Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5097508012

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 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.

DC (CE/CB) 302739/3

[Turn over

1 **(a)** The water potential of mammalian blood needs to be maintained within narrow limits so that cells function efficiently. This process is called osmoregulation.

The relative medullary thickness (RMT) indicates the proportion of a kidney that is composed of medullary tissue.

$$\text{RMT} = \frac{\text{thickness of medulla}}{\text{kidney size}} \times 10$$

Table 1.1 shows the relationship between the RMT and the concentration of urine produced by four mammals from different habitats.

Table 1.1

mammal	habitat	RMT	urine concentration / arbitrary units
beaver	rivers and lakes	1.4	0.90
warthog	savannah	2.8	2.35
human	variable	3.2	2.50
kangaroo rat	desert	8.6	10.50

(i) Name the parts of the nephron that are located in the medulla.

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(ii) Name a hormone involved in osmoregulation.

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(iii) Describe the relationship between the RMT and the concentration of urine produced **and** explain the differences between the data for the beaver and the kangaroo rat.

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(b) The warthog, *Phacochoerus africanus*, is a member of the pig family. The warthog lives in dry savannah areas of sub-Saharan Africa.

Fig. 1.1 shows a warthog.

Fig. 1.1

A warthog and a human have similar values of RMT and concentration of urine. A human can survive only a few days without drinking water, whereas a warthog can live for several months without drinking water.

Suggest how a warthog is able to survive several months without drinking water.

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[Total: 9]

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2 Photosynthesis is an energy transfer process that results in the production of carbohydrate. It has two stages: the light-dependent stage and the light-independent stage.

Cyclic photophosphorylation and non-cyclic photophosphorylation are essential pathways in photosynthesis that occur in the light-dependent stage.

(a) (i) Describe the similarities and differences between cyclic photophosphorylation and non-cyclic photophosphorylation.

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(ii) Explain why herbicides that prevent cyclic photophosphorylation and non-cyclic photophosphorylation stop carbohydrate being produced in the chloroplast.

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(b) The rate of regeneration of RuBP in the Calvin cycle is known to limit the rate of photosynthesis.

Sedoheptulose-1,7-bisphosphatase (SBPase) is an enzyme in the Calvin cycle that controls the rate of regeneration of RuBP. SBPase is coded for by the gene *SBPase*.

In an experiment, wheat plants were genetically modified to make more SBPase by introducing the *SBPase* gene from another grass species, *Brachypodium distachyon*. The resulting GM wheat plants were named Sox4.

- Wild type plants (not GM) and Sox4 plants were grown.
- A leaf from the wild type plant was placed in a sealed glass vessel.
- The carbon dioxide (CO_2) concentration in the vessel was increased so that the intercellular air spaces also had an increase in CO_2 concentration.
- The other environmental conditions were kept constant.
- The rate of fixation of CO_2 was measured for the leaf.
- The experiment was repeated with a leaf from a Sox4 plant.

Fig. 2.1 shows the rate of fixation of CO_2 by the leaves of wild type plants and Sox4 plants when the intercellular air space CO_2 concentration was increased.

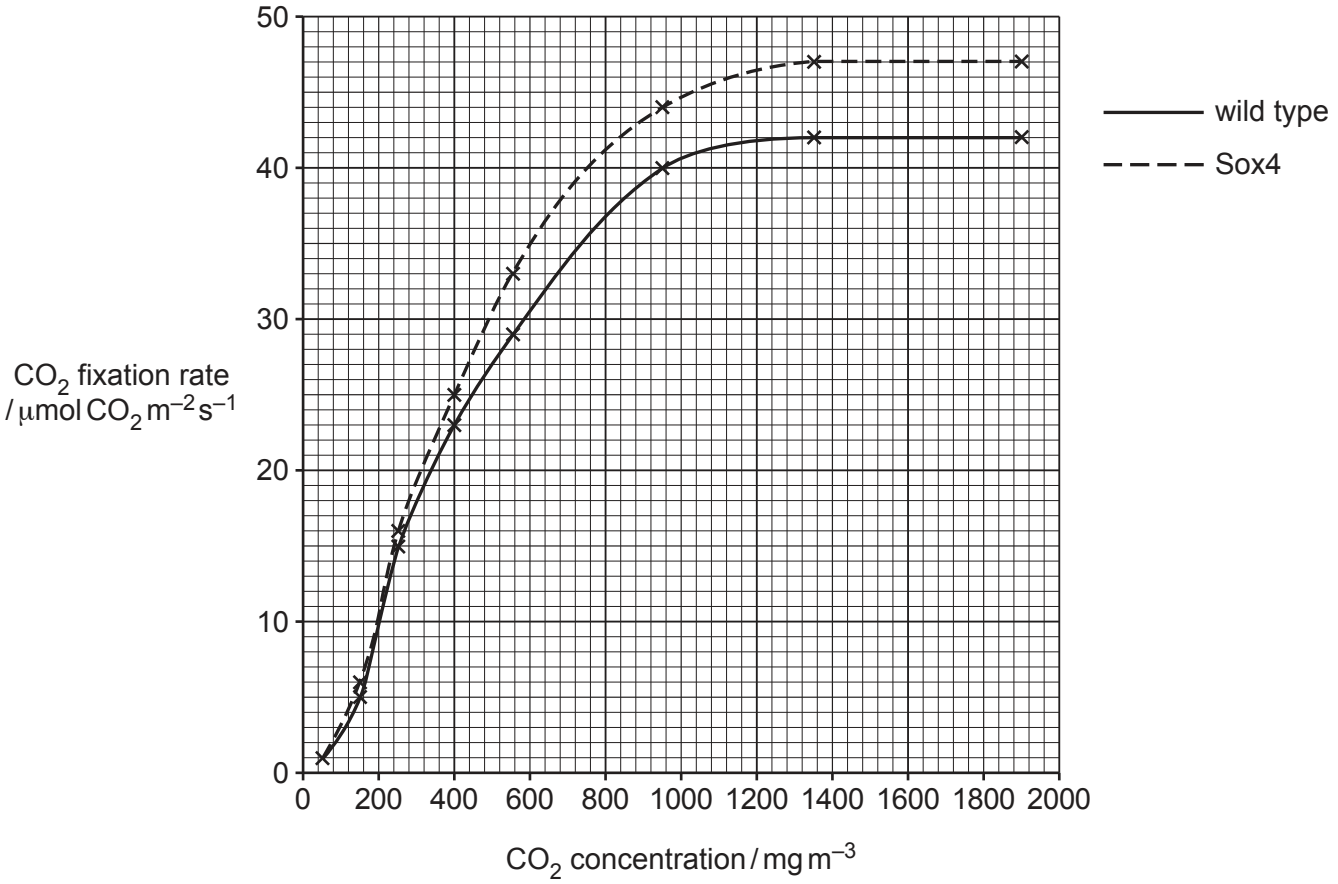

Fig. 2.1

(i) With reference to Fig. 2.1, describe **and** explain the results shown by the **wild type** plants.

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(ii) With reference to Fig. 2.1, describe **and** suggest explanations for the differences in the rate of fixation of CO_2 between wild type plants and Sox4 plants.

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[Total: 13]

3 **(a)** ATP is synthesised from ADP and P_i in a phosphorylation reaction.

State the **two** different ways in which this phosphorylation reaction occurs in aerobic respiration.

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(b) Coenzymes are important in all four stages of aerobic respiration.

Describe **and** explain the role of the coenzymes NAD and FAD in aerobic respiration.

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(c) The enzyme pyruvate dehydrogenase catalyses the link reaction. Pyruvate dehydrogenase is inhibited when the ratio of acetyl coenzyme A to coenzyme A increases.

Suggest the importance of this inhibition to the functioning of the cell.

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[Total: 10]

4 In 1973, a technique for genetic engineering was used for the first time. Recombinant DNA was made using a plasmid and this was successfully transferred into an organism.

In 2012, a new technique for genetic engineering, called gene editing, was developed.

(a) Table 4.1 lists some statements about the two genetic engineering techniques.

Complete Table 4.1 to compare the original genetic engineering technique using a plasmid vector with the newer technique of gene editing.
For each row, place a tick (✓) in the correct column if the statement applies and leave a blank if the statement does not apply.

Table 4.1

statement	genetic engineering using a plasmid	gene editing
It can add a new phenotypic characteristic to an organism.		
It can change an A–T base pair to C–G.		
It can inactivate a desired selected gene in an organism.		
It may change DNA in a way that cannot be distinguished from a natural mutation.		
It requires a DNA donor and a recipient.		

[5]

(b) *Camelina sativa* is a fast-growing plant with oil-rich seeds.

C. sativa grows in dry and poor soils and so it may be important as a food crop in the future. The oil from its seeds has a high content of polyunsaturated fatty acids. This shortens the time that the oil can be stored for, which is a disadvantage.

Scientists used gene editing to develop two types of *C. sativa* with different genetic changes. The gene edited *C. sativa* seeds produced oil with longer storage times.

Fig. 4.1 shows the percentage composition of fatty acids in the oil extracted from seeds of gene edited and wild type (not gene edited) *C. sativa*.

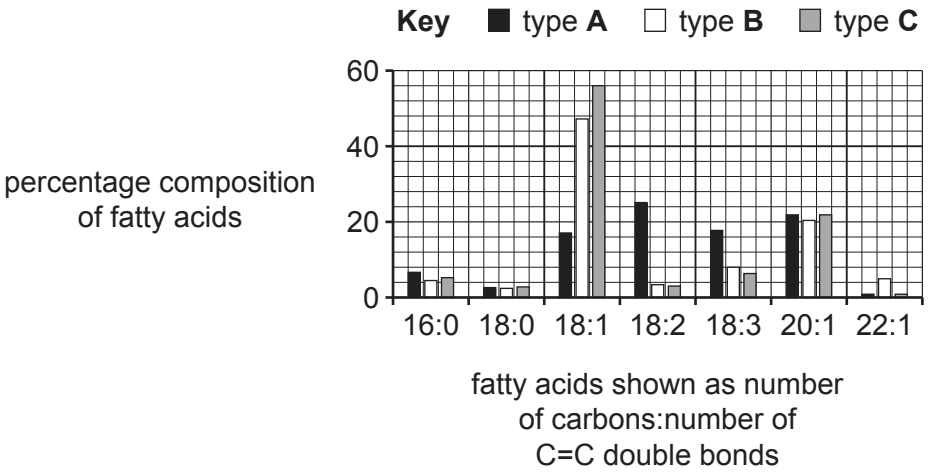

Fig. 4.1

(i) Identify the letter that represents the oil of the wild type *C. sativa* on Fig. 4.1.

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(ii) With reference to Fig. 4.1, discuss the social benefits of this example of gene editing.

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[Total: 9]

5 The puma, *Puma concolor*, lives in North and South America.

Fig. 5.1 shows a puma.

Fig 5.2 shows the distribution of the puma species.

Fig. 5.1

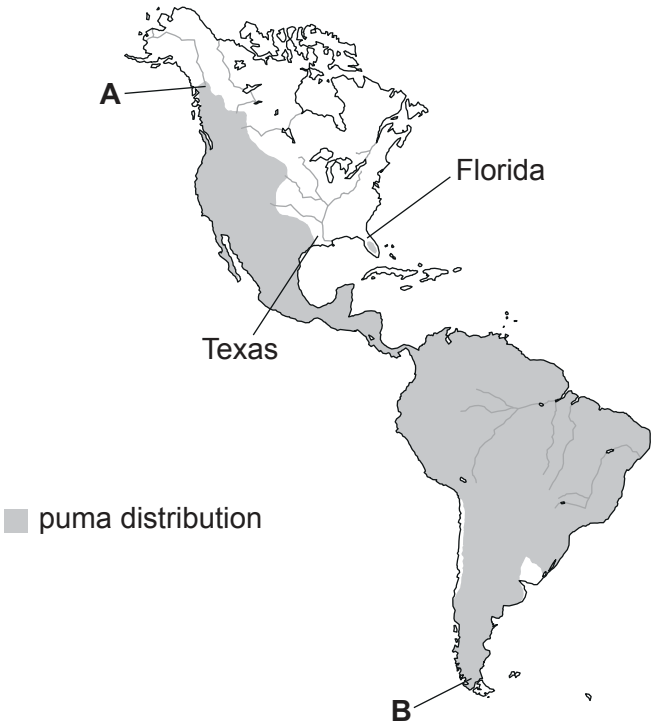

Fig. 5.2

(a) Members of different subspecies belong to the same species but have some morphological differences and are found in different geographical locations.

In the past the puma has been divided into 32 subspecies. The subspecies of puma varied in body size, coat colour and behaviour to adapt each population to its environment.

Explain how the different subspecies of puma evolved.

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In 2016, genetic analysis concluded that there are only two genetically distinct subspecies of puma, one in North and Central America and one in South America.

(b) Outline how practical techniques could be used to conduct a genetic analysis of the puma species.

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(c) Fig. 5.2 shows the location of an isolated puma population in Florida. In 1990, the size of this population was very small, with fewer than 30 individuals.

Three phenotypic features that vary in pumas are the shape of the tail, the pattern of hair growth on the back and the position of the testes in male pumas.

Variant forms of these phenotypic features that are normally rare occur at a high frequency in the small Florida population. These variant forms are:

- bent tail
- abnormal pattern of hair growth on the back
- testes remain in abdomen (undescended) in some male pumas.

(i) Predict, with reasons, whether these phenotypic features show a continuous or a discontinuous pattern of variation.

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(ii) Explain how the small size of the Florida population resulted in a high frequency of these normally rare variant forms.

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(iii) In 1995, eight puma females from Texas were introduced to Florida to increase the breeding success and future size of the puma population in Florida. In the next 20 years the population grew substantially.

Suggest why the introduced females were taken from Texas and not from points **A** or **B** on Fig. 5.2.

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[Total: 14]

6 The role of sensory receptor cells in mammals is to detect stimuli and generate action potentials in sensory neurones.

Human taste buds on the tongue contain chemoreceptor cells. Different chemoreceptor cells respond to different chemical stimuli.

Fig. 6.1 is a diagram of chemoreceptor cells in a taste bud.

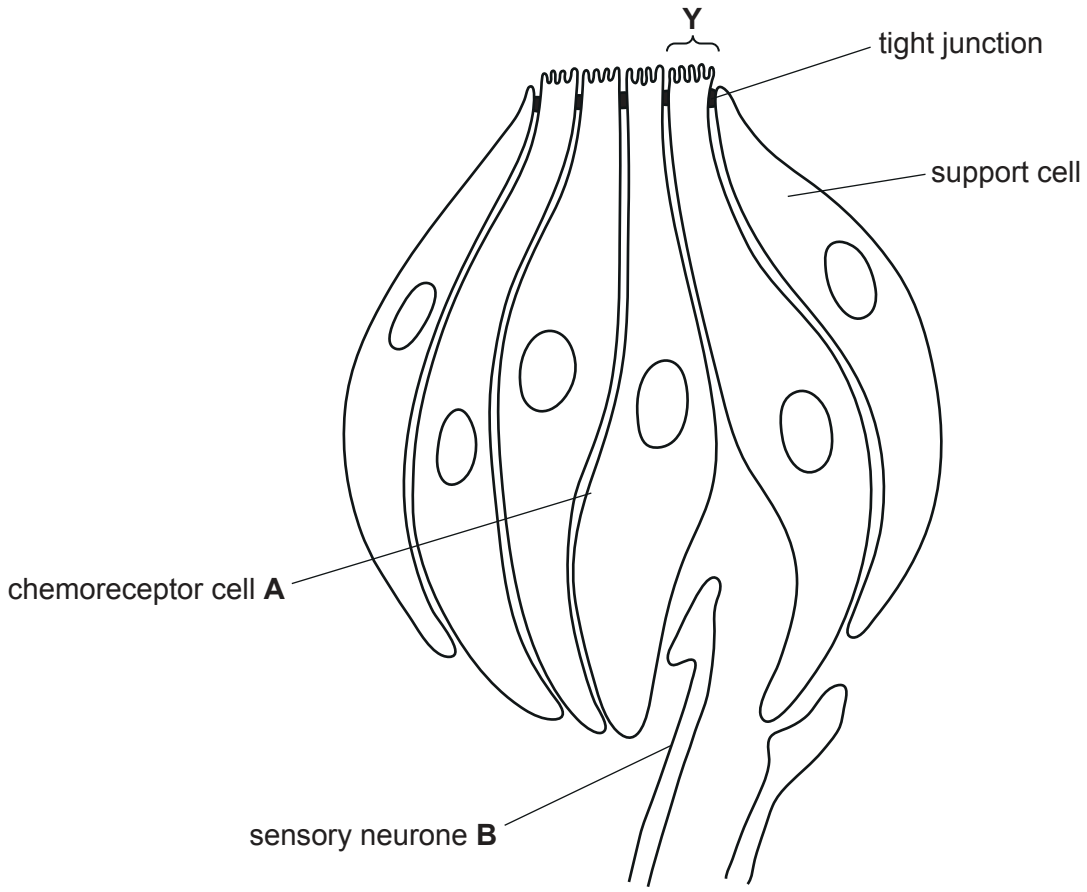

Fig. 6.1

(a) Name the structures in the region **Y and** describe their function in a chemoreceptor cell.

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(b) When a sugar molecule binds to a receptor protein on the cell surface membrane of cell **A**, calcium ions are released into the cytoplasm of the cell by the endoplasmic reticulum.

Explain how the release of calcium ions will lead to an action potential being generated in sensory neurone **B**.

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[Total: 9]

7 **(a)** Epistasis occurs when a gene at one locus can affect the expression of a gene at another locus.

Define the terms gene and locus.

gene .....

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locus .....

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[2]

(b) Fur colour in mice, *Mus musculus*, is determined by a number of genes. One example is the result of epistatic interaction between two genes, **A** and **B**.

- Allele **A** codes for the production of pigment in the fur.
- Allele **a** does not code for the production of pigment and results in white fur (albino).

- Allele **B** codes for the production of brown fur.
- Allele **b** codes for the production of black fur.

Construct a genetic diagram to show the results, including the ratio, of a cross between two mice heterozygous for both genes.

parent genotypes **AaBb** **x** **AaBb**

parent phenotypes

gametes

ratio..... [6]

(c) White fur is due to a mutation of the *TYR* gene. This is called albinism.

Explain how a mutation of the *TYR* gene can result in albinism.

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[Total: 11]

8 **(a)** The Malayan tapir, *Tapirus indicus*, lives in the rainforest of South East Asia.

Fig. 8.1 shows a Malayan tapir and her calf.

Fig. 8.1

On the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, the Malayan tapir is categorised as endangered and could become extinct. One problem is the illegal trade in the Malayan tapir.

Apart from illegal trading, suggest **and** explain reasons why the Malayan tapir has become endangered and could become extinct.

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(b) The trade in Malayan tapirs is regulated by the Convention on International Trade in Endangered Species (CITES).

Suggest ways by which CITES attempts to regulate the trade in wild fauna and flora.

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(c) Many endangered species, such as the Malayan tapir, are protected in zoos.

Outline the role of zoos in the conservation of endangered species.

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[Total: 9]

9 **(a)** Fig. 9.1 shows a cross-section through a myelinated neurone.

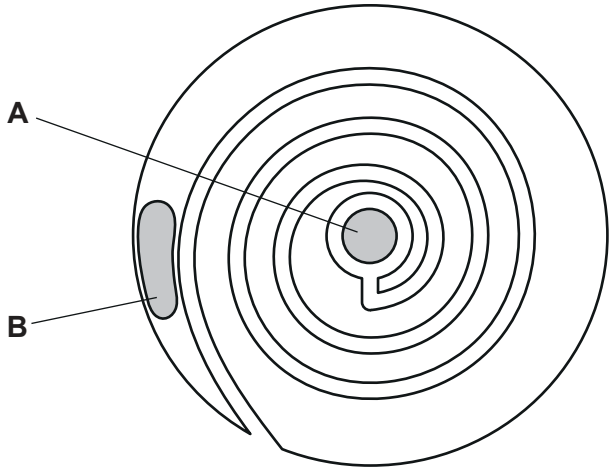

Fig. 9.1

Identify structures **A** and **B**.

A .....

B .....
[2]

(b) With reference to voltage-gated sodium ion channels, explain the difference in speed of transmission of an action potential along a myelinated neurone and a non-myelinated neurone.

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[Total: 6]

10 (a) Insulin has an important role in the maintenance of blood glucose concentration.

An investigation measured how blood glucose concentration and blood insulin concentration changed after a glucose-rich meal had been eaten.

The results are shown in Fig. 10.1.

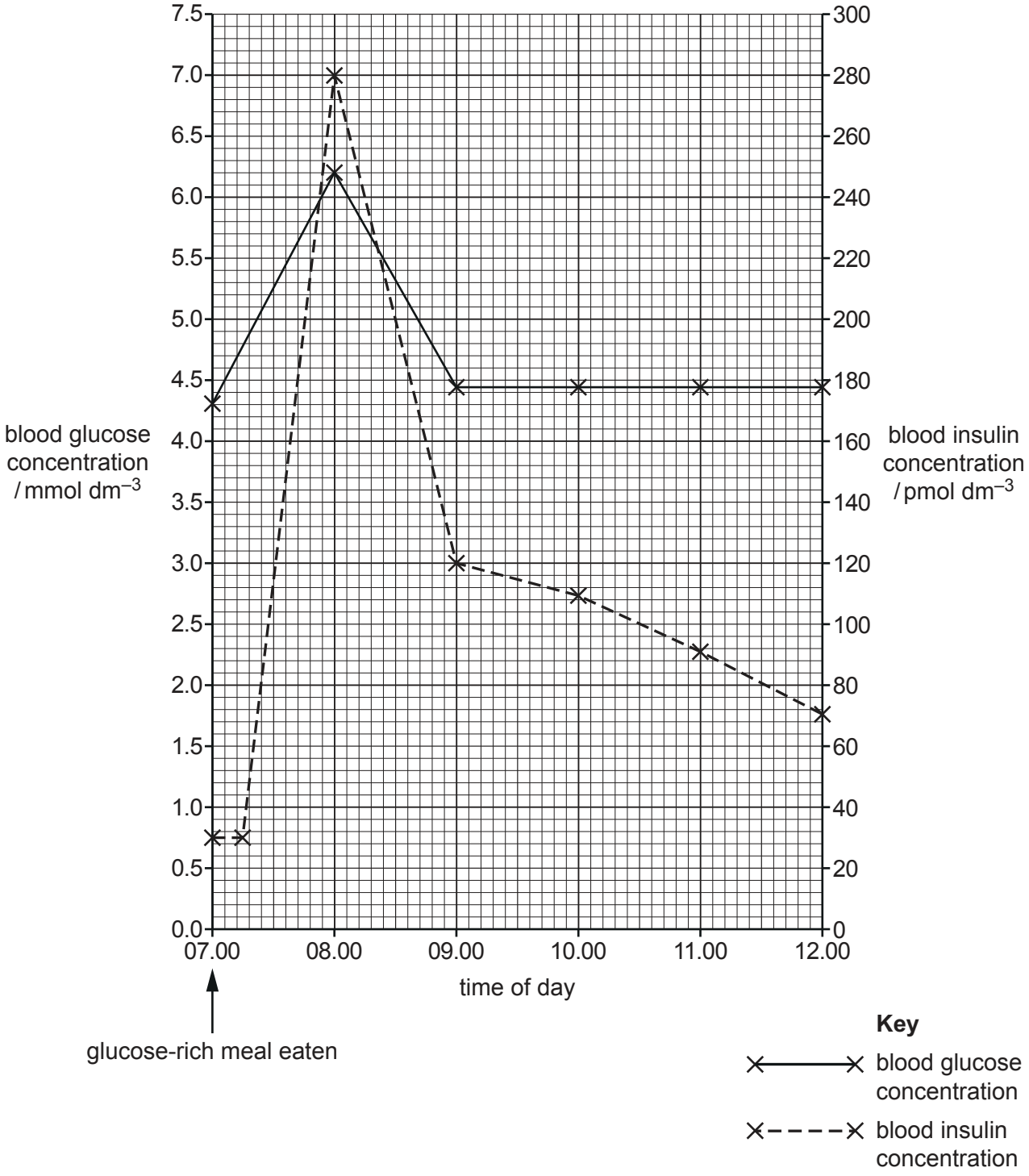

Fig. 10.1

(i) Describe **and** explain how the results shown in Fig. 10.1 indicate a relationship between blood glucose concentration and blood insulin concentration after the consumption of a glucose-rich meal.

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(ii) Suggest **and** explain how the results shown in Fig. 10.1 would change if the meal was mostly starch rather than glucose.

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(b) Glucagon is synthesised by cells in the pancreas known as alpha (α) cells. Glucagon binds to G-protein-coupled receptors in the cell surface membrane of liver cells. This results in the activation of G-proteins.

Outline the sequence of events occurring within the cell after the activation of G-proteins that helps to restore the blood glucose concentration to its set point.

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[Total: 10]