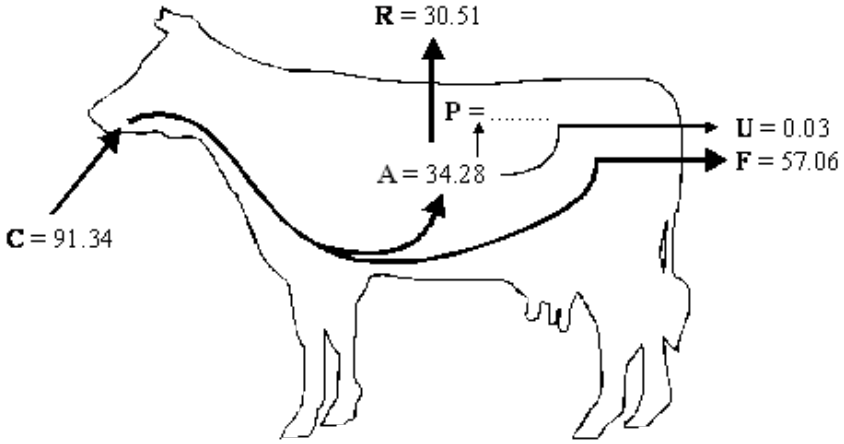
Q1. The diagram shows the transfer of energy through a cow. The figures are in kJ × 10^6 $year^{-1}$.



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.

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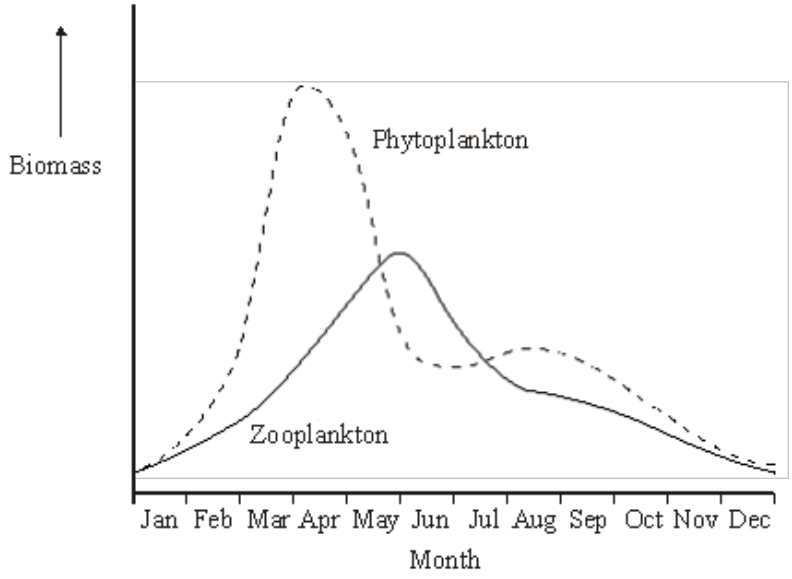
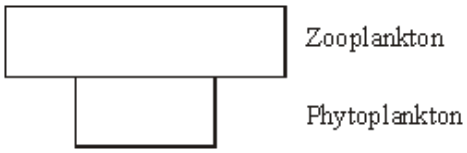
(1)

(Total 5 marks)

Q2. Phytoplankton are microscopic photosynthesising organisms which live in water. In favourable environmental conditions they have a very high rate of reproduction. They are eaten by microscopic animals called zooplankton. In an investigation, samples of water were removed from a lake at intervals over a twelve-month period and the biomasses of these organisms were determined. The results are shown in the graph.



The diagram shows the relationship between the biomass of the phytoplankton and the biomass of the zooplankton for one of the months during this investigation.



(a) Use the graph to give **one** month in which this relationship would have been found.

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(1)

(b) Explain why the biomass of the primary consumers is less than the biomass of the producers in most communities.

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(3)

(c) Explain why the biomass of the phytoplankton in the lake could be less than that of the zooplankton, as shown in the diagram.

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(1)
(Total 5 marks)

Q3. (a) Fertilisers are added to soils to replace the nutrients lost when crops are harvested.

Give **two** advantages of using

(i) an organic fertiliser such as farmyard manure;

1 .....

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2 .....

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(2)

(ii) an inorganic fertiliser.

1 .....

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2 .....

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(2)

(b) The table shows the effects of adding manure or inorganic fertiliser to some crops grown in plots.

	Yield of crop / tonnes per hectare		
Crop	**Control plot**	**Farmyard manure only**	**Inorganic fertiliser only**
Sugar beet	3.8	15.6	15.6
Mangold	3.8	22.3	30.9
Wheat	2.1	3.5	3.1

(i) How should the control plot be treated?

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(2)

(ii) Suggest why inorganic fertiliser improved the yield of the mangold crop more than the sugar beet crop.

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(1)

(Total 7 marks)

Q4. (a) Explain how large-scale deforestation for agriculture would lead to a decrease in the diversity of organisms in the area.

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(2)

(b) Explain how large-scale deforestation could

(i) increase the concentration of carbon dioxide in the atmosphere in the area;

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(ii) decrease the concentration of carbon dioxide in the atmosphere in the area.

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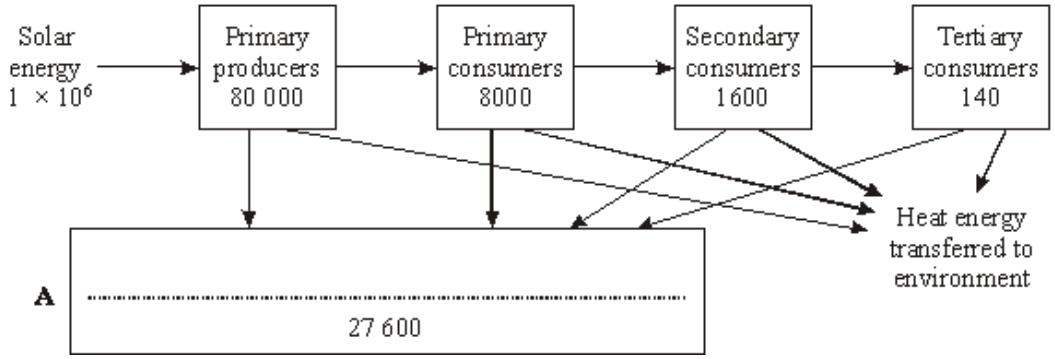
(3)
(Total 5 marks)

Q5. The diagram shows the energy transfer through the trophic levels in an ecosystem. The numbers in the boxes show the amounts of energy in the biomass at each trophic level.



(a) Complete box **A** in the diagram with the name of a group of organisms.

(1)

(b) Suggest suitable units for energy transferred between trophic levels.

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(2)

(c) Give **three** explanations for the difference between the amount of solar energy reaching the primary producers and the energy in the biomass of the primary producers.

1 .....

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2 .....

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3 .....

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(3)
(Total 6 marks)

Q6. 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**.

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(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)

(c) Explain **two** advantages and **one** disadvantage of an inorganic fertiliser such as sodium nitrate compared with an organic fertiliser such as manure.

Advantage 1 .....

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Advantage 2 .....

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Disadvantage .....

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(3)

(Total 10 marks)

Q7. (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)

Q8. (a) Explain how including leguminous plants in a crop rotation reduces the need to use artificial fertilisers.

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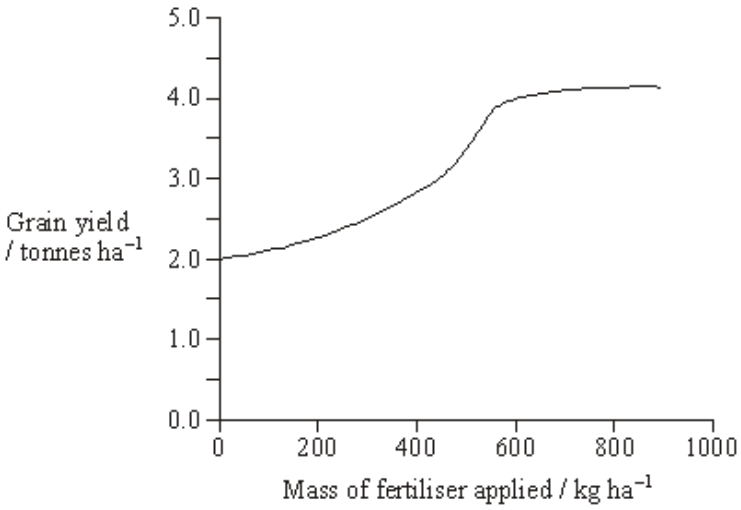
(2)

(b) The graph shows the effects of applying potassium fertiliser at different rates to a crop of wheat.



Explain how the graph shows the law of diminishing returns.

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(2)

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

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(2)
(Total 6 marks)

Q9. 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.

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(2)

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

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(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.

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(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.

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(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.

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(2)
(Total 8 marks)

Q10. (a) Explain how the use of insecticides may poison the animals at the top of a food chain.

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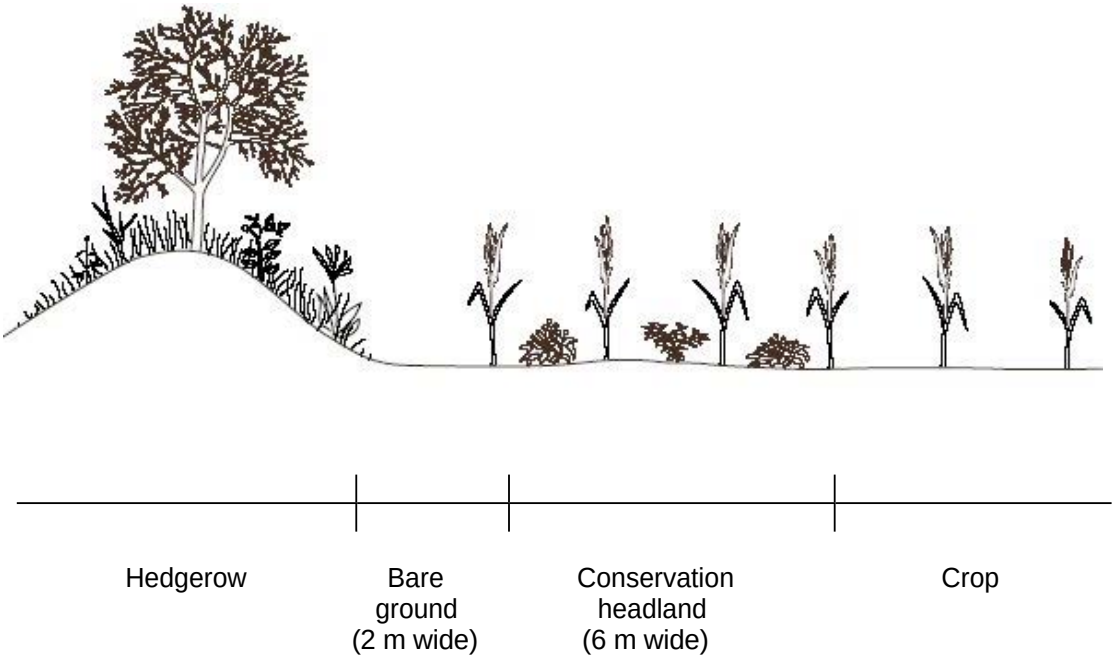
(2)

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.



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

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(1)

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

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(2)

S (d) 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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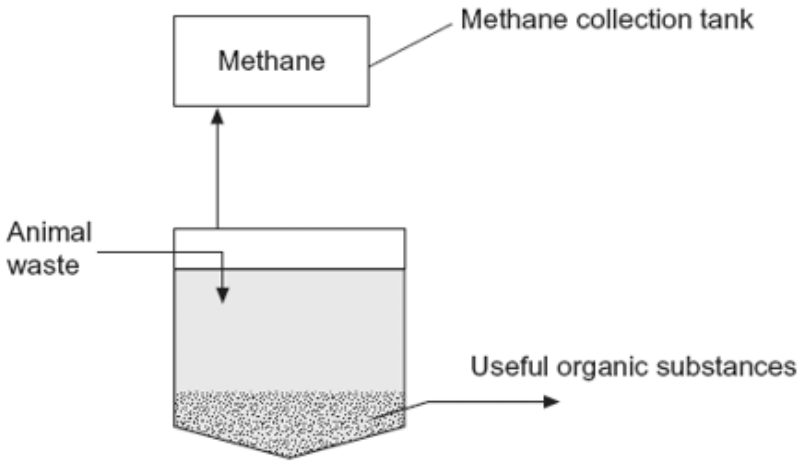
(4)
(Total 9 marks)

Q11. 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 .....

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2 .....

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(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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(*Extra Space)* .....

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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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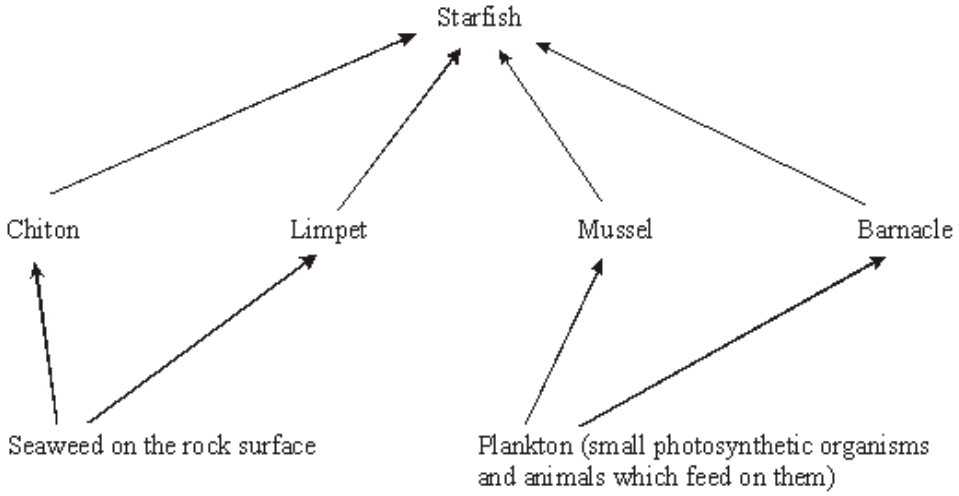
(1)

(Total 8 marks)

Q12. 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) Explain why a starfish can be described as both a secondary and a tertiary consumer.

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(1)

(b) 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.

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(3)

(c) 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 6 marks)

Q13. The herring is a fish found in the North Sea. In the food chain below, the figures represent biomass. The units are g m^{-3}.

Phytoplankton → Zooplankton → Herring
4.0 21.0 1.7

(a) Sketch and label a pyramid of biomass to represent this food chain.

(1)

(b) In this food chain, the phytoplankton reproduce very rapidly. Suggest why this rapid rate of reproduction is essential to sustain the food chain.

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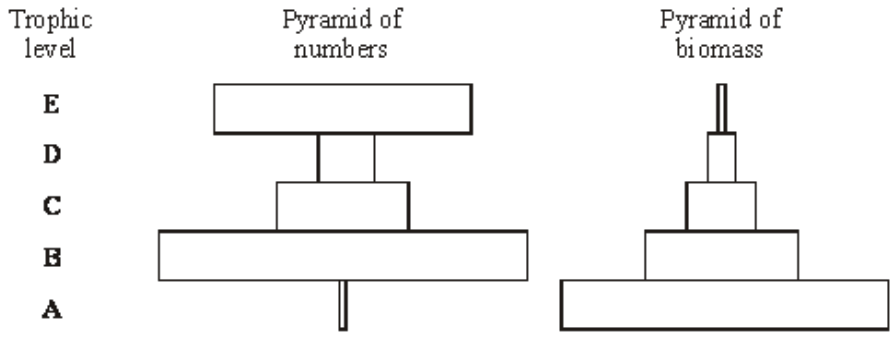
(2)
(Total 3 marks)

Q14. A food chain found in oak woodland is shown below.

Organism	Oak Tree →	Aphid →	Hoverfly →	Great tit →	Parasitic mite
Trophic level	**A**	**B**	**C**	**D**	**E**

The pyramid of numbers and pyramid of biomass representing this food chain are shown in the diagram.



(a) Not all the light energy entering the leaves of the oak tree is used in photosynthesis. Give **one** reason for this.

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(1)

(b) Give **two** ways in which energy is lost between trophic levels **A** and **B**.

1 .....

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2 .....

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(2)

(c) Explain the difference between the shapes of the two pyramids at trophic levels **D** and **E**.

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(2)
(Total 5 marks)

Q15. 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) Sketch and label a pyramid of energy for the organisms found in the treatment tank.

(1)

(ii) Explain what causes this pyramid of energy to be this shape.

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(2)

(b) (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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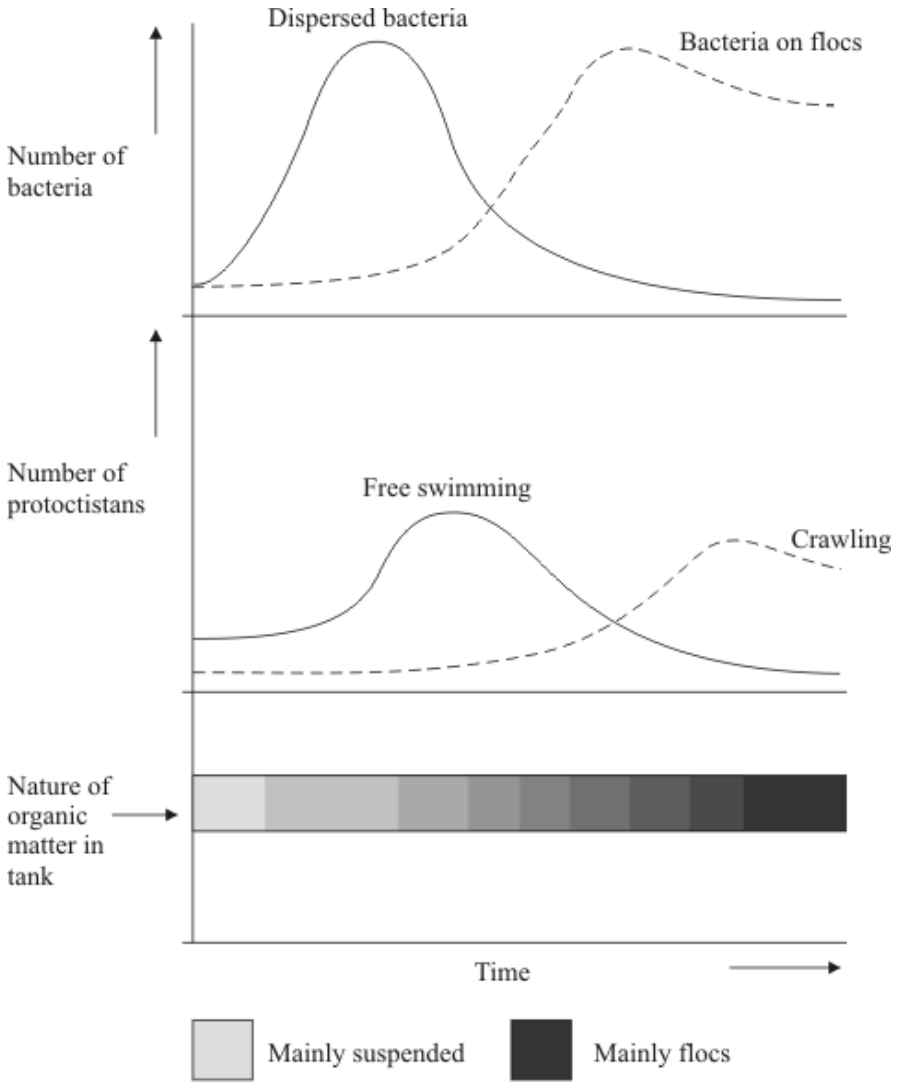
(2)

(c) 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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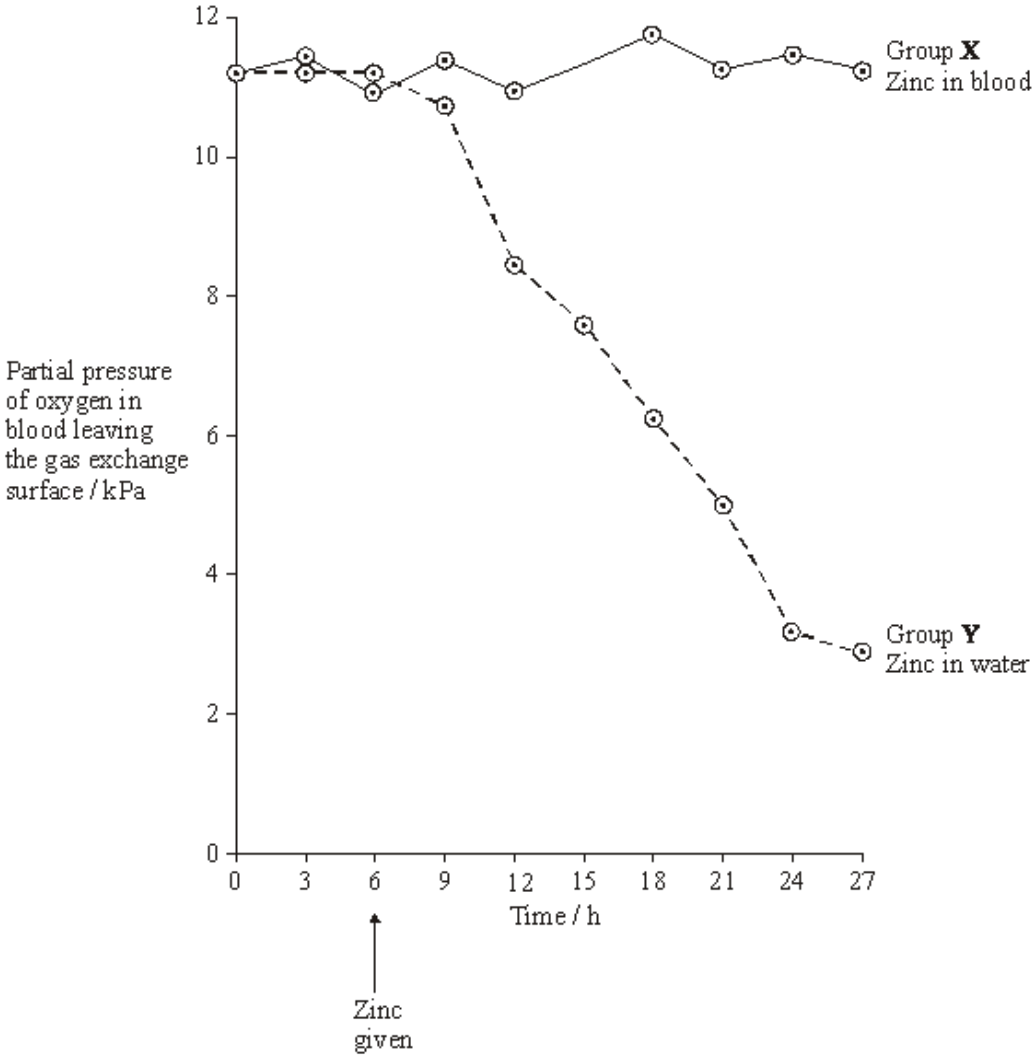
(4)
(Total 15 marks)

Q16. 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.

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(1)

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

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

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(1)

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

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(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.

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(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.

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(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.

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(1)

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

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(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?

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(1)

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

1 .....

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2 .....

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(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.

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(3)

(Total 20 marks)

Q17. Purple loosestrife is a plant which grows in Europe. It was introduced into the USA where it became a pest.

(a) Suggest why purple loosestrife became a pest when it was introduced into the USA, but is not a pest in Europe.

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(2)

(b) A European beetle was tested to see whether it could be used for the biological control of purple loosestrife in the USA. In an investigation, beetles were released in an area where purple loosestrife was a pest. The table shows some of the results.

Time after releasing beetles / years	Mean number of purple loosestrife stems per square metre	Mean number of beetles per square metre
1	22	5
2	8	40
3	6	68
4	7	62

Are the beetles effective in controlling purple loosestrife? Give evidence from the table to support your answer.

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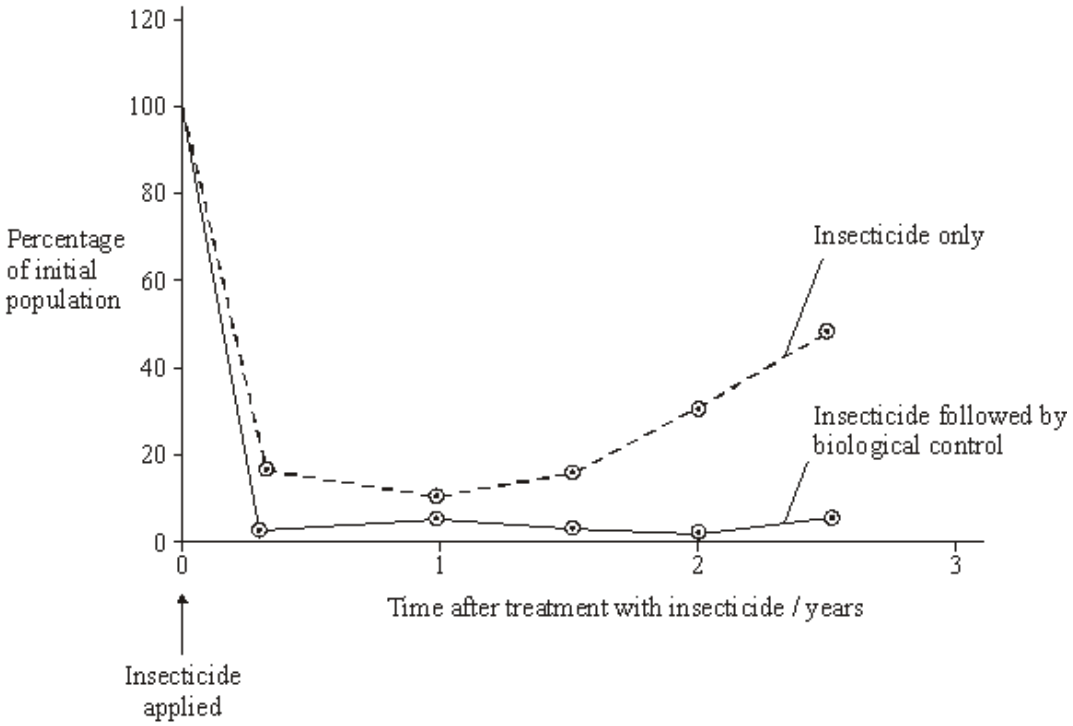
(2)

(c) Fire-ants are a serious pest in parts of the USA. An investigation was carried out to find the best way to control the fire-ant population. The graph shows the results of this investigation.



(i) Describe the effect of using insecticide followed by biological control.

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(2)

(ii) Explain the change in fire-ant population over the period when they were treated with an insecticide alone.

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(3)

(d) Give the advantages and disadvantages of using biological control.

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(6)
(Total 15 marks)

Q18. 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.

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(2)

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

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(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

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Environmental temperature

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(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

(i) Suggest a null hypothesis for this investigation.

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(1)

(ii) Selectively breeding cattle with a low RFI may help to limit global warming. Use the information in **Table 1** to explain how.

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(2)

(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?

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(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?

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(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.

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(2)

(Total 15 marks)

Q19. (a) Dead leaves contain starch. Describe how microorganisms make carbon in starch available to plants.

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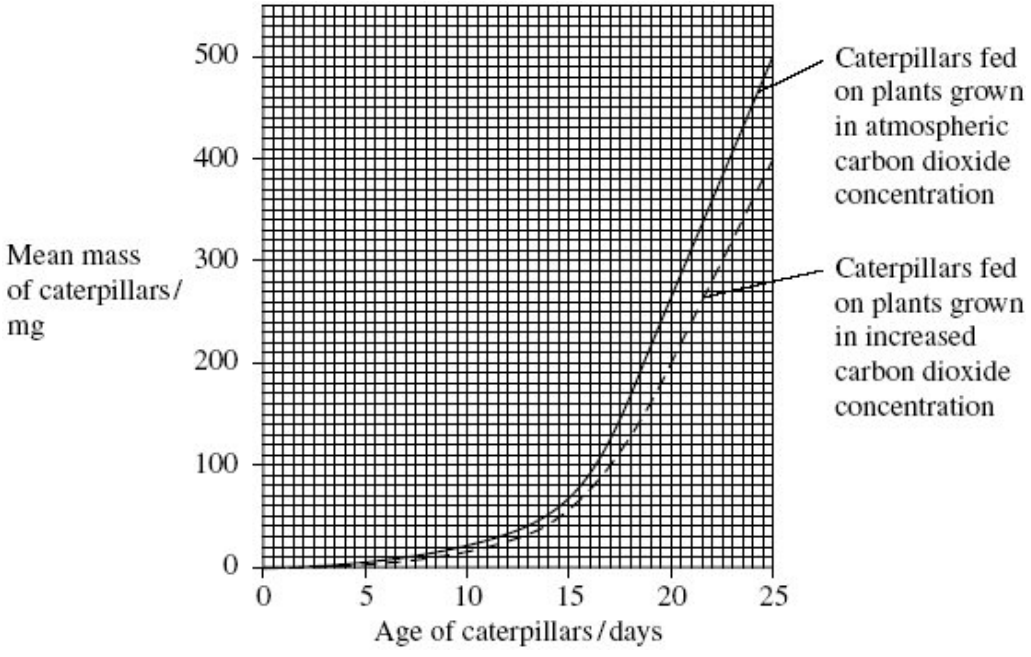
(2)

Scientists grew groups of the same species of crop plant in a greenhouse in two different concentrations of carbon dioxide. They fed caterpillars on plants from each group and measured the growth of the caterpillars. The results of their investigation are shown in the graph.



(b) Calculate the maximum rate of growth of the caterpillars on the plants grown in the increased carbon dioxide concentration. Show your working.

Answer ..... mg day^{-1}

(2)

(c) Other scientists showed that plants grown in an increased concentration of carbon dioxide have a higher carbon : nitrogen ratio than plants grown in atmospheric carbon dioxide concentration. What does this suggest about the protein concentration in the plants grown in the increased concentration of carbon dioxide? Explain your answer.

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(2)

(d) It would not be valid to conclude from the investigations described in this question that an increase in carbon dioxide concentration would reduce crop losses due to caterpillars. Give **two** reasons why this conclusion might not be valid in field conditions.

1 .....

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2 .....

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(2)
(Total 8 marks)

Q20. (a) In the light-dependent reaction of photosynthesis, light energy generates ATP.

Describe how.

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(5)

(b) Energy is transferred through an ecosystem.

Describe how and explain why the efficiency of energy transfer is different at different stages in the transfer.

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(6)

(c) Explain how the intensive rearing of domestic livestock increases net productivity.

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(4)
(Total 15 marks)