Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

2626613177

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **October/November 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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 pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

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.

This document consists of **24** printed pages.

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CAMBRIDGE International Examinations

Section A

Answer **all** questions.

1 The Bali starling, *Leucopsar rothschildi*, is found on the island of Bali, Indonesia.

Fig. 1.1 shows a Bali starling.



Fig. 1.1

(a) The International Union for Conservation of Nature (IUCN) is the world's largest global environmental organisation. The IUCN Red List of Threatened Species™ evaluates the conservation status of plant and animal species.

The Bali starling is categorised as critically endangered on the IUCN Red List, which means that it is nearly extinct in the wild.

The Bali starling is protected by Indonesian law and trapping of the birds for sale as pets is illegal. In 2001 there were only six Bali starlings in the wild and about 1000 in captivity.

(i) Suggest reasons, other than the trapping of the birds for sale as pets, for the very low numbers of Bali starlings in the wild.

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(ii) Describe the roles zoos can take in the protection of the Bali starling.

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(b) Explain the consequences on genetic biodiversity of having a wild population of just six birds.

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[Total: 9]

2 In the fruit fly, *Drosophila melanogaster*, two different genes control body colour and eye colour.

- **G**/**g** are alleles of the body colour gene.
- **G** results in grey body, **g** results in black body.

- **R**/**r** are alleles of the eye colour gene.
- **R** results in red eyes, **r** results in brown eyes.

Each gene is autosomal.

A dihybrid cross was carried out using a fly with a grey body and red eyes crossed with a fly with a black body and brown eyes. Both parents were homozygous for both genes. The offspring from the F1 generation were crossed to obtain the F2 offspring.

(a) A statistical test showed that the results of the cross were significantly different from those expected.

State the name of the statistical test used **and** state the expected phenotypic ratio for the F2 generation.

statistical test .....

expected ratio .....

[2]

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(b) A test cross can be carried out in order to identify flies from an F2 generation that are heterozygous for both genes.

Draw a genetic diagram to show how a test cross between a heterozygous grey-bodied, red-eyed F2 fly and a fly with a black body and brown eyes can produce four different offspring phenotypes.

Use the symbols **G**/**g** and **R**/**r**.

[4]

(c) The results of the test cross in **(b)** are shown in Table 2.1. These results are significantly different from the expected results.

Table 2.1

phenotypes of offspring of test cross	number of individuals
grey body, red eyes	123
grey body, brown eyes	7
black body, red eyes	6
black body, brown eyes	132

Describe how these results are different from the expected results **and** explain why they are different.

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..... [5]

[Total: 11]

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3 **(a)** Meiosis is one process that contributes to genetic variation.

(i) State **precisely** the stage of meiosis where single chromosomes line up on the equator.

..... [1]

(ii) Outline the events taking place during anaphase I of meiosis.

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..... [2]

(iii) Describe how crossing over during meiosis leads to genetic variation.

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Mutation also causes genetic variation. Some populations of water hemp, *Amaranthus tuberculatus*, have evolved herbicide resistance as a result of a mutation. This is a problem for farmers as water hemp grows in crop fields, lowering productivity.

Two populations of water hemp were tested for resistance to the herbicide mesotrione. One was a population known to be resistant (control) and the other was a test population, whose resistance was unknown.

- Leaves were removed and immersed in a radioactively labelled solution of mesotrione.
- The leaves absorbed some mesotrione and became radioactive.
- Resistant leaves are able to degrade mesotrione by metabolism.
- The time for 50% of absorbed mesotrione to degrade was calculated by measuring the radioactivity of the leaves.

The results are shown in Table 3.1.

Table 3.1

population of water hemp	mean time for 50% of absorbed mesotrione to degrade / hours	standard deviation
test	27.5	4.75
control	10.1	2.34

(b) (i) Explain how the results in Table 3.1 show that the two populations differ in their resistance to mesotrione.

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..... [2]

(ii) Explain why this example of genetic variation is important for natural selection in water hemp populations.

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..... [2]

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(iii) Farmers can send in a sample of leaves of water hemp from their fields to a laboratory to be tested for resistance to mesotrione or other herbicides.

Suggest the benefit of this to a farmer.

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..... [1]

(c) The null hypothesis states there is no significant difference between the mean times for 50% of absorbed mesotrione to degrade in the two populations.

A *t*-test can be carried out to compare these two means. The critical value for ***t*** at the $p = 0.05$ significance level is 2.23.

(i) Use the formula in Fig. 3.1 to calculate the value of ***t***.

Show your working.

$$t = \frac{\left|\overline{x}_1 - \overline{x}_2\right|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

Key
$\overline{x}$ = mean
s = standard deviation
n_1 = 6 (number of readings for test population)
n_2 = 6 (number of readings for control population)

Fig. 3.1

t = ... [2]

(ii) Use your calculated value of ***t*** to explain whether the null hypothesis should be accepted or rejected.

accept or reject .....

explanation .....

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.....[2]

[Total: 14]

4 The Hawaiian archipelago is a group of volcanic islands in the Pacific ocean.

Fig. 4.1 shows the relative locations of five of these islands.

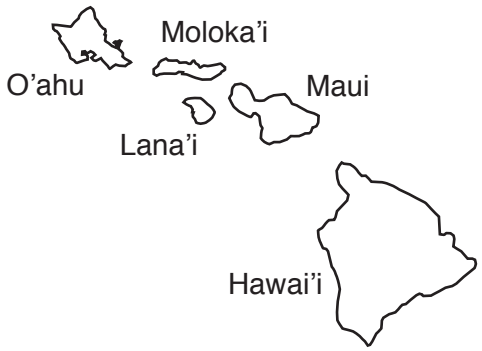


Fig. 4.1

Table 4.1 shows the size and age of these five islands and the total number of *Mecyclothorax* ground beetle species and their species density, on each island.

Data for the island of Maui is shown as two distinct regions, West and Haleakalã. This is because they formed at different times from two separate volcanoes.

Table 4.1

island	**area / km^2**	**age of island / million years**	**total number of *Mecyclothorax* species**	**species density / number of species per km^2**
Hawai'i	10433	0.4	30	0.003
Lãna'i	364	1.3	3	0.008
Maui (West)	443	1.3	27	0.061
Maui (Haleakalã)	1440	1.1	116	0.081
Moloka'i	673	1.9 – 1.8	43	0.064
O'ahu	1545	3.7 – 2.6	20	.....

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Fig. 4.2 shows a ground beetle of the genus *Mecyclothorax*. All the beetle species of this genus on the Hawaiian archipelago form a monophyletic group, descended from one original colonising species that reached Maui from Australia.

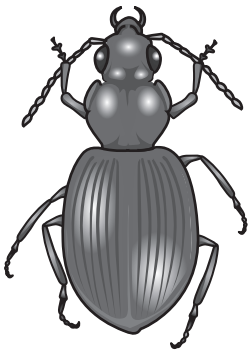


Fig. 4.2

(a) (i) Complete Table 4.1 by calculating the density of *Mecyclothorax* beetle species on the island of O'ahu. [1]

(ii) Use Table 4.1 to explain why the island of Hawai'i has the lowest density of *Mecyclothorax* beetle species.

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..... [2]

(iii) Use Fig. 4.1 and Table 4.1 to suggest why O'ahu has a lower number of *Mecyclothorax* beetle species than Moloka'i.

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..... [2]

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[Turn over

(b) The rate of speciation of *Mecyclothorax* beetles on the slopes of the volcano Haleakalã, on Maui, is the highest recorded for any genus or location on earth.

The volcano last erupted 400 years ago. This produced lava flows which cut through ancient forest and vegetation, dividing it into many separate microhabitats.

Explain how the large number of *Mecyclothorax* beetle species on Haleakalã developed.

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.....[4]

[Total: 9]

5 **(a)** Leber's congenital amaurosis (LCA) is an autosomal recessive eye disease. LCA results in eye disorders, including severe loss of vision, at birth. LCA has been successfully treated by gene therapy, using a virus instead of a plasmid as the vector.

Adeno-associated virus (AAV) vectors containing the therapeutic allele were injected directly into the retina, the layer at the back of the eye containing the photoreceptor cells. People who had been blind from a young age were able to see again.

There is a risk associated with the injection method used to deliver the vectors, as it might cause the retina to detach, damaging vision. This method of delivery was first used for LCA before being trialled on other retinal diseases that gradually reduce the vision of people as they get older.

(i) Suggest the main steps involved in creating recombinant DNA for this example of gene therapy.

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..... [4]

(ii) Explain why the fact that LCA is an autosomal recessive genetic disease makes it suitable for treatment with gene therapy.

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..... [2]

(iii) Suggest why the retinal injection method of gene therapy was used for LCA before it was trialled on other retinal diseases that gradually reduce the vision of people as they get older.

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.....[2]

(b) Scientists tried to create an improved virus vector for gene therapy.

step 1 – The scientists used a special form of the polymerase chain reaction (PCR). This form of PCR causes mutations in the DNA sequence of AAV by base substitution.

step 2 – The viruses containing different base substitutions were tested. This was done by using the different viruses to deliver a new gene, the gene for green fluorescent protein (GFP), into the photoreceptor cells of mice, using the retinal injection method.

step 3 – The best virus, known as 7m8, caused the photoreceptor cells in the retina of the mouse to fluoresce brightly, even when the recombinant virus was injected into the fluid inside the eye instead of into the retina itself.

step 4 – The 7m8 virus was used to cure a mouse with LCA by injecting this virus containing the therapeutic allele into the fluid inside the eye of the mouse.

(i) Suggest how errors occurring during PCR can cause base substitution mutations in the DNA sequence of AAV.

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..... [3]

(ii) Explain why the photoreceptor cells of the mouse fluoresced in step 3.

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..... [2]

(iii) Predict the impact of the 7m8 AAV on treatment for age-related retinal diseases.

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.....[1]

[Total: 14]

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6 **(a)** Fig. 6.1 outlines some of the steps of glycolysis.

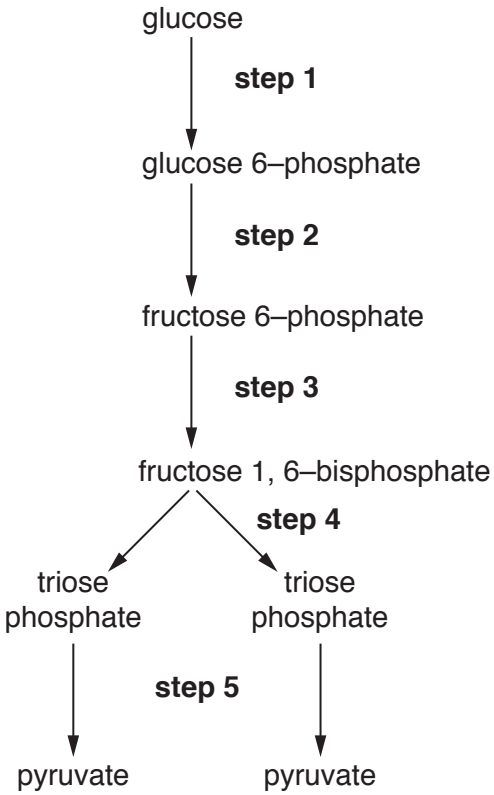


Fig. 6.1

(i) State the precise location of glycolysis in the cell.

..... [1]

(ii) With reference to Fig. 6.1:

state the steps where phosphorylation occurs

.....

state the step where oxidation occurs

.....

name the type of reaction by which ATP is made during **step 5**.

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[3]

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[Turn over

(b) Some cancer cells have different metabolic requirements from normal cells. These cancer cells obtain most of their ATP from glycolysis, even if oxygen is available.

State how the glucose and oxygen requirements of these cancer cells differ from normal cells.

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..... [2]

[Total: 6]

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7 **(a)** Fig. 7.1 is a transmission electron micrograph of a chloroplast.

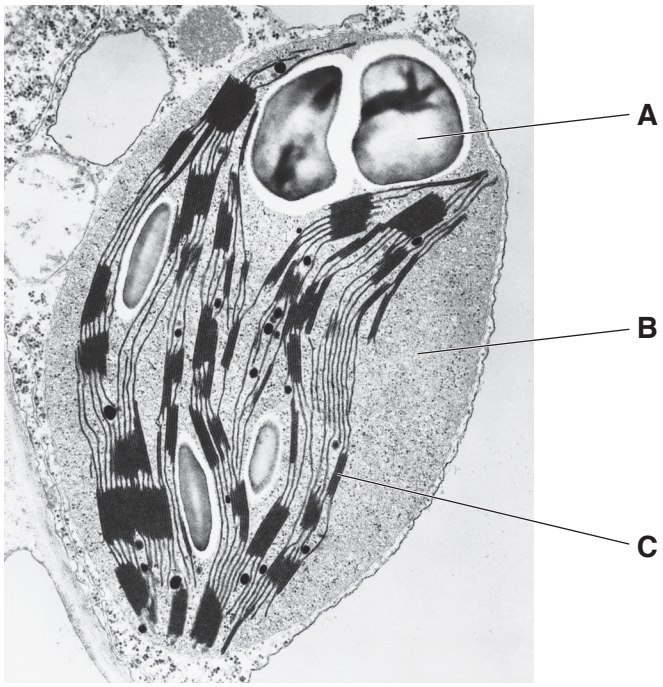


Fig. 7.1

Many compounds and structures involved in photosynthesis are located in a chloroplast.

Using the labels **A**, **B** or **C**, complete Table 7.1 to show the location of four of these compounds or structures.

You may use each of the letters **A**, **B** and **C** once, more than once, or not at all.

Table 7.1

compound or structure	location
ATP synthase	……..
rubisco	……..
starch grain	……..
phospholipid bilayer	……..

[3]

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[Turn over

(b) *Elodea canadensis* is an aquatic plant that lives submerged in freshwater.

Equal-sized plants of *E. canadensis* were exposed to different wavelengths of light for the same period of time. As each plant photosynthesised, the number of bubbles of oxygen leaving the plant was counted.

For each wavelength, the rate of oxygen production was calculated.

The results are shown in Fig. 7.2.

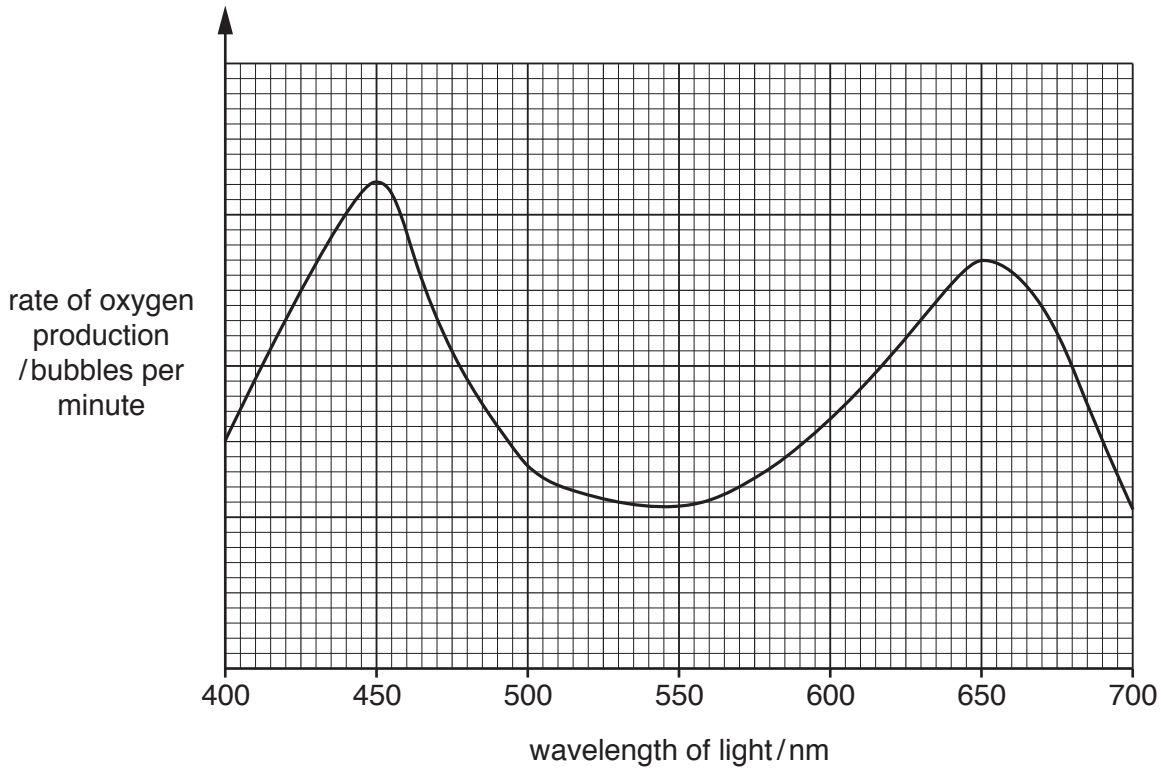


Fig. 7.2

Describe **and** explain the results shown in Fig. 7.2.

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.....[3]

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(c) Chlorophyll b, carotene and xanthophyll are known as accessory pigments. Describe the role of the accessory pigments in photosynthesis.

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..... [2]

[Total: 8]

8 **(a)** Outline the roles of sensory receptor cells in the mammalian nervous system.

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..... [3]

(b) Fig. 8.1 shows the changes in potential difference (p.d.) across the membrane of a receptor cell over a period of time. The membrane was stimulated at time **A** and at time **B** with stimuli of different intensities.

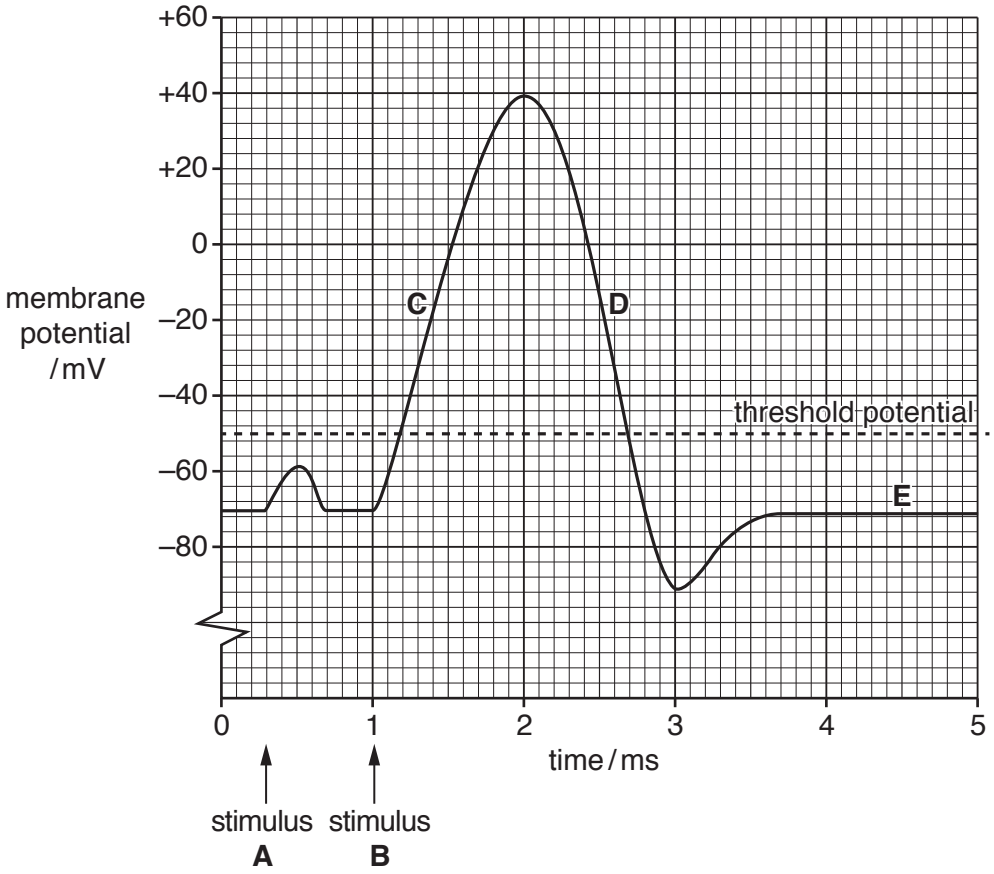


Fig. 8.1

(i) State which of the letters **C**, **D** and **E** on Fig. 8.1 correspond to each of these events. You may use each of the letters **C**, **D** or **E** once, more than once or not at all.

The Na^+/K^+ pump is operating .....

The voltage-gated Na^+ channels are open .....

The voltage-gated K^+ channels are open .....

[3]

(ii) Explain why stimulus **A** did not result in an action potential being produced whereas stimulus **B** did.

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..... [2]

(iii) Describe the importance of the refractory period in the transmission of action potentials.

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..... [2]

(iv) Describe how action potentials are transmitted along a myelinated axon.

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..... [4]

[Total: 14]

Section B

Answer **one** question.

9 **(a)** Outline the characteristic features of organisms in the domain Bacteria. [8]

(b) Describe the role of botanic gardens in the protection of endangered species. [7]

[Total: 15]

10 **(a)** Describe how the structure of the nephron and its associated blood vessels are adapted to the process of ultrafiltration. [8]

(b) Describe the effects of insulin on its main target tissues **and** explain how this leads to changes in blood glucose concentration. [7]

[Total: 15]

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