather plant	Mean percentage cover of heather	Other plant species present
4		10	Many
12		90	Few
19		75	Several

24		30	Many

(b) Explain why the number of other plant species decreases between 4 and 12 years after burning.

_____

_____

_____

_____

(2)

(c) The rate at which a heather plant produced new biomass was measured in g per kg of heather plant per year. This rate decreased as the plant aged. Use the information in the table to explain why.

_____

_____

_____

_____

_____

(3)

(Total 8 marks)

Q32.

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 added/kg ha^{-1}	**Mass of crop/kg m^{-2}**	
	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}.

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

(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.

_____

_____

_____

_____

(2)

(Total 7 marks)