Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8251875797

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **October/November 2022**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- 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 **24** pages. Any blank pages are indicated.

[Turn over

1 The wild Bactrian camel, *Camelus ferus*, lives only in the desert regions of Mongolia and northern China.

Fig. 1.1 shows a wild Bactrian camel.

Fig. 1.1

(a) The wild Bactrian camel is at risk of extinction in the wild and is categorised as critically endangered by the International Union for Conservation of Nature (IUCN). There are only 950 wild Bactrian camels left in their natural habitat.

Suggest reasons why the wild Bactrian camel has become critically endangered.

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(b) Outline the role of the IUCN.

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(c) Some zoos use assisted reproduction techniques, such as embryo transfer, in their captive breeding programmes for endangered species. Embryo transfer has resulted in domesticated dromedary camels giving birth to wild Bactrian camel calves.

Describe the procedure of embryo transfer in a mammal such as a camel.

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[Total: 9]

2 Photosynthesis is an important energy transfer process.

(a) Name **one** chloroplast pigment.

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(b) Explain the relationship between the **absorption** spectrum of the main chloroplast pigments in a species of plant and the **action** spectrum for photosynthesis for that species.

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(c) Explain why temperature can be a limiting factor of photosynthesis.

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(d) Outline how the light-independent stage of photosynthesis leads to the production of carbohydrates such as starch in plant leaves.

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[Total: 9]

3 **(a)** The results of investigations carried out on mitochondria show how the structure of a mitochondrion is related to its role in aerobic respiration.

- Intact mitochondria (not damaged) were removed from cells.
- A technique was used to remove the outer mitochondrial membrane, leaving the inner membrane intact.
- The inner mitochondrial membrane was separated from the contents of the matrix so that both could be analysed.

(i) The removal of the outer membranes of mitochondria involves placing the organelles in pure water. This results in the rupture (bursting) of the outer membrane. The inner mitochondrial membrane does not rupture and remains intact.

Suggest **and** explain why the inner membrane of a mitochondrion remains intact when the organelle is placed in pure water.

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(ii) Name **three** molecules, other than coenzymes, that are found in the mitochondrial matrix **and** explain their role in aerobic respiration.

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(iii) The inner membrane contains a very high proportion of the molecule cardiolipin. Cardiolipin makes the membrane impermeable to some ions.

Suggest why the inner membrane contains a very high proportion of cardiolipin.

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(b) In further experiments it was found that, in an intact mitochondrion:

- there is a membrane potential across the inner mitochondrial membrane, with the matrix having a negative charge
- the transport of ATP, ADP and inorganic phosphate (P_i) is driven by the membrane potential across the inner membrane.

Fig. 3.1 shows the location of some inner membrane carrier proteins.

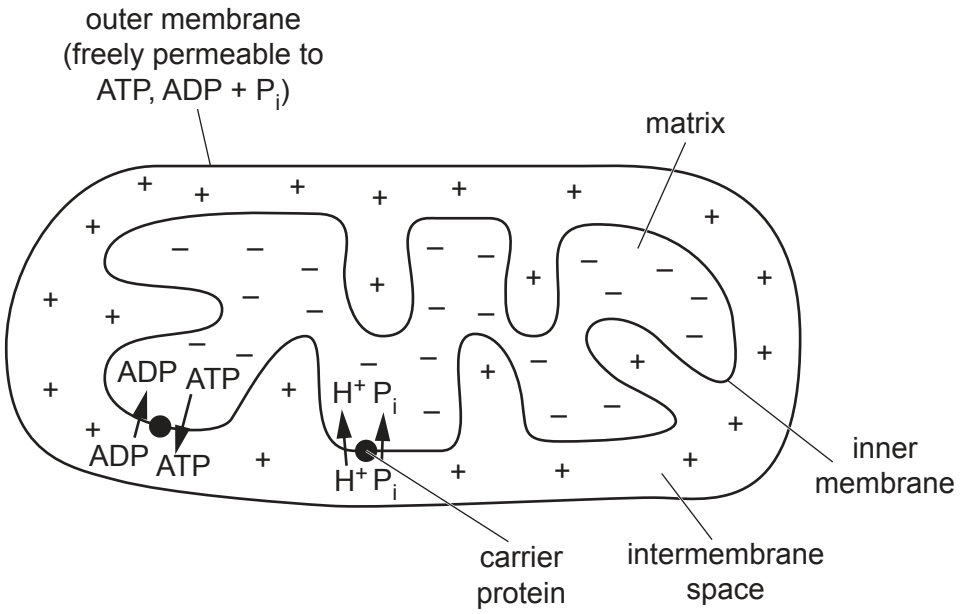

Fig. 3.1

(i) Reduced NAD and reduced FAD transfer hydrogen atoms to carriers located in the inner mitochondrial membrane.

Explain how hydrogen atoms from reduced NAD and reduced FAD lead to a membrane potential forming across the inner mitochondrial membrane during oxidative phosphorylation.

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(ii) Suggest **and** explain how P_i is transported across the inner membrane of the mitochondrion into the matrix.

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(iii) Suggest the advantages of linking ATP transport to ADP transport across the inner membrane of the mitochondrion.

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[Total: 14]

4 Adenosine deaminase (ADA) deficiency is an immune system disorder caused by a recessive autosomal mutation.

Severe combined immunodeficiency caused by a lack of ADA is called ADA-SCID.

(a) Genetic engineering is used to make a recombinant human protein to treat people with ADA-SCID.

Outline the principles of genetic engineering.

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(b) In 2016 gene therapy to cure ADA-SCID was approved in Europe. The gene therapy involves three main steps.

- Blood (haematopoietic) stem cells are taken from the bone marrow of the person with ADA-SCID.
- The functional gene and its promoter are inserted into the blood stem cells.
- A single infusion (injection) of the gene-corrected cells is given to the patient.

(i) Explain why a single infusion of gene-corrected stem cells is enough to cure the disease.

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(ii) Explain why a promoter has to be transferred as well as the desired gene.

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(iii) A modified retrovirus is used to insert the new gene into the DNA of the blood stem cells.

State **two** ethical considerations of using a retrovirus for gene therapy.

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(c) The gene therapy technique used to cure ADA-SCID is **not** suitable for treating the genetic disease called Huntington's disease. A newer technique called gene editing could potentially be used instead to cure Huntington's disease.

Explain why gene editing is more suitable as a potential cure for Huntington's disease.

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[Total: 13]

5 A large number of alpine plant species grow in the mountains of New Zealand's South Island. Alpine plants are defined as plants that live above the treeline, which is the height above which trees cannot grow. The current treeline for most of South Island is 1200 m.

(a) The alpine areas nearest to South Island are 1500–2000 km away across the sea. Many of South Island's alpine species live nowhere else in the world.

Explain how a large number of alpine plant species developed on South Island.

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(b) Fig. 5.1 shows two aspects of the history of South Island over the last 3.9 million years.

- The dashed line shows how the mean height of mountains in the Clyde region of South Island increased over time. The mountains in this range have a mean height of 2400 m at the present time.
- The solid line models the height of the treeline over time based on geological climate data. The treeline was higher when the climate was warmer, and the treeline was lower when the climate was colder, during ice ages.

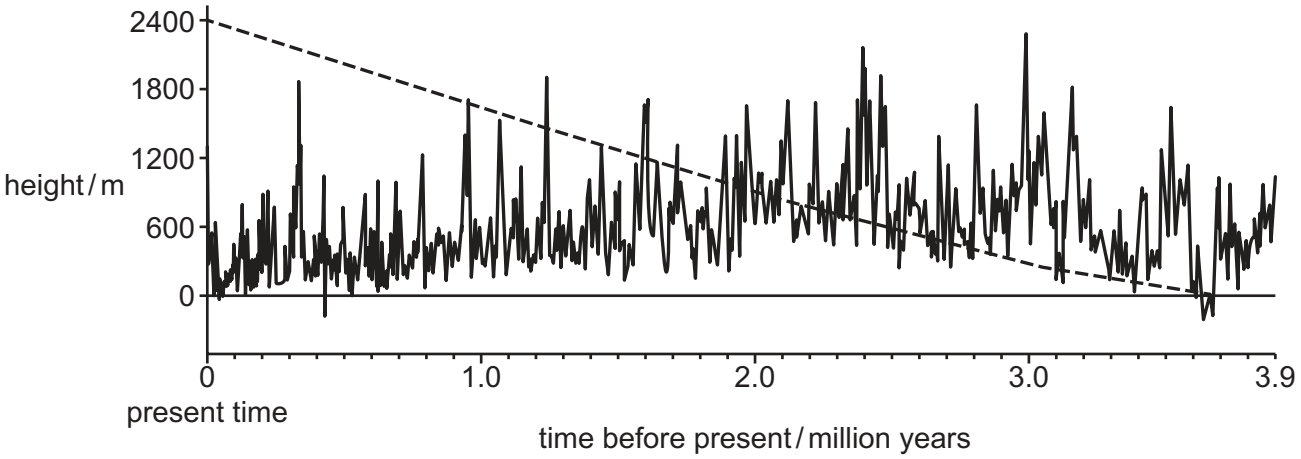

Fig. 5.1

(i) With reference to Fig. 5.1, identify with reasons the time period when South Island's alpine plant species developed.

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(ii) Suggest how DNA sequence data could be used to confirm the time period you identified in **(i)**.

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[Total: 10]

6 Selective breeding has been used to improve the characteristics of crop plants, including maize and rice.

(a) Outline how vigorous, uniform varieties of maize were developed by selective breeding.

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(b) IR8 is a variety of rice plant that was developed in the 1960s.

IR8 was developed by breeding together two different varieties of rice:

- PETA, which produces a high yield
- DGWG, which is a dwarf variety.

Fig. 6.1 is a diagram showing the three varieties of rice.

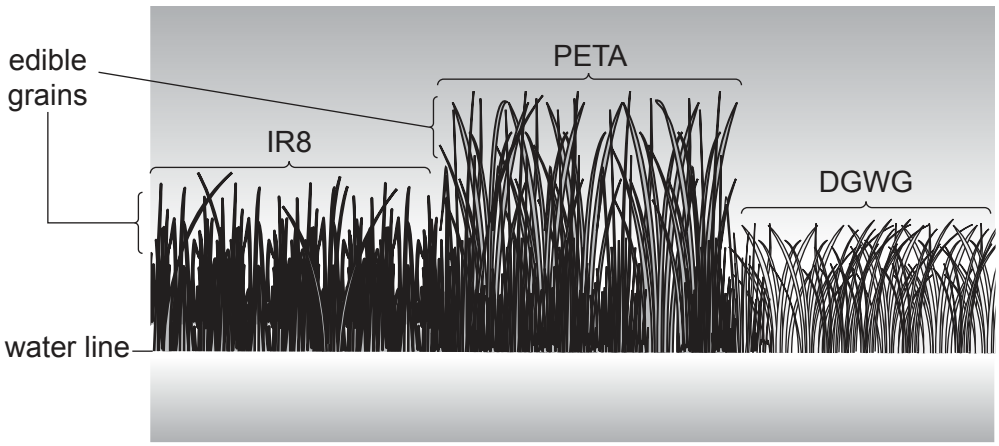

Fig. 6.1

(i) Suggest why IR8 is an improvement on the PETA variety of rice.

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(ii) In 2009, scientists produced a new variety of rice, IR64-Sub1, by breeding together:

- FR13A, a variety which has a low yield but has an allele for flood tolerance
- IR64, a variety which produces a high yield.

The scientists sequenced the DNA of these three rice varieties.

Suggest the benefit of sequencing the DNA of IR64-Sub1.

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(iii) After a few generations of breeding, the scientists crossed IR64-Sub1 with IR64.

Explain why the scientists crossed IR64-Sub1 with IR64.

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..... [1]

(c) Thale cress, *Arabidopsis thaliana*, is another plant that has dwarf varieties.

Scientists treated three varieties of *A. thaliana* with gibberellin:

- the wild type (normal, non-dwarf variety)
- dwarf variety **A**
- dwarf variety **B**.

Fig. 6.2 shows the responses of the three varieties to treatment with gibberellin.

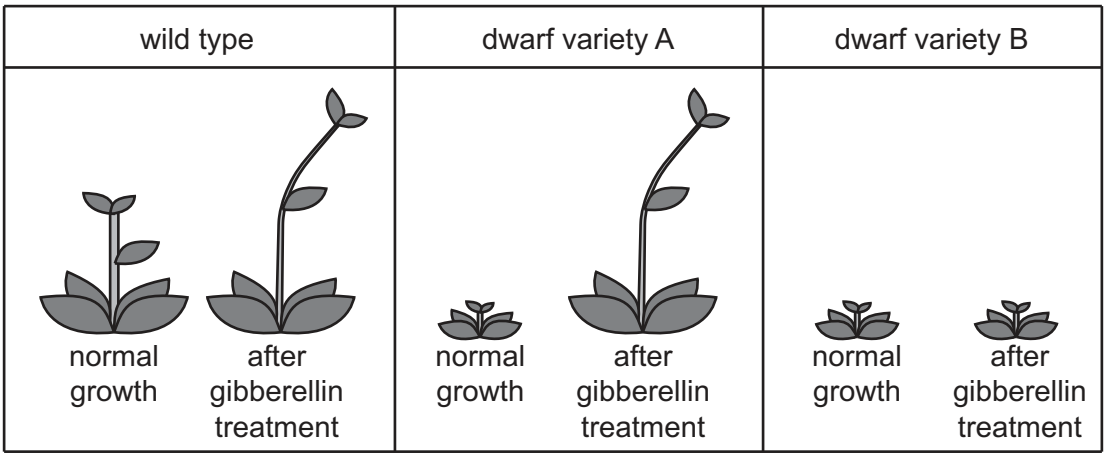

Fig. 6.2

(i) With reference to Fig. 6.2, suggest explanations for the different responses to gibberellin shown by dwarf variety **A** and dwarf variety **B**.

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(ii) BZR1 is a transcription factor that helps to regulate growth and development in *A. thaliana*.

Outline the features of a transcription factor such as BZR1.

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[Total: 13]

7 **(a)** In some varieties of domestic cats the gene for fur colour is located on the **X** chromosome. This gene has two alleles. One allele codes for black fur and the other allele codes for ginger fur. The two alleles are codominant so a heterozygous cat will have fur with patches of black and ginger colours. A cat with fur of two colours is known as a tortoiseshell.

Using appropriate symbols, construct a genetic diagram to show the results of a cross between a female tortoiseshell cat and a male ginger cat.

symbols

parent phenotypes tortoiseshell female ginger male

parent genotypes

gametes

offspring genotypes

offspring phenotypes

[5]

(b) In humans the *TYR* gene is involved in the production of a dark pigment, melanin, in some cells.

Describe how the expression of the *TYR* gene leads to the production of melanin.

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[Total: 8]

8 **(a)** Fig. 8.1 is a diagram of a kidney nephron.

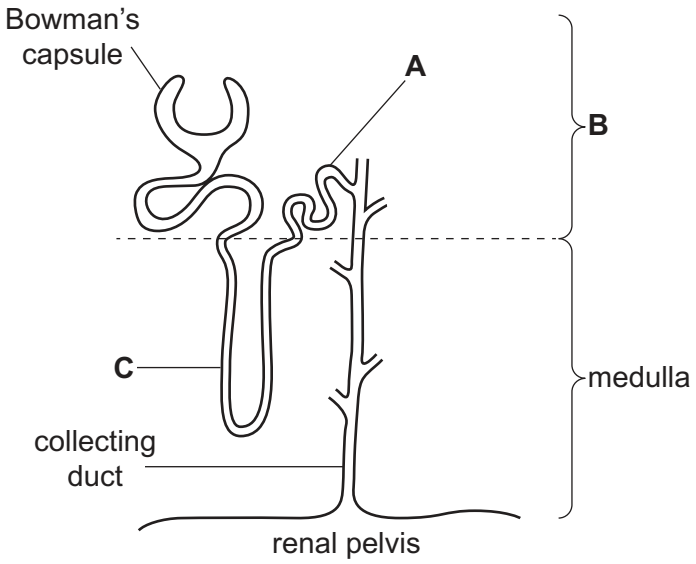

Fig. 8.1

With reference to Fig. 8.1, name **A**, **B** and **C**.

A .....

B .....

C .....

[3]

(b) Antidiuretic hormone (ADH) is involved in the maintenance of the water potential of the blood.

Fig. 8.2 shows the relationship between blood ADH concentration, urine concentration and the flow rate of urine.

The flow rate of urine is the rate of production of urine by the kidneys.

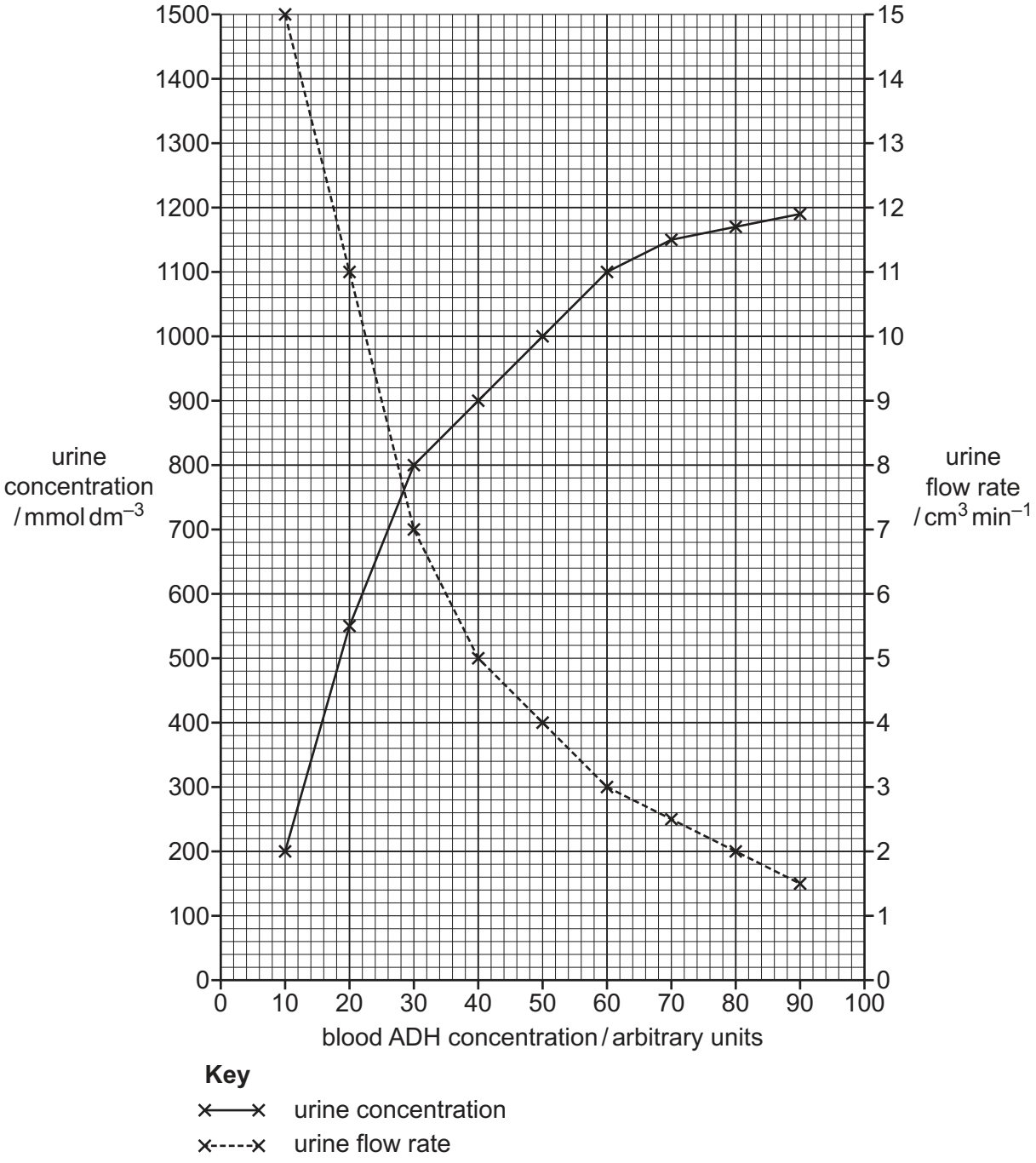

Fig. 8.2

Describe the relationships shown in Fig. 8.2.

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(c) Describe **and** explain the action of ADH on the cells of the collecting duct when the water potential of the blood decreases.

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[Total: 11]

9 **(a)** A neuromuscular junction allows the transmission of an action potential from a motor neurone to a striated muscle fibre, causing it to contract.

Fig. 9.1 is a graph of an action potential in a motor neurone.

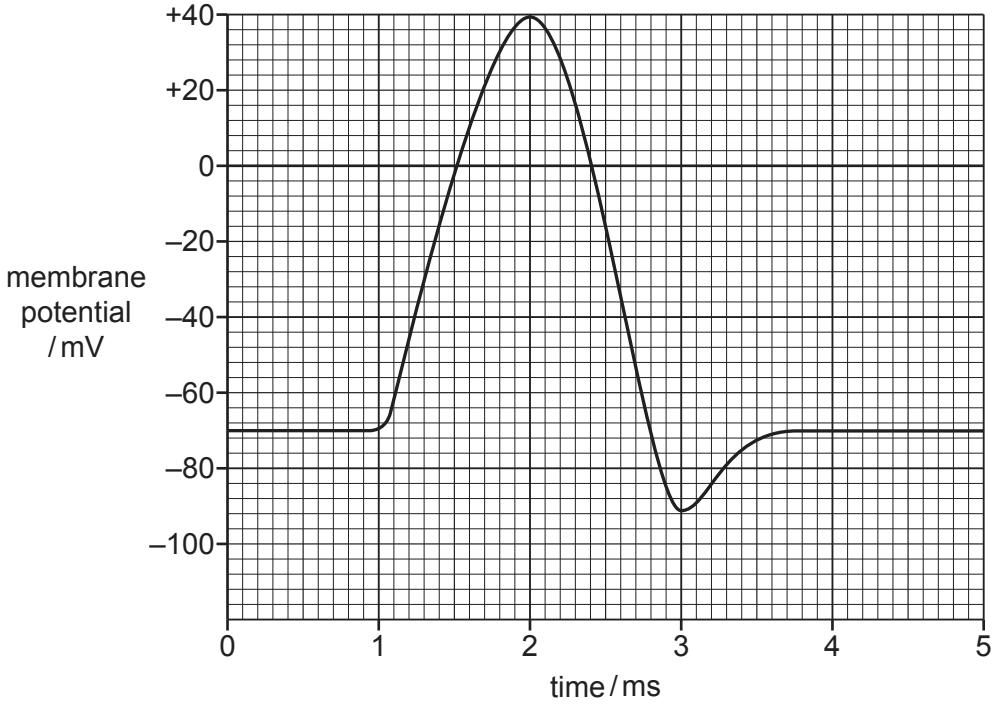

Fig. 9.1

Fig. 9.2 is a graph of an action potential in a striated muscle fibre.

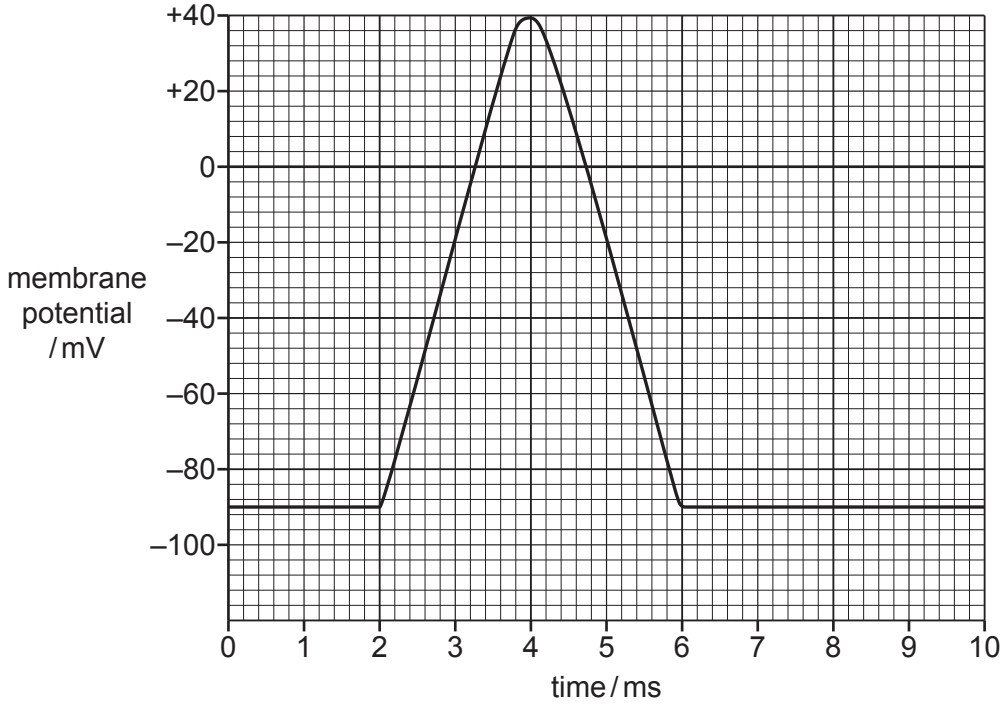

Fig. 9.2

With reference to Fig. 9.1 and Fig. 9.2, describe the differences between the action potential in a motor neurone and the action potential in a striated muscle fibre.

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(b) There are three phases in the contraction of a striated muscle: latent phase, contraction phase and relaxation phase.

The tension in a muscle represents the degree of contraction of its fibres.

Fig. 9.3 is a graph of the tension in a striated muscle during the three phases of contraction.

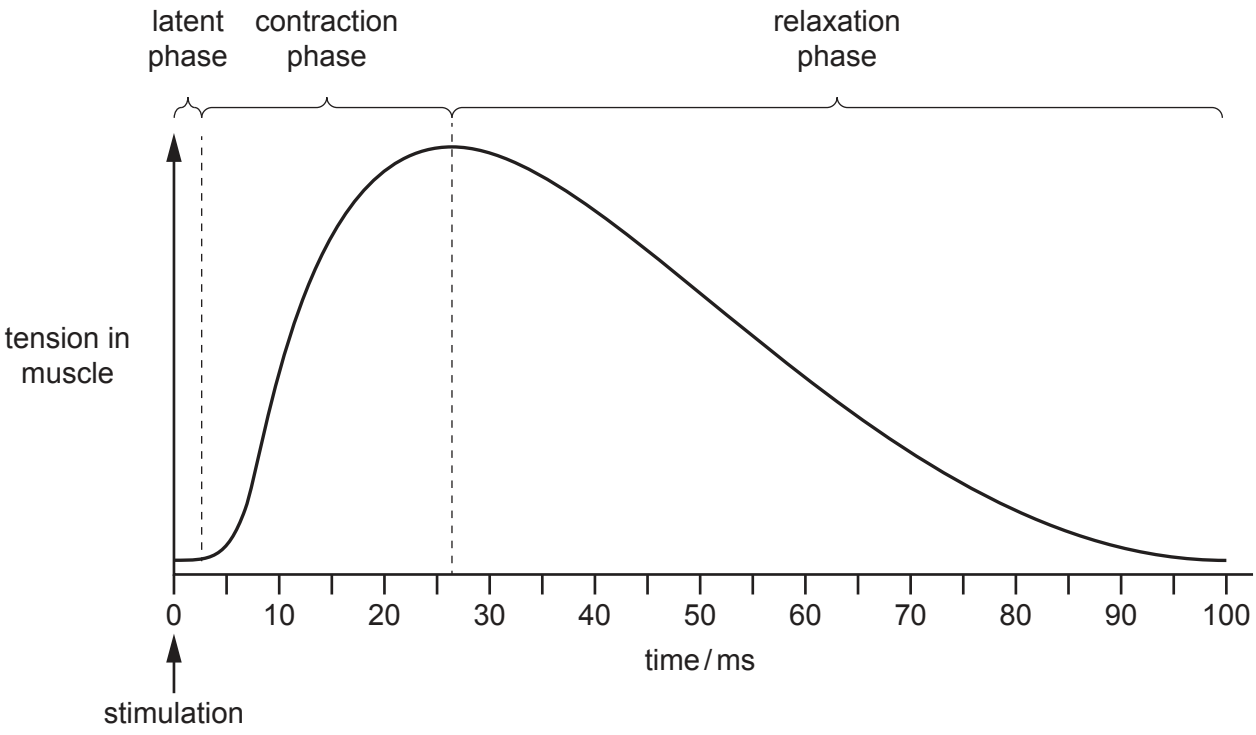

Fig. 9.3

(i) With reference to Fig. 9.3, explain what is happening in the striated muscle fibre during the latent phase.

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(ii) Suggest why the relaxation phase shows a gradual decrease in muscle tension.

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[Total: 8]

10 The passage below outlines homeostasis.

Complete the passage by using the most appropriate scientific terms.

Homeostasis, in mammals, is the process of keeping the ..... environment of the body in optimum conditions so that cells can function efficiently. Blood water potential, core temperature and blood glucose concentration are all factors that need to be kept at optimum values or set-point.

When a condition deviates from its set-point, a corrective mechanism is triggered. An increase in blood glucose concentration triggers processes to decrease it and vice versa. This corrective mechanism is called ..... .

The pancreas is involved in the control of blood glucose concentration. Glucose binds to ..... on the cell surface membrane of pancreatic cells. These are ..... cells, which secrete hormones such as insulin and glucagon. The two hormones have opposite effects on the blood glucose concentration. For example the action of one hormone stimulates the uptake of glucose by cells for respiration and the action of the other hormone stimulates the breakdown of ..... to glucose in the liver.

[Total: 5]

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