UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4940590719

BIOLOGY **9700/41**

Paper 4 A2 Structured Questions **May/June 2012**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black ink.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in Section A and **one** question from Section B.
Circle the number of the Section B question you have answered in the grid below.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
7	
8	
Section B	
9 or 10	
Total	

This document consists of **24** printed pages and **4** lined pages.

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Section A

For Examiner's Use

Answer **all** the questions.

1 The greenish warbler, *Phylloscopus trochiloides*, is a species of small bird that originated in northern India, on the southern edge of the Himalayan mountain range.

Fig. 1.1 shows a greenish warbler.



Fig. 1.1

Thousands of years ago, populations of the greenish warbler spread around the western and eastern edges of the Himalayan mountain range to establish themselves in north-eastern Europe and Siberia.

- A gradual change in characteristics occurred in these populations, leading to different forms of the greenish warbler.
- One example of gradual change is in the song of the male warbler, which is very distinctive and is used in mating behaviour.
- When greenish warblers from north-eastern Europe meet those from Siberia no mating takes place.
- The greenish warblers from north-eastern Europe and Siberia are now considered to be two separate species.

Fig. 1.2 shows the spread of the greenish warbler.

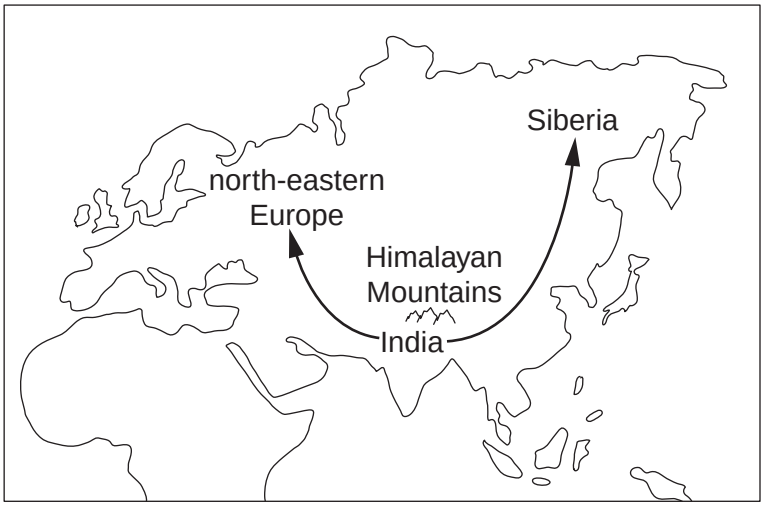


Fig. 1.2

(a) Explain what is meant by the term *species.*

For Examiner's Use

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.....[2]

(b) State the likely isolating mechanism taking place in populations of the greenish warbler.

.....[1]

(c) Explain how the process of speciation occurred in the greenish warbler populations.

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.....[5]

[Total: 8]

2 Some of the steps in the production of monoclonal antibodies are shown in Fig. 2.1.

For Examiner's Use

step 1
A mouse is injected with an antigen, A.

↓

step 2
The mouse is left for a few weeks to allow an immune response to occur.

↓

step 3
Plasma cells (effector B lymphocytes) are extracted from the mouse's spleen.

↓

step 4
Hybridoma cells are formed.

↓

step 5
Each hybridoma cell is isolated and allowed to grow and divide.

↓

step 6
The hybridoma cells producing anti-A antibodies are identified and cultured on a large scale.

Fig. 2.1

(a) With reference to Fig. 2.1, explain:

(i) what happens during an immune response (**step 2**)

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..... [4]

(ii) what is meant by a hybridoma cell (**step 4**)

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..... [1]

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(iii) why hybridoma cells need to be formed (**step 4**)

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.....[2]

(iv) how hybridoma cells producing anti-A antibody can be identified.

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.....[1]

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(b) Rheumatoid arthritis (RA) is an autoimmune disease in which T lymphocytes attack the cartilage of joints by secreting a protein, TNFα. When RA is untreated, joint damage increases considerably.

For Examiner's Use

The monoclonal antibody, infliximab, is used to treat RA. Infliximab specifically binds to TNFα.

A trial was set up to compare the effectiveness of infliximab and a standard treatment for RA, the anti-inflammatory drug, MTX.

Five groups of people with RA received the following treatments for one year:

- group **P** – MTX only
- group **Q** – MTX plus low dosage of infliximab at intervals of eight weeks
- group **R** – MTX plus low dosage of infliximab at intervals of four weeks
- group **S** – MTX plus high dosage of infliximab at intervals of eight weeks
- group **T** – MTX plus high dosage of infliximab at intervals of four weeks.

At the end of the year's treatment, the proportion of people in each group with increased joint damage was determined.

The results are shown in Fig. 2.2.

The number of people in each group is shown in brackets.

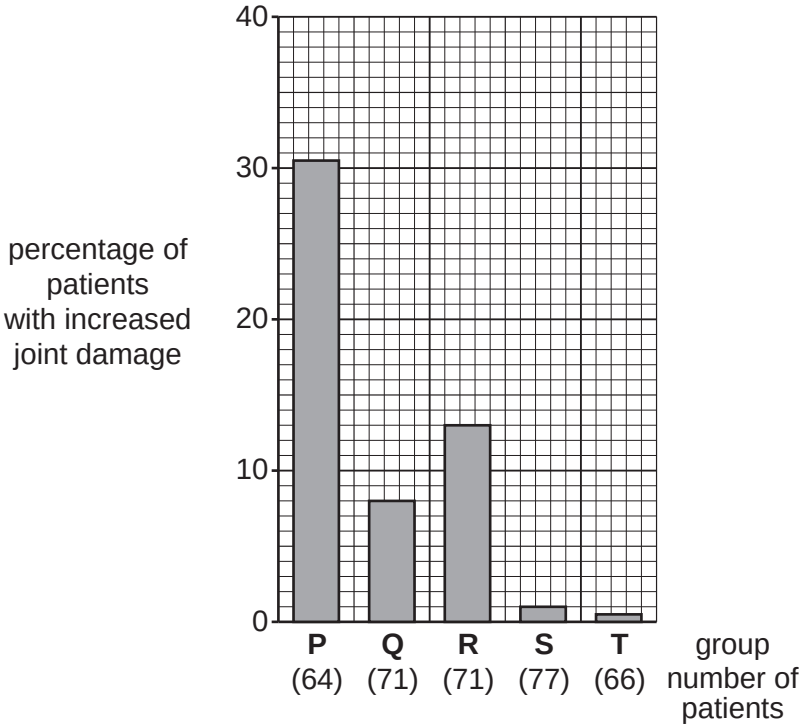


Fig. 2.2

With reference to Fig. 2.2:

For Examiner's Use

(i) describe the effect of infliximab treatment on these people

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(ii) suggest why the results in groups **Q** and **R** do not follow the general trend.

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(c) Explain the advantages of the use of monoclonal antibodies, compared with conventional methods, in the **diagnosis** of disease.

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[Total: 15]

For Examiner's Use

3 Variable number tandem repeats (VNTRs) are repetitive, non-coding sections of DNA. A particular VNTR is located at the same locus in different individuals, but the number of repeats in that VNTR varies between individuals.

(a) Explain how, in the process of genetic fingerprinting, gel electrophoresis is able to distinguish between the VNTRs that occur at the same loci of different individuals.

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..... [3]

(b) Gel electrophoresis is also used in genetic screening.

The mutation of the β-globin gene which gives rise to sickle cell anaemia removes a recognition site of a restriction enzyme, **R**, as shown in Fig. 3.1. **R** cuts DNA at the sites indicated by arrows (↓). The lengths of the resulting fragments are shown in kilobases (kb).

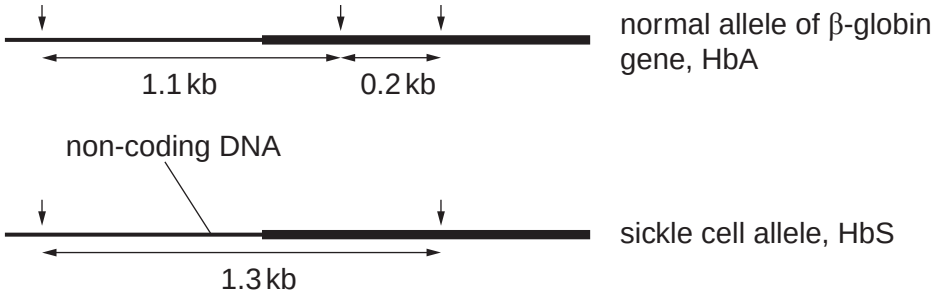


Fig. 3.1

Fig. 3.2 shows an electrophoresis gel with a stained band of DNA from an individual who was homozygous for the normal allele for β-globin, HbA HbA. This band is the 1.1 kb fragment shown in Fig. 3.1. The 0.2 kb fragment is **not** shown.

Complete Fig. 3.2 by drawing the stained DNA that would result from an individual who is heterozygous for the sickle cell allele, HbA HbS.

Put your answer on to Fig. 3.2. [2]

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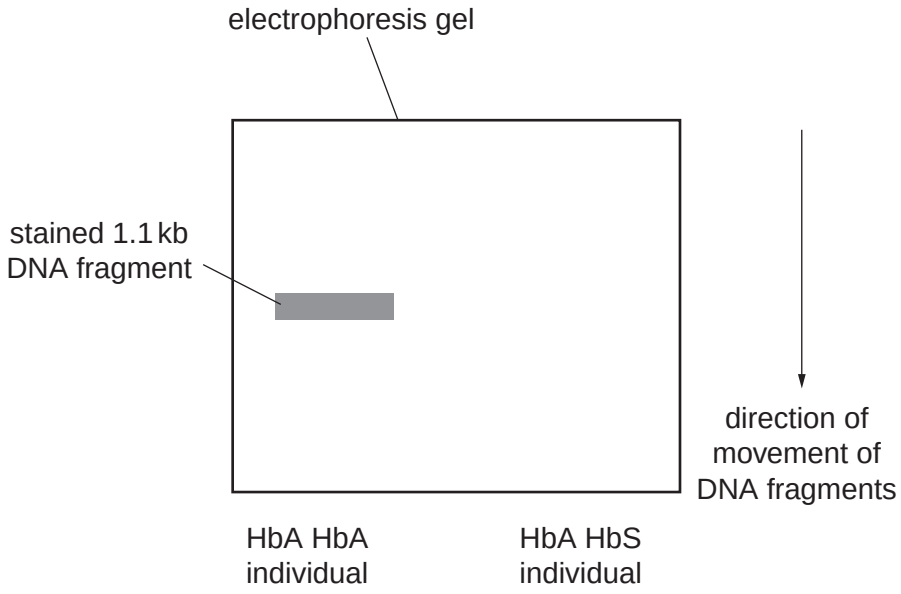


Fig. 3.2

(c) Describe the different circumstances in which this genetic screening for the sickle cell allele, HbS, might be used.

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[Total: 8]

For Examiner's Use

4 **(a)** Fig. 4.1 shows the structure of a male flower of maize, *Zea mays*.

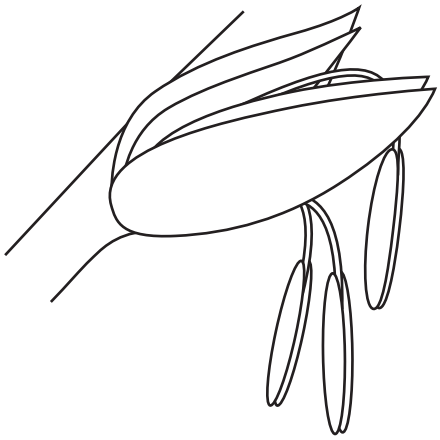


Fig. 4.1

With reference to Fig. 4.1, explain how **two** features of this flower adapt it for wind pollination.

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.....[2]

(b) The corn borer, *Ostrinia nubilalis,* is an insect pest of maize. The larvae are caterpillars that eat the leaves of the maize plants. The adults can fly. Adult corn borers do not feed on maize plants.

Much of the maize that is grown in the USA has been genetically modified to produce *Bt* toxin, which is lethal to insects that feed on the leaves. However, many populations of the corn borer have now evolved resistance to the *Bt* toxin.

Explain how this resistance could have evolved.

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.....[3]

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(c) The recessive allele, **r**, of the gene in corn borers confers resistance to *Bt* toxin. Larvae that are homozygous for the normal, dominant allele **R**, or that are heterozygous, are killed when they feed on *Bt* maize**.**

For Examiner's Use

State the genotype of the corn borers that successfully turn from larvae into adults in the fields where *Bt* maize is grown.

..... [1]

(d) In order to reduce the number of corn borers resistant to *Bt* toxin, farmers in the USA are required to grow up to 50% of their maize as non-*Bt* varieties. The non-*Bt* maize is grown in separate areas, called 'refuges', close to the fields of *Bt* maize. This is called the HDR strategy.

Almost all corn borer larvae feeding on this non-*Bt* maize have the genotypes **RR** or **Rr**. The HDR strategy assumes that, when these become adults, they will interbreed with the adults developing in the *Bt* maize fields.

Explain how the HDR strategy could reduce the proportion of corn borers that are resistant to the *Bt* toxin.

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(e) The HDR strategy works only if a high proportion of the adult corn borers developing in the *Bt* fields mate with adult corn borers from the non-*Bt* refuges. An investigation was carried out to determine the extent to which female corn borers mate with males from their own field, or from outside that field.

- Several hundred male and female adult corn borers were marked and then released into a maize field that contained no corn borers.
- After 36 hours, as many corn borers as possible were recaptured from the field and the number of marked and non-marked male and female corn borers was recorded.
- The percentage of the marked females that had mated with marked males was also recorded.
- This was repeated on four more occasions.

The results are shown in Table 4.1.

Table 4.1

trial	percentage of recaptured males that were marked	percentage of recaptured females that were marked	percentage of marked females that had mated	percentage of marked females that had mated with marked males
1	30	19	96	10
2	43	96	100	38
3	67	83	90	67
4	25	9	67	50
5	18	21	100	35

(i) With reference to the two shaded columns in Table 4.1, explain what the results indicate about the degree of mixing between corn borers from different fields.

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(ii) With reference to Table 4.1, suggest and explain the implications of the results of this investigation for the effectiveness of the HDR strategy.

For Examiner's Use

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.....[4]

[Total: 15]

5 **(a)** In girls, the first menstrual cycle occurs at the onset of puberty.

Outline the role of progesterone in the human menstrual cycle.

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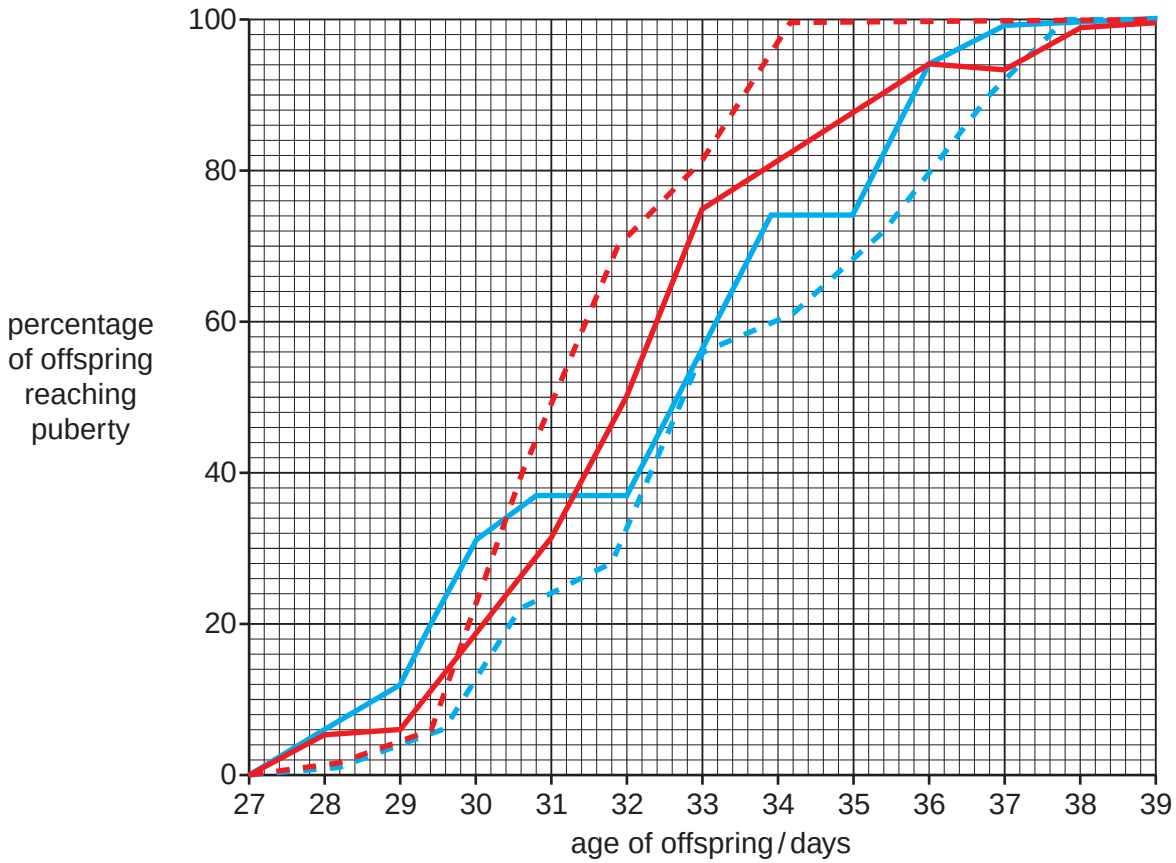
.....[3]

For Examiner's Use

(b) An investigation was carried out into the effect of the diet of pregnant female rats on the mean age of onset of puberty in their female offspring.

Pregnant female rats were fed either a high fat diet or a normal diet. Their offspring were also fed either a high fat diet or a normal diet. The percentage of offspring that had reached puberty was measured at intervals until the offspring were 39 days old.

The results are shown in Fig. 5.1.



Key:

	mother's diet	**offspring's diet**
———	high fat	high fat
- - -	high fat	normal
———	normal	high fat
- - -	normal	normal

Fig. 5.1

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(i) State the age at which 50% of offspring reached puberty when both the mother and her offspring ate a normal diet.

For Examiner's Use

.....[1]

(ii) During the 20th century, the average age of onset of puberty in European girls decreased from about 17 years to about 12 years of age. It has been suggested that a change to a richer diet is largely responsible for this decrease.

With reference to the data in Fig. 5.1, discuss the evidence that changes in diet may be responsible for this decrease in the age of onset of puberty in European girls.

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.....[4]

[Total: 8]

For Examiner's Use

6 **(a)** The plant *Rafflesia arnoldii*, which grows in the jungles of South East Asia, is noted for producing the largest flower of all plants.

- The flower is reddish-brown and can grow up to one metre in diameter.
- The flower gives off a smell similar to rotting flesh to attract flies, which then pollinate it.

Fig. 6.1 shows a flower of *R. arnoldii.*



Fig. 6.1

R. arnoldii is classified as an endangered species.

Suggest why *R. arnoldii* has become an endangered species.

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(b) (i) Explain the meaning of the term *biodiversity.*

For Examiner's Use

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(ii) Suggest reasons for maintaining **plant** biodiversity.

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[Total: 8]

For Examiner's Use

7 The fruit fly, *Drosophila melanogaster*, has many phenotypic variations and has been used in experiments to demonstrate the principles of inheritance.

(a) The majority of fruit flies have red eyes but there is a variant with white eyes.

Fig. 7.1 shows the red-eyed and white-eyed variants of the fruit fly.



Fig. 7.1

The gene for eye colour is located on the X chromosome.

Using suitable symbols, draw a genetic diagram to show the possible offspring of a cross between a heterozygous red-eyed female fruit fly with a white-eyed male fruit fly.

key to symbols:

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parental phenotypes	red-eyed female	white-eyed male
parental genotypes		
gametes		
offspring genotypes		
offspring phenotypes		

[5]

(b) One of the genes controlling the clotting of blood in humans is also located on the X chromosome. A rare variation of the gene, a recessive allele for haemophilia, can lead to a condition where the blood fails to clot properly.

For Examiner's Use

(i) State why a man who has haemophilia is unable to pass the condition on to his son.

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.....[1]

(ii) Queen Victoria of Great Britain in the 19th century was a carrier of haemophilia, but did not have the condition.

State the term used to describe the genotype of a carrier.

.....[1]

(iii) Neither of Queen Victoria's parents carried the allele for haemophilia.

Suggest how Queen Victoria could have become a carrier.

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.....[1]

[Total: 8]

For Examiner's Use

8 **(a)** Fig. 8.1 shows the effect of temperature on the rate of photosynthesis of a plant at a constant light intensity and a carbon dioxide concentration of 0.03%.

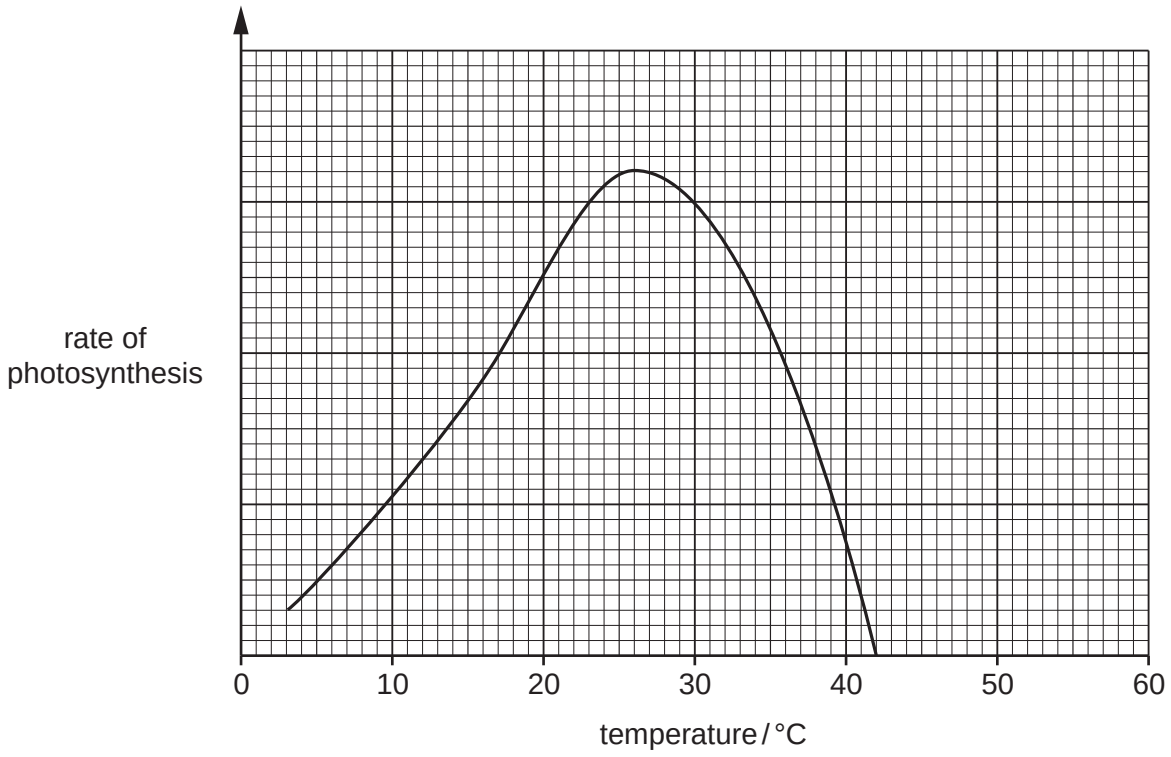


Fig. 8.1

(i) Suggest and explain why the rate of photosynthesis of the plant decreases to zero just above 40 °C.

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(ii) Draw, **on Fig. 8.1**, the likely curve if the same experiment were carried out on a C4 plant, such as sorghum.

For Examiner's Use

Give reasons to explain your curve.

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.....[3]

For Examiner's Use

(b) Experiments were carried out to determine the effect of light intensity on the rate of photosynthesis of a species of the unicellular protoctist, *Chlorella*. A cell suspension of *Chlorella* was used.

- The suspension of *Chlorella* was illuminated at a light intensity of 5 lux for 20 seconds.
- The carbon dioxide uptake by *Chlorella* was measured at the end of the 20 second period of illumination.
- The experiment was repeated at 10, 13 and 15 lux.
- The suspension was maintained at a temperature of 20 °C.

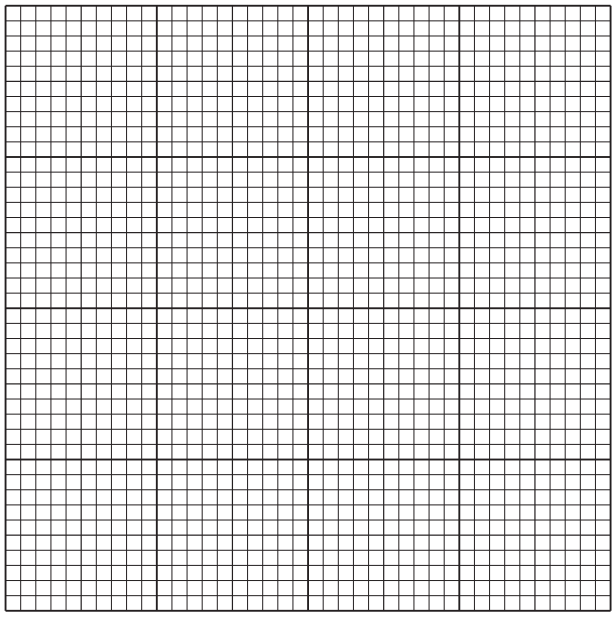
Table 8.1 shows the results of the experiments.

Table 8.1

light intensity / lux	**total CO_2 uptake after 20 seconds / μmol**	**rate of photosynthesis / μmol s^{-1}**
5	36	1.8
10	84	
13	104	
15	120	

(i) Complete Table 8.1. [1]

(ii) Use the data in the table to plot a graph on the grid below to show the effect of light intensity on the rate of photosynthesis.



[3]

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(iii) With reference to photosynthesis, state what is meant by a limiting factor.

For Examiner's Use

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.....[2]

(iv) State the limiting factor in these four experiments.

.....[1]

[Total: 15]

Section B

Answer **one** question.

For Examiner's Use

9 **(a)** Describe how ATP is synthesised by oxidative phosphorylation. [8]

(b) Using examples, outline the need for energy in living organisms. [7]

[Total: 15]

10 **(a)** Describe the structure of a kidney, including its associated blood vessels. [6]

(b) Describe the mechanisms involved in reabsorption in the proximal convoluted tubule **and** describe how the epithelial cells of the proximal convoluted tubule are adapted to carry out this process. [9]

[Total: 15]

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Question 6 Fig. 6.1 © KJELL B. SANDVED / SCIENCE PHOTO LIBRARY.

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