Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8351327560

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **February/March 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **one** question.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **28** pages. Any blank pages are indicated.

Section A

Answer **all** questions.

1 **(a)** The European eel, *Anguilla anguilla*, is a fish. The sizes of eel populations tend to remain relatively stable despite eels producing large numbers of offspring.

Suggest **two** reasons why the population sizes of eels tend to remain relatively stable.

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..... [2]

(b) Explain what is meant by the general theory of evolution.

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(c) The generation time of a species is the mean (average) time from one generation (parents) to the next generation (offspring). For example, the generation time of humans is about 25 years.

Fig. 1.1 shows a graph of the relationship between the rate of evolution and the generation time for a wide range of different species.

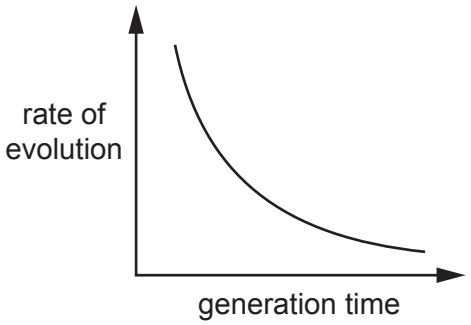

Fig. 1.1

Describe **and** explain the relationship shown in Fig. 1.1.

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(d) The tuatara, *Sphenodon punctatus*, is a reptile that is native to New Zealand. It is found nowhere else in the wild.

Fig. 1.2 shows a tuatara.

Fig. 1.2

Tuataras have a slow growth rate and can live for over one hundred years. Fossil evidence shows that there has been little morphological change in the tuatara over the last 200 million years. This is a much lower rate of evolution than would be expected from the generation time of this species.

Suggest **and** explain why the tuatara has remained largely unchanged over the last 200 million years.

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[Total: 10]

2 **(a)** The grey wolf, *Canis lupus*, is a large predator. During the 20th century, the grey wolf in south-west Europe was hunted almost to extinction.

Fig. 2.1 shows a grey wolf.

Fig. 2.1

(i) State the genus of the grey wolf.

..... [1]

(ii) Suggest **and** explain the effects on the biodiversity of south-west Europe if the grey wolf becomes extinct.

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..... [3]

(b) Grey wolves can have territories of up to 950 km^2. Grey wolves can travel up to 1000 km to start a new population.

State reasons why the mark-release-recapture method is **not** suitable for estimating the size of a grey wolf population.

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..... [2]

(c) In 1992, new laws were introduced across south-west Europe to protect the grey wolf.

Fig. 2.2 shows the distribution of grey wolf populations in south-west Europe in 1970 and 2012. No grey wolves from captive-breeding populations were released into the wild in south-west Europe during the period from 1970 to 2012.

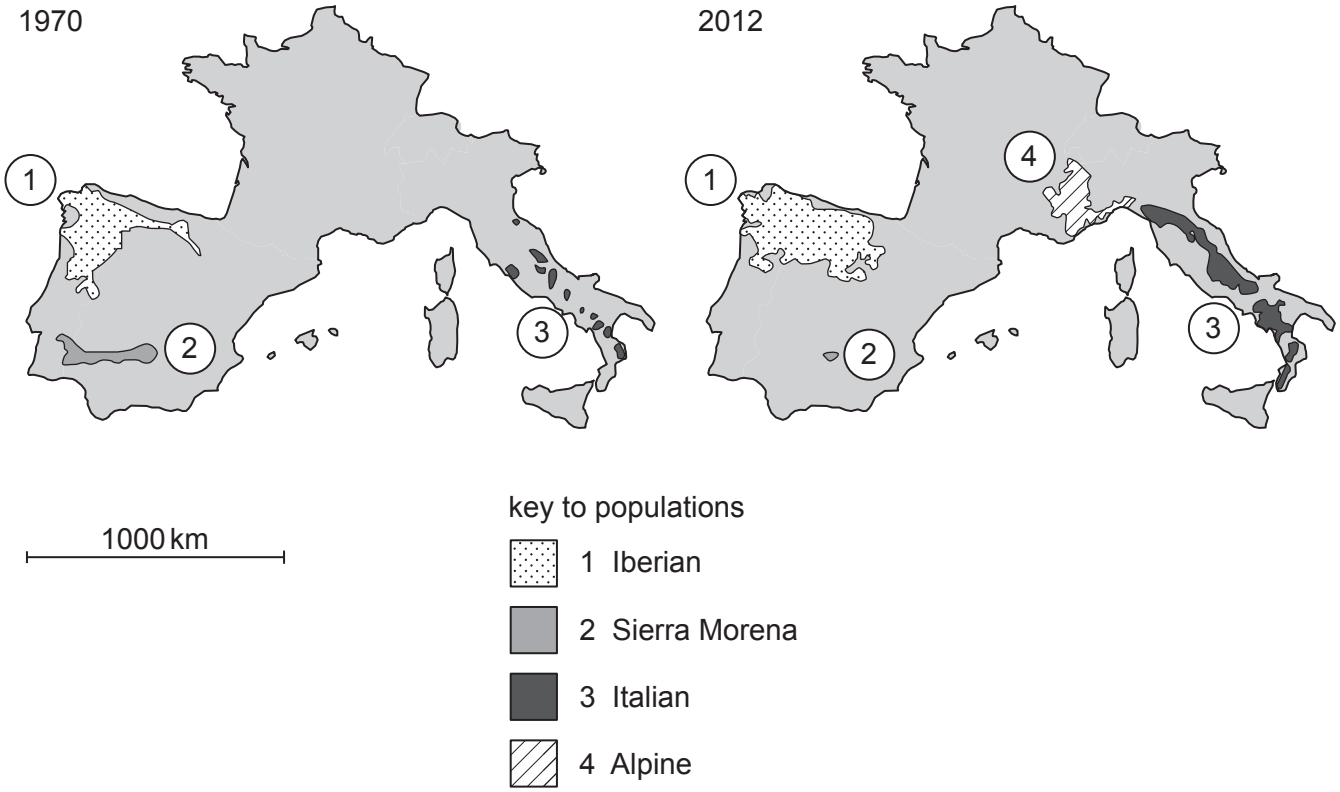

Fig. 2.2

Table 2.1 shows the sizes of the populations of grey wolf shown in Fig. 2.2.

Table 2.1

population	size of population in 1970	size of population in 2012	percentage change
1 Iberian	700	2500	.....
2 Sierra Morena	60	6	–90
3 Italian	100	800	+700
4 Alpine	0	160	

(i) Complete Table 2.1 to show the percentage change in the size of the Iberian grey wolf population from 1970 to 2012.

Write your answer in the table to the nearest whole number. [1]

(ii) With reference to Fig. 2.2 and Table 2.1, describe the changes to the grey wolf populations in south-west Europe from 1970 to 2012.

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(d) (i) In regions of south-west Europe where grey wolf populations are present, farmers are concerned for the safety of their livestock, such as sheep.

Suggest how governments can help farmers who are concerned for the safety of their livestock.

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..... [1]

(ii) Suggest measures that could help to protect **wild** populations of grey wolves in south-west Europe.

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..... [3]

[Total: 14]

3 Vitamin A deficiency is a widespread public health problem.

One source of vitamin A is carotene in the diet. Carotene can be converted to vitamin A in the body.

White rice grains are not a dietary source of vitamin A because they do not contain carotene.

Scientists have genetically modified a variety of rice to improve the diet of people who are vitamin A deficient. The grains of this genetically modified rice contain carotene.

(a) Describe how genetic engineering could be used to modify a variety of rice so that the grains contain carotene.

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In a 2018 report, the United Nations Children's Fund (UNICEF) estimated that:

- more than 140 million children are at high risk of vitamin A deficiency
- 1.15 million child deaths are caused by vitamin A deficiency each year.

Vitamin A deficiency is also a leading cause of childhood blindness.

The recommended dietary allowance (RDA) of vitamin A for a 5-year-old child is 400 μg per day.

Genetically modified (GM) rice contains 12 μg of carotene per gram of rice. In 2018, four countries approved GM rice as safe to eat.

The development of GM rice has been partly paid for by governments. It has been agreed that seeds of GM rice will be made available to farmers in countries with high levels of poverty at the same cost as seeds of normal rice.

Some international organisations, such as Greenpeace, campaign against all GM crops.

More than 100 respected scientists have asked Greenpeace to stop campaigning against GM rice.

(b) Discuss social and ethical arguments that support the position of the scientists.

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..... [4]

[Total: 8]

4 Red algae are multicellular photosynthetic protoctists that contain phycoerythrin. Phycoerythrin is a photosynthetic pigment.

(a) Fig. 4.1 shows:

- the absorption spectrum of phycoerythrin
- the action spectrum of red algae.

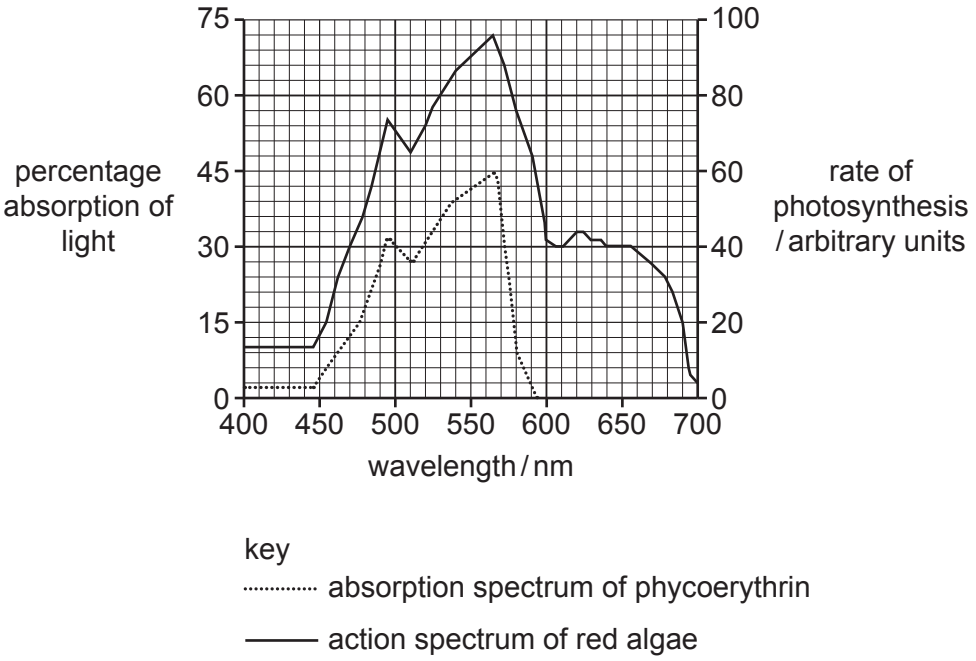

Fig. 4.1

(i) With reference to Fig. 4.1, state the wavelength of peak absorption by phycoerythrin.

..... [1]

(ii) Explain how the data in Fig. 4.1 show that phycoerythrin is **not** the only photosynthetic pigment in red algae.

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..... [2]

(iii) Phycoerythrin is **not** the primary pigment (reaction centre pigment) for photosynthesis in red algae.

Suggest the role of phycoerythrin in photosynthesis in red algae.

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..... [2]

(b) Phycoerythrin is rarely found in plants that have green leaves.

(i) State the name of a technique that can be used to separate and identify photosynthetic pigments.

..... [1]

(ii) Explain how the results of this technique would be used to confirm that phycoerythrin is present in red algae and **not** present in a plant with green leaves.

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..... [3]

[Total: 9]

5 (a) Many processes and actions in plants and animals are due to the movement of ions.

Table 5.1 lists several ions, the direction of movement of each ion and the action resulting from that movement.

Complete Table 5.1.

Table 5.1

ion	direction of movement of ion	action resulting from movement of ion
Na^+	from lumen of proximal convoluted tubule into proximal convoluted tubule cell	....
.....	into guard cell	opening of stoma(ta)
.....	into presynaptic knob	depolarisation of presynaptic membrane
.....	into presynaptic knob	release of acetylcholine into synapse
H^+	from intermembrane space into matrix of mitochondrion	....
Ca^{2+}	from sarcoplasmic reticulum to cytoplasm of muscle fibre	....

[6]

(b) The Venus fly trap is a plant that is able to capture and digest insects. It has modified leaves, which have sensory hairs that respond to touch. When an insect comes into contact with the hairs, receptor potentials are generated.

(i) Name the ion that moves into the cells at the base of the sensory hairs to generate receptor potentials.

..... [1]

(ii) If two or more of these hairs are stimulated within a period of 20–35 seconds, action potentials are generated, causing the leaf to close quickly and trap the insect.

Suggest why it is beneficial to the plant for stimulation of two or more hairs to be necessary before the leaf will close.

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..... [1]

(iii) The trapped insect is digested by enzymes released from the leaf cells.

Name the mechanism by which the enzymes are released.

..... [1]

(iv) Suggest why Venus fly trap plants need to capture insects.

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..... [1]

[Total: 10]

6 Dogs have an exceptionally good sense of smell. They can detect molecules in the air with a concentration of one part per trillion (10^{12}).

(a) Olfactory receptor cells are the sensory receptors in the nasal cavity that respond to chemicals in the air. They function in a similar way to the chemoreceptor cells in the taste buds of the tongue.

Describe how olfactory receptor cells in the nasal cavity of dogs respond to chemicals to generate an action potential.

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..... [5]

(b) Dogs can use their sense of smell to detect differences between the breath of people with lung cancer and the breath of people without lung cancer. These differences are due to the presence of particular chemicals at very low concentrations in the breath of people with lung cancer. Dogs can be trained to sit when a person's breath indicates that lung cancer is present.

Screening people for lung cancer is important for early detection and treatment.

Suggest **two** advantages of using **dogs** in this way to screen people for lung cancer.

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..... [2]

[Total: 7]

7 **(a)** Fig. 7.1 shows two chromosomes in one stage of meiosis.

The letters G to M represent the dominant alleles of seven genes and the letters g to m represent the recessive alleles of the same seven genes.

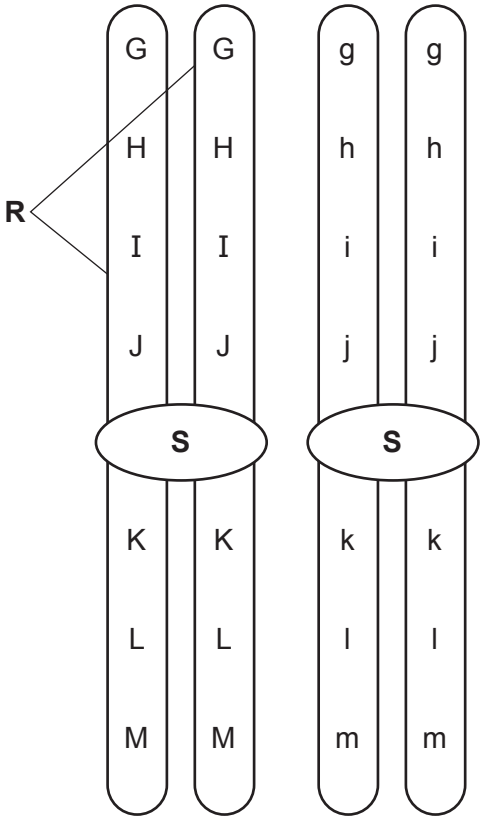

Fig. 7.1

(i) Name the structures labelled **R** and **S** on Fig. 7.1.

R .....

S .....

[2]

(ii) State **three** features visible on Fig. 7.1 that identify the chromosomes as a homologous pair.

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..... [3]

(iii) Fig. 7.2 shows the same two chromosomes a little later in the same stage of meiosis. Crossing over is beginning to occur at point **T**.

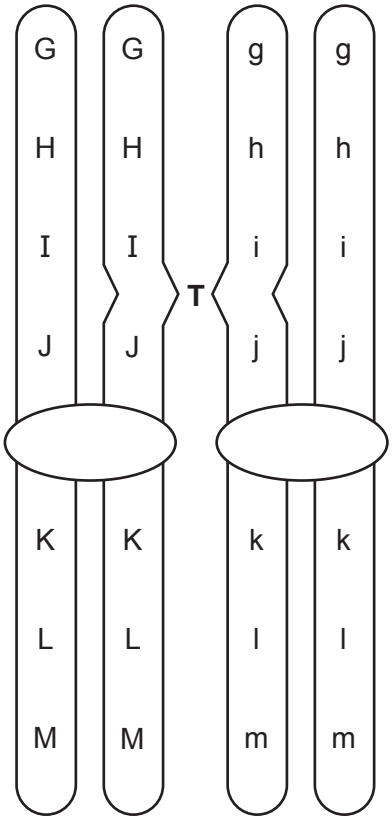

Fig. 7.2

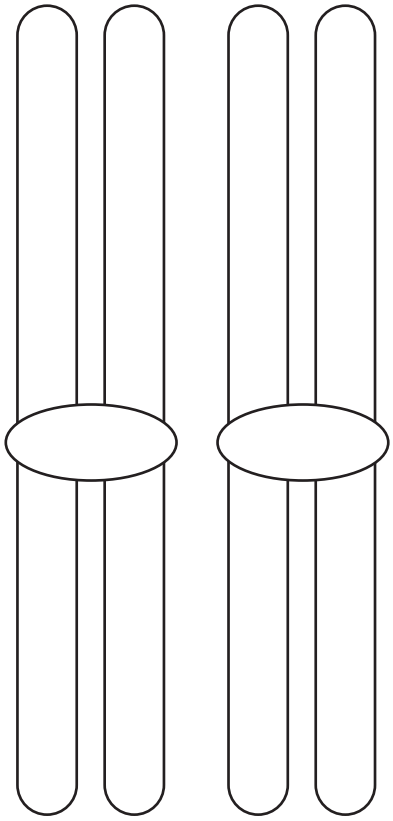

Fig. 7.3

Fig. 7.3 shows an outline of the same two chromosomes after crossing over has occurred.

Complete Fig. 7.3 by writing in the letters of the alleles along both chromosomes. Take care to clearly show the difference between letters representing dominant alleles and letters representing recessive alleles.

[2]

(b) State the stage in meiosis in which crossing over occurs.

..... [1]

(c) Crossing over results in genetic variation.

Explain how random assortment of homologous chromosomes also results in genetic variation.

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..... [3]

[Total: 11]

8 **(a)** Fig. 8.1 shows a transmission electron micrograph of a mitochondrion.

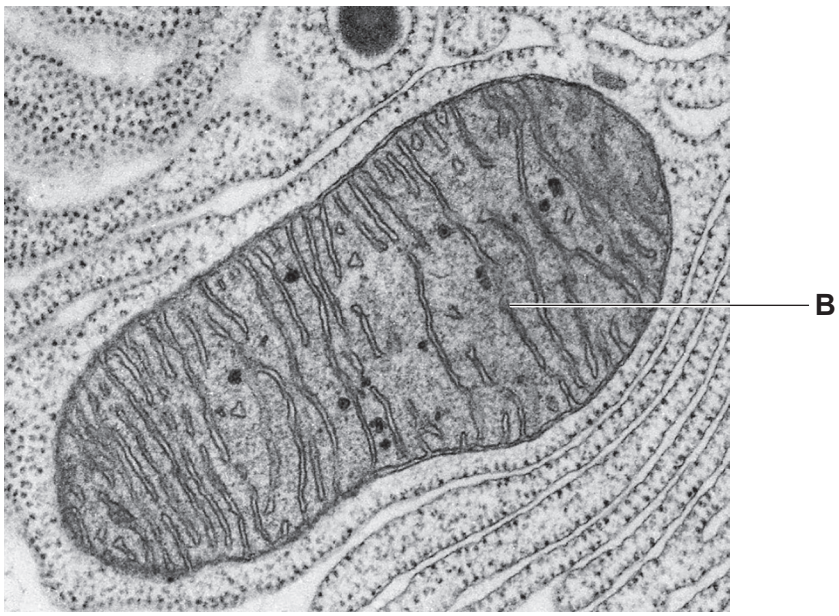

Fig. 8.1

(i) On Fig. 8.1, use the letter **A** with a label line to show a location where the Krebs cycle occurs. [1]

(ii) Name the structure labelled **B** on Fig. 8.1 that forms part of the inner mitochondrial membrane.

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(iii) The inner mitochondrial membrane is the site of oxidative phosphorylation.

Explain how the structure of the inner mitochondrial membrane is linked to its function.

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..... [5]

(b) The activity of succinate dehydrogenase, an enzyme in the Krebs cycle, is used as a measure of the rate of respiration in the mitochondria. The redox reaction catalysed by succinate dehydrogenase is shown in Fig. 8.2.

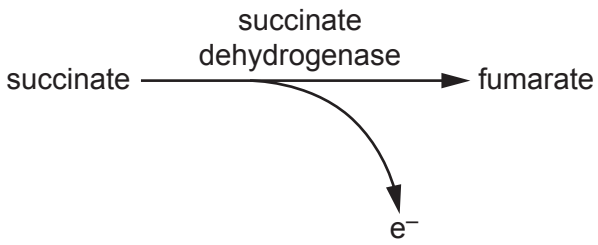

Fig. 8.2

The activity of succinate dehydrogenase can be measured using a redox indicator.

Name a redox indicator **and** explain why this indicator can be used to measure the activity of succinate dehydrogenase.

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..... [2]

(c) Fig. 8.3 shows a ground squirrel, *Ictidomys tridecemlineatus*.

Fig. 8.3

In the winter, the ground squirrel curls into a spherical shape underground and sleeps for long periods. During this time, the ground squirrel switches between two states:

- torpor, when the body temperature is maintained at 10 °C
- euthermia, when the body temperature is maintained at 37 °C.

Scientists used the activity of succinate dehydrogenase to investigate the rate of respiration in the mitochondria of ground squirrels. Mitochondria were extracted from liver and muscle samples of ground squirrels. The rate of respiration was measured at different concentrations of succinate and at temperatures that corresponded to torpor (10 °C) and euthermia (37 °C).

The results are shown in Fig. 8.4.

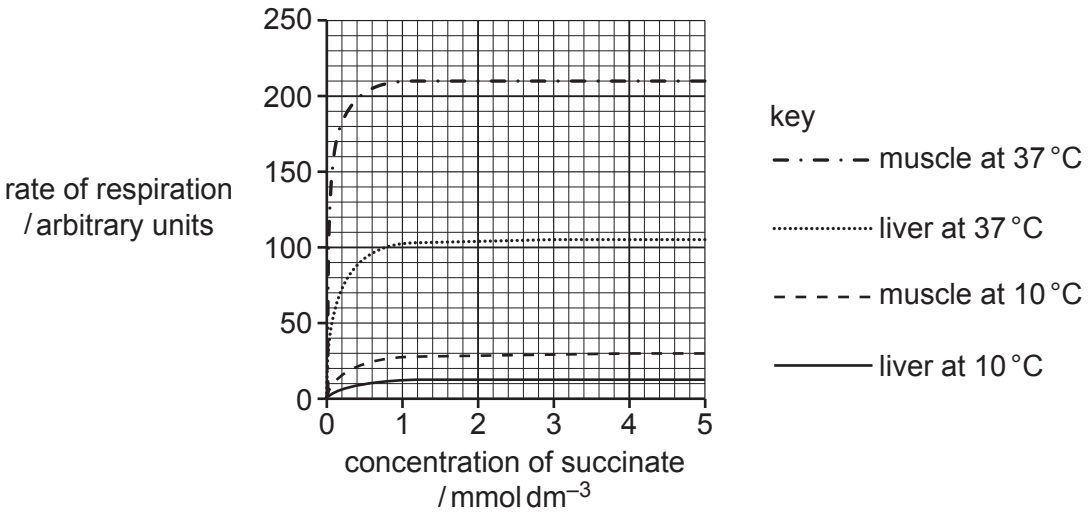

Fig. 8.4

(i) Describe the trends shown in Fig. 8.4.

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(ii) Explain the difference in the rates of respiration between liver at 37 °C and muscle at 37 °C.

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..... [3]

(iii) During torpor in ground squirrels, muscle tissue uses more energy than liver tissue.

Suggest **one** reason for this difference.

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..... [1]

[Total: 16]

Section B

Answer **one** question.

9 **(a)** Compare the characteristic features of the domains Eukarya and Bacteria. [8]

(b) Describe the methods used to conserve endangered **plant** species. [7]

[Total: 15]

10 **(a)** Explain what is meant by bioinformatics **and** outline the role of bioinformatics following the sequencing of genomes of humans and parasites. [6]

(b) Explain how a microarray can be used to analyse gene expression in a tissue sample. [9]

[Total: 15]

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