UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

2775960183

BIOLOGY **9700/41**

Paper 4 A2 Structured Questions **October/November 2011**

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 in the spaces provided at the top of this page.
Write in dark blue or black ink.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question
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	
9	
Section B	
10 or 11	
Total	

This document consists of **19** printed pages, **3** lined pages and **2** blank pages.

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Section A

For Examiner's Use

Answer **all** the questions.

1 The Ethiopian wolf, *Canis simensis*, is a member of the Canidae family of carnivores.

Fig. 1.1 shows an Ethiopian wolf.



Fig. 1.1

(a) Ethiopian wolves evolved from an ancestor similar to the grey wolf that crossed into Northern Africa from Europe about 100 000 years ago.

They live in the alpine grasslands and heathlands at, or above, 3000 m altitude in Ethiopia.

State the most likely type of speciation that led to the evolution of the Ethiopian wolf.

.....[1]

(b) A population of Ethiopian wolves is called a pack.

Heterozygosity has been found to be low in all of the packs of Ethiopian wolves that have been studied.

Suggest why the heterozygosity may be low in Ethiopian wolf packs.

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.....[2]

For Examiner's Use

(c) The Ethiopian wolf is classified as an endangered species by the International Union for the Conservation of Nature and Natural Resources (IUCN). It publishes an annual list of endangered species called the Red List.

Complete Table 1.1 to summarise four of the main reasons, with further explanation, as to why the Ethiopian wolf has become an endangered species.

Table 1.1

reason	explanation
	an activity that accompanies human expansion and reduces the size of the wolf habitat
rabies, a lethal viral disease of wolves	
	a human activity to control wolves, considered to be pests
	the result of wolves breeding with domestic dogs

[4]

(d) According to the Red List, the number of endangered mammal species in 2007 was 349 and in 2008 was 448.

Calculate the percentage increase in endangered mammal species between 2007 and 2008.

Give your answer to the **nearest whole number.**

Show your working.

answer .....% [2]

[Total: 9]

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2 **(a)** The first diagnostic test strip using immobilised enzymes was a dip stick to estimate the concentration of glucose in urine.

The dip stick is a thin strip of plastic with a cellulose pad containing two enzymes and a colour reagent (chromogen) at one end. The pad responds with a colour change after being dipped into a sample of urine that contains glucose. The colour can be matched against a graded colour chart to give a 'semi-quantitative' estimate of the concentration of glucose in the sample, as shown in Fig. 2.1. The chart shows the colours of a negative reaction (–) and three increasingly positive reactions (+, ++ and +++).

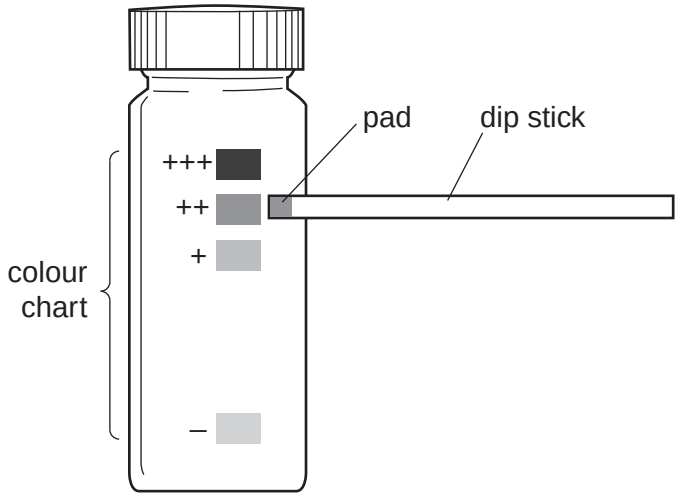


Fig. 2.1

Explain why the estimate of glucose concentration achieved by this method is only 'semi-quantitative'.

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..... [2]

For Examiner's Use

(b) One of the two enzymes immobilised in the cellulose pad on the test strip is glucose oxidase, which catalyses the following reaction:

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{glucose oxidase}} \text{gluconic acid} + \text{hydrogen peroxide}$$

This reaction does **not** result in the development of colour by the chromogen. This is achieved by the activity of the second immobilised enzyme in the pad.

(i) Name the second immobilised enzyme in the pad.

.....[1]

(ii) Explain how the reaction catalysed by this enzyme results in the chromogen changing colour.

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.....[2]

(iii) The cellulose pad on the test strip is covered by a layer of cellulose acetate, which is permeable to glucose molecules, but not to larger molecules.

Suggest why the layer of cellulose acetate is present.

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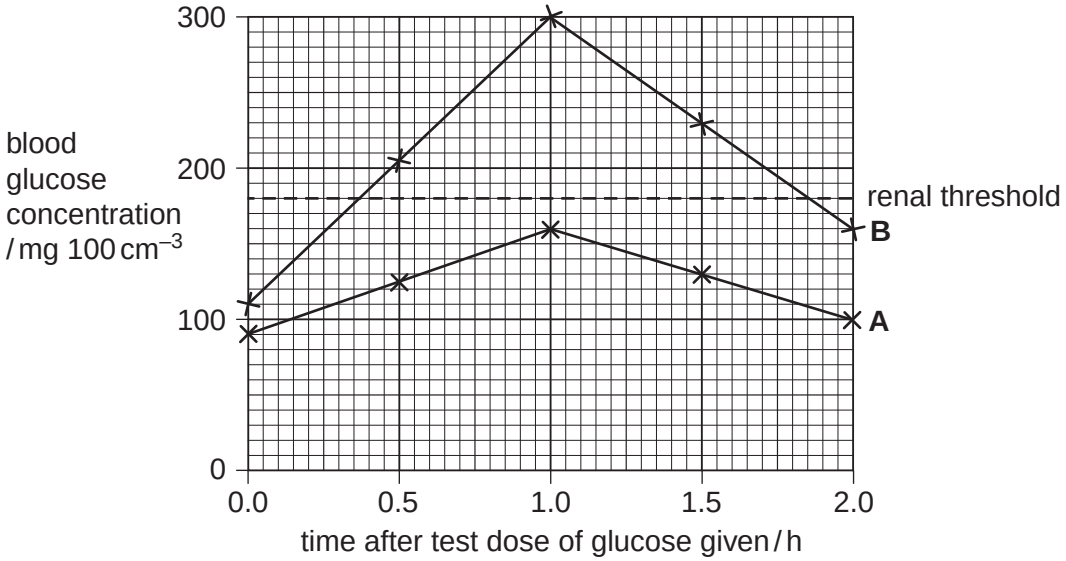
.....[2]

(c) Two young men, subjects **A** and **B**, were each given a standardised test dose of glucose after fasting.

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- The blood glucose concentration of each subject was then measured immediately and at 30 minute intervals for two hours.
- Samples of their urine were taken and tested at the same time intervals. The colour change of each test strip was compared with the colour chart and recorded as **–**, **+**, **++** or **+++**.

The results of the investigation are shown in Fig. 2.2.



Results of urine tests:

	time after test dose of glucose given / h				
subject	0.0	0.5	1.0	1.5	2.0
A	–	–	–	–	–
B	–	+	++	++	+++

Fig. 2.2

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With reference to Fig. 2.2:

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(i) explain the differences between the **blood glucose** concentrations of **A** and **B**

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.....[4]

(ii) suggest what is meant by the term 'renal threshold'

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.....[1]

(iii) describe the events in the kidneys, after ultrafiltration, that result in the increasing quantity of glucose in **B**'s urine.

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.....[3]

[Total: 15]

For Examiner's Use

3 **(a)** Outline the differences in the process of gametogenesis in a man compared with that in a woman.

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.....[3]

(b) The hormone testosterone is secreted by Leydig cells in the testis. These cells form an endocrine gland.

Explain what is meant by an *endocrine gland*.

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.....[2]

(c) In 2009, a research laboratory for family planning in Beijing announced that it had injected 1000 healthy, fertile men with testosterone over a two-year period and found that only 10 of the men were then able to father a child. The men's normal fertility was restored six months after their last injections.

The injections, each of 500 mg of testosterone, resulted in a reduced production of follicle stimulating hormone (FSH) and of luteinising hormone (LH) in the injected men.

Describe the **similarities** between the effect of these testosterone injections on a fertile man with the effect of the oestrogen/progesterone contraceptive pill on production of FSH and LH by a fertile woman.

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.....[3]

[Total: 8]

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Question 4 starts on page 10

4 Cultivated rice, *Oryza sativa*, is often grown in fields flooded with water.

For Examiner's Use

(a) Explain how rice plants are adapted for growth with the roots submerged in water.

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..... [3]

(b) Some varieties of cultivated rice are able to grow long internodes when they are submerged in water, keeping the leaves and flowers above water level (an internode is a length of stem between leaves). These varieties are known as deepwater rice.

The snorkel genes *SK1* and *SK2*, thought to be responsible for this response, were identified in a variety of deepwater rice, C9285. A non-deepwater variety, T65, did not have these genes.

When submerged, rice plants produce the gaseous plant hormone ethene. This has a very low solubility in water, so it accumulates in the aerenchyma tissue in the rice stems.

Fig. 4.1 shows the concentration of ethene in the aerenchyma of T65 and C9285 when the plants are submerged in water for 18 hours.

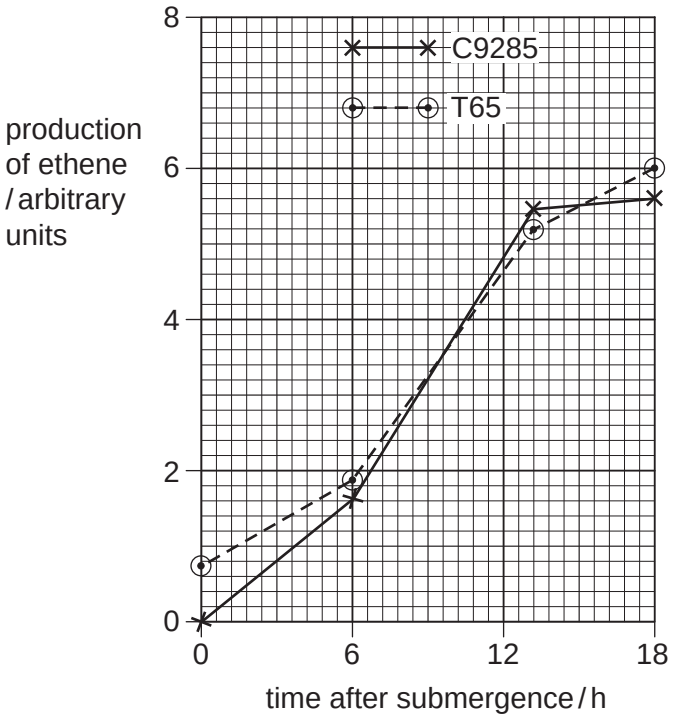


Fig. 4.1

Fig. 4.2 shows the results of exposing T65 and C9285 to different concentrations of ethene in dry conditions.

For Examiner's Use

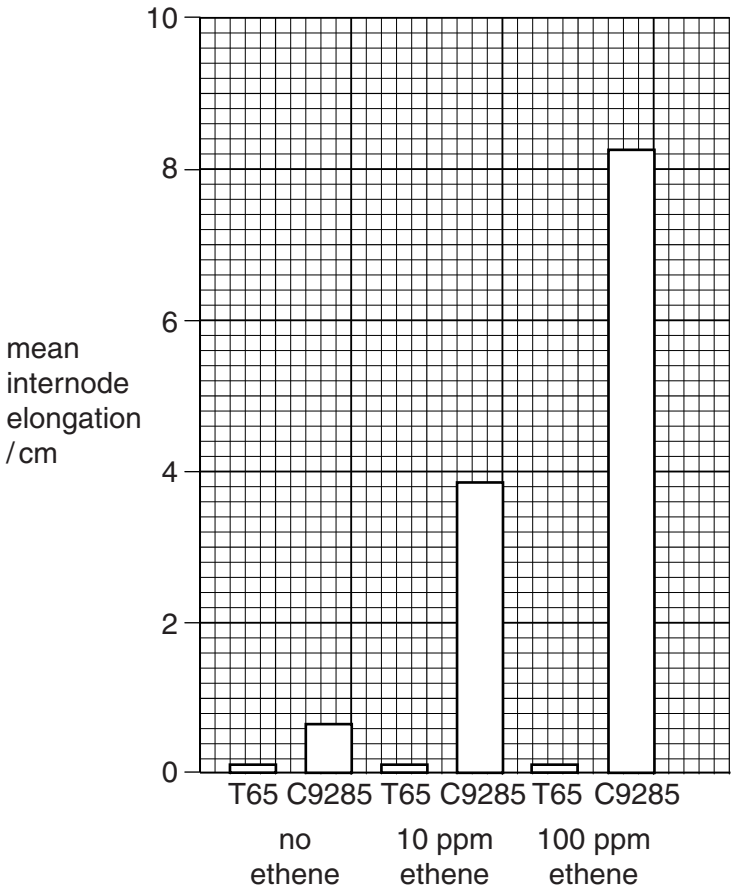


Fig. 4.2

(i) With reference to Fig. 4.1, describe the effect of submergence in water on the production of ethene in rice.

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.....[2]

(ii) With reference to Fig. 4.2, compare the effect of ethene on internode elongation in C9285 and T65.

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.....[2]

(c) The snorkel genes were found to be expressed when the plant was exposed to ethene. The expression of these genes results in increased production of gibberellin, GA.

For Examiner's Use

Fig. 4.3 shows the effect of submergence on GA production in C9285 and in T65.

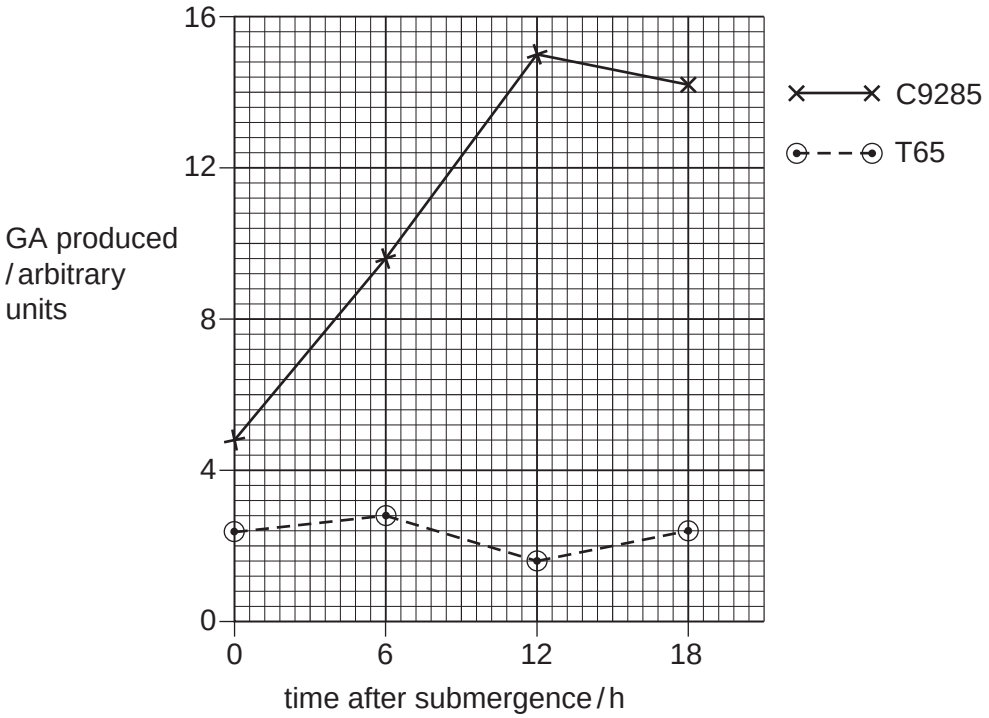


Fig. 4.3

With reference to Fig. 4.3, and your knowledge of the functions of GA, suggest an explanation for the differences in the effects of ethene in C9285 and T65 shown in Fig. 4.2.

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.....[3]

(d) Cultivated rice has been developed from the wild rice species *Oryza rufipogon* and *Oryza nivara*. *O. rufipogon* has a strong deepwater elongation response, but *O. nivara* has only a slight elongation response. Another species, *Oryza glumaepatula*, shows a strong elongation response.

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- *O. rufipogon* has both the snorkel genes, *SK1* and *SK2*.
- *O. nivara* has *SK1*, but an addition (insertion) mutation has produced a stop triplet within *SK2*.
- *O. glumaepatula* has *SK2*, but not *SK1*.

(i) Describe what this information indicates about the relative importance of the genes *SK1* and *SK2* in the deepwater elongation response.

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.....[2]

(ii) Explain how an addition mutation could produce a stop triplet.

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.....[2]

(iii) Deepwater rice is the main food crop in many parts of the world that undergo flooding in the rainy season. Many varieties of deepwater rice have lower yields than non-deepwater varieties.

Suggest how a deepwater rice variety with high yield could be produced, using artificial selection.

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.....[3]

[Total: 17]

For Examiner's Use

5 In humans, the gene *RPE65* encodes a protein responsible for regenerating visual pigment in rod and cone cells after they have been exposed to light. A recessive allele of this gene causes impaired vision from birth, progressing to complete blindness in early adulthood. This condition is called LCA.

In 2008, trials were carried out into the possibility and safety of treating LCA using gene therapy.

(a) Suggest and explain why LCA is suitable for treatment using gene therapy.

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.....[3]

(b) Six adults with this condition were used in the study. Genetically modified adenoviruses (a type of virus that can cause respiratory infections) were used as vectors. The vectors were injected beneath the retina of one eye of each of the participants.

Suggest two ways in which the genome of the adenoviruses used as vectors would differ from that of normal adenoviruses.

1. .....

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2. .....

.....[2]

(c) Improvements were found in the vision of all the participants, but the small number in the trials made most of these improvements not statistically significant.

Suggest why these trials were designed to include such a small number of participants.

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.....[2]

[Total: 7]

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Question 6 starts on page 16

6 During the process of glycolysis, glucose is converted by a series of steps into two molecules of pyruvate.

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Fig. 6.1 outlines glycolysis.

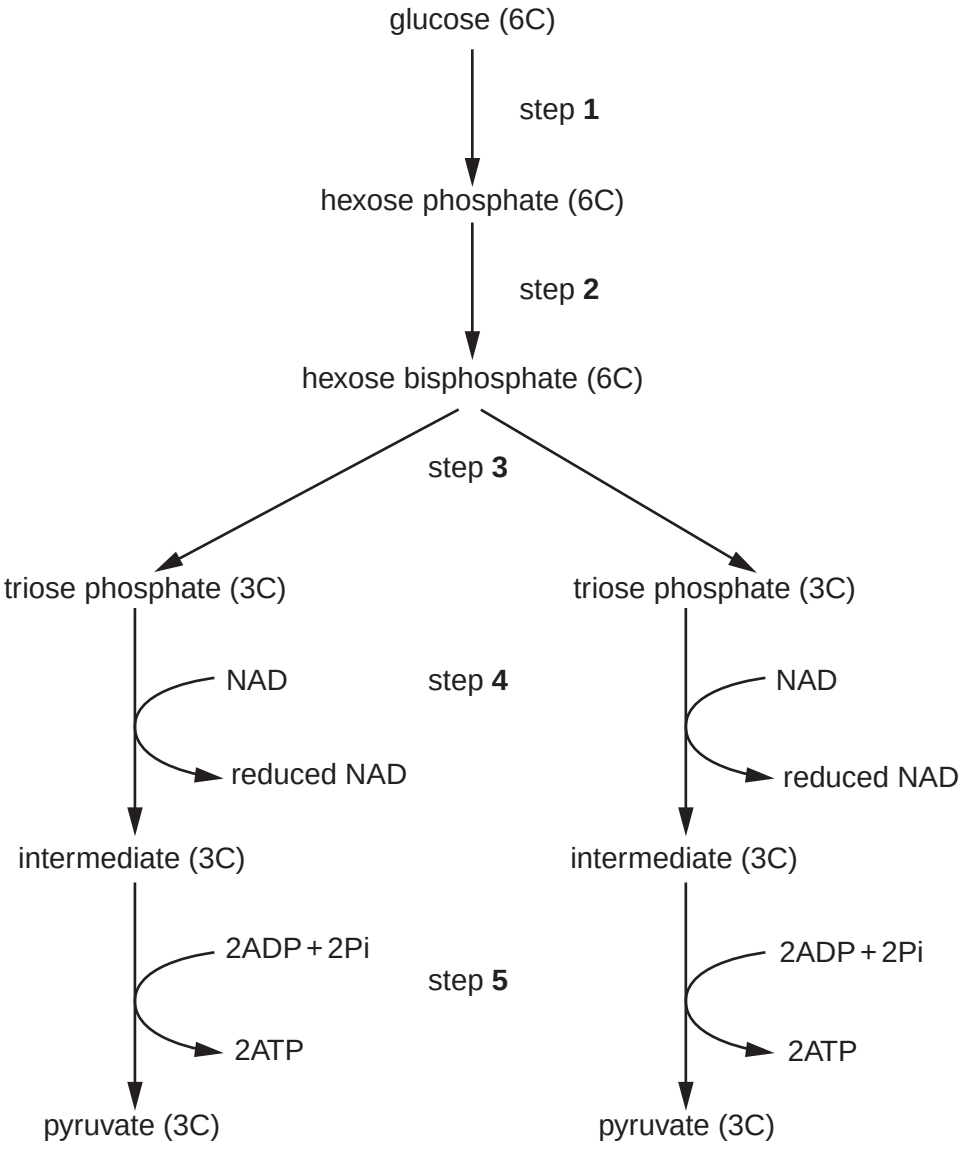


Fig. 6.1

(a) With reference to Fig. 6.1, state the process occurring at:

(i) steps **1** and **2** ..... [1]

(ii) step **3** ..... [1]

(iii) step **4**. ..... [1]

(b) Explain why glucose needs to be converted to hexose bisphosphate.

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.....[2]

(c) Pyruvate can enter a mitochondrion when oxygen is present.

Describe what happens to pyruvate in a yeast cell when oxygen is **not** present.

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.....[4]

[Total: 9]

7 Insulin can be produced on a large scale using gene technology and prokaryotes such as *Escherichia coli.*

For Examiner's Use

Table 7.1 summarises the sequence of steps in one method of production of insulin by *E. coli.*

Complete Table 7.1 by adding one statement in each of the empty boxes.

Table 7.1

step	reason for step
obtain copies of gene with sticky ends	the gene codes for the synthesis of insulin
	acts as a vector for the transfer of the gene into the host
use restriction endonuclease enzyme	
mix vector and gene	
	to seal the sugar-phosphate backbone
	to obtain transformed host *E. coli* cells
screen for, and obtain, successfully transformed cells	
	to obtain large amounts of insulin for extraction and purification

[7]

[Total: 7]

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8 Asthma is a disease of the respiratory system.

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- During an asthma attack the membranes lining the airways release mucus and become inflamed.
- This causes the muscles of the airways to contract and narrow the lumen of the airways, making breathing difficult.
- Most asthma attacks are triggered by allergens.
- Allergens are harmless substances that, in some people, stimulate an immune response that leads to an allergic reaction.
- There has been a large increase in cases of asthma over the last 40 years.

(a) Many allergens that can trigger an asthma attack are inhaled during normal breathing.

Suggest **two** examples of these allergens.

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.....[2]

(b) Over the past 20 years a study has been carried out on the 261 inhabitants of a remote island in the South Atlantic called Tristan da Cunha.

- There are only seven different family names on the island.
- Half of the islanders displayed symptoms of asthma.
- A gene, *ESE3*, is responsible for the normal deposition of collagen in the walls of the airways.
- When the gene is faulty, too much collagen is produced and this can lead to asthma-like symptoms, making breathing difficult.
- This faulty gene has been found among the inhabitants of Tristan de Cunha.

(i) Collagen is also found in the walls of blood vessels.

State **one** property of collagen that enables it to carry out its main function in the walls of blood vessels and airways.

.....[1]

(ii) Suggest why this form of asthma was very common amongst the population of Tristan da Cunha.

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.....[3]

[Total: 6]

For Examiner's Use

9 Tuberous Sclerosis Complex (TSC) is a genetic condition caused by a dominant allele of the *TSC* gene, which leads to abnormal growth of tissue in organs such as the heart, lungs and kidneys.

Children with TSC can, with treatment, lead reasonably normal lives.

About 33% of people with TSC have at least one parent with the condition.

(a) Explain the meaning of the terms *dominant* and *gene.*

dominant .....

.....

gene .....

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.....[2]

(b) A couple wish to start a family. The man does not have TSC but the woman does have TSC. The woman's father does not have the condition.

Complete the genetic diagram below to show the probability of the couple's first child having TSC.

key
TSC allele = T
normal allele = t

parental phenotypes	man without TSC	woman with TSC
parental genotypes	.....	.....
gametes	.....	.....
offspring genotypes	.....	
offspring phenotypes	.....	

probability of first child having TSC ..... [3]

(c) Suggest how a person may develop TSC when there is no family history of the condition.

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.....[2]

[Total: 7]

Section B

Answer **one** question.

For Examiner's Use

10 **(a)** Describe how the structure of a chloroplast is related to its functions. [9]

(b) Describe how you would separate chloroplast pigments using chromatography. [6]

[Total: 15]

11 **(a)** Describe how a resting potential is maintained in an axon. [9]

(b) Describe, using named examples, how sensory receptors in mammals generate action potentials. [6]

[Total: 15]

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