Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

3617713944

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **October/November 2016**

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 and **4** lined pages.

CAMBRIDGE International Examinations

Section A

Answer **all** the questions.

1 **(a)** Diabetes insipidus (DI) is a condition that results in excessive thirst and the excretion of large amounts of dilute urine. A main cause of DI is a deficiency of ADH.

ADH normally binds to receptor proteins on cell surface membranes of cells in the collecting ducts of nephrons.

Outline the effect of ADH on the collecting ducts.

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(b) An inherited form of DI may be caused by faulty membrane receptors. These receptors are coded for by a sex-linked allele.

(i) Explain the term *sex linkage*.

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(ii) Use a genetic diagram to show how parents who do not have this condition can have a child with the inherited form of DI.

symbols

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parental genotypes

gametes

offspring genotypes

offspring phenotypes

[4]

[Total: 8]

2 Grass crops such as maize, sorghum and sugarcane are C4 plants. They are common grass crops of tropical regions.

Oats and wheat, commonly grown in temperate regions, are C3 plants. Most plants are C3 plants. They are termed 'C3' because the first product of photosynthesis is a three carbon compound.

(a) Outline how the biochemistry of C4 plants differs from that of C3 plants.

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(b) The C4 pathway for fixing carbon dioxide was worked out in 1966 by Hatch and Slack. During their investigation they measured the rates of fixation of carbon dioxide at high light intensities in leaves removed from both temperate and tropical grasses.

They also measured the rates of activity of two carboxylase enzymes in the leaves, ribulose bisphosphate carboxylase (rubisco) and PEP carboxylase.

All rates were measured at 30 °C.

Some of their results are shown in Table 2.1.

Table 2.1

grass crop	rate of fixation of carbon dioxide / arbitrary units	rate of activity of rubisco / arbitrary units	rate of activity of PEP carboxylase / arbitrary units
maize	3.5	0.62	17.50
sorghum	3.1	0.35	15.80
sugarcane	2.9	0.30	18.50
oats	1.6	4.50	0.33
wheat	1.7	4.70	0.29

(i) With reference to Table 2.1, compare the rates of fixation of carbon dioxide in C3 and C4 grasses.

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(ii) Describe the role of rubisco in the Calvin cycle.

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(iii) With reference to Table 2.1, suggest reasons for the differences in activity of the two carboxylase enzymes in C3 and C4 grasses.

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(c) It has been calculated that, to produce one molecule of glucose, the C3 pathway uses 18 molecules of ATP and the C4 pathway uses 30 molecules of ATP.

Suggest why C4 plants can afford this high cost of ATP.

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[Total: 13]

3 The polymerase chain reaction (PCR) is used to produce large amounts of DNA from a very small original sample. The main stages of a PCR are shown in Fig. 3.1.

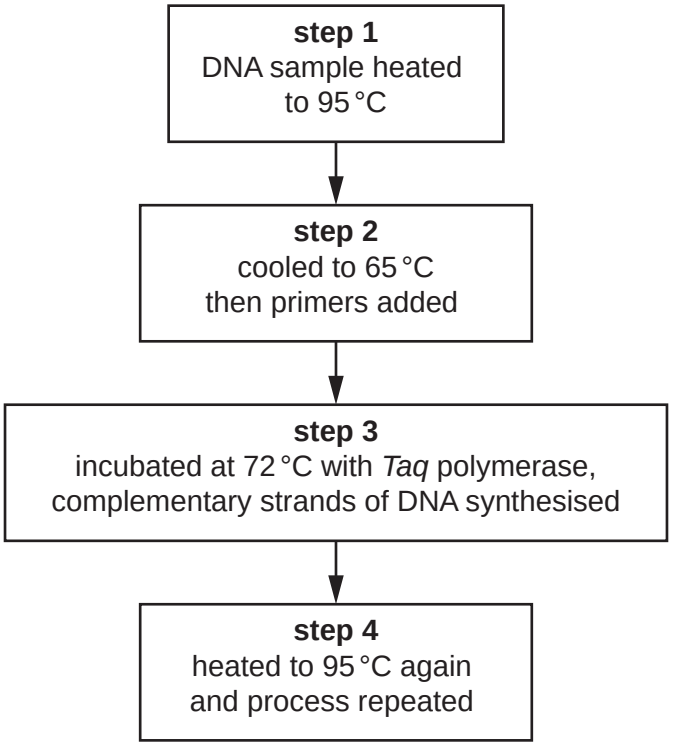

Fig. 3.1

(a) (i) Explain why the DNA sample is heated to 95 °C in **step 1**.

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(ii) Explain why primers are added in **step 2**.

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(iii) Explain why the enzyme *Taq* polymerase is used in **step 3**.

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(b) After an organism dies, its DNA gradually breaks down. However, cells in bones that were buried hundreds of years ago may still yield small amounts of DNA that can be extracted, amplified using PCR and then analysed. Mitochondrial DNA (mtDNA) is often used because there are usually more than 100 copies of it in one cell, compared with only two copies of nuclear DNA.

For example, in 1994, mtDNA from bones that had been found in a grave in Russia was analysed to confirm that these were the remains of the royal family, who were known to have been killed in 1918. The mtDNA extracted from the bones was compared with the mtDNA from a living relative of the family.

The family tree of the Russian royal family and some of their relatives is shown in Fig. 3.2.

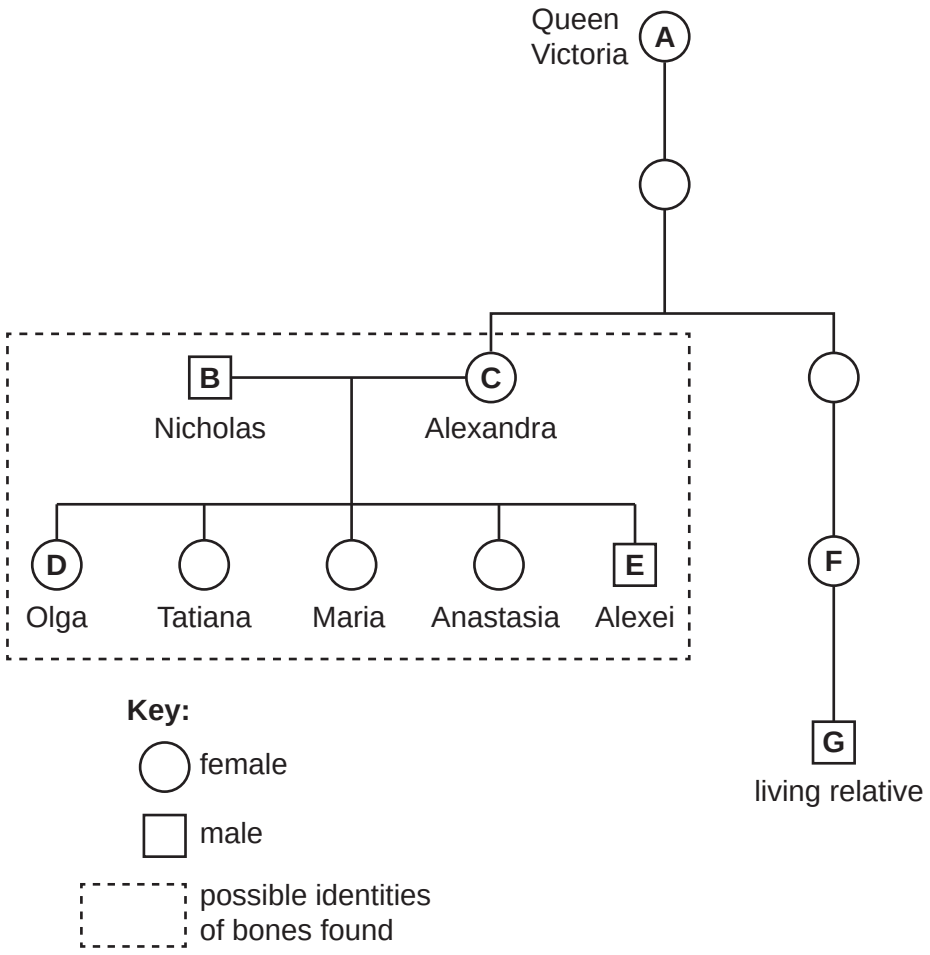

Fig. 3.2

(i) Explain why there are usually more than 100 copies of mtDNA in a cell, but only two copies of nuclear DNA.

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(ii) All of the mitochondria in a zygote come from the egg, not the sperm.

List the **letters** of the people in the family tree in Fig. 3.2 who would be expected to have mtDNA identical to the mtDNA of the living relative, **G**.

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.....[1]

[Total: 9]

4 Spraying insecticide on the walls inside houses is the main method of controlling a species of *Anopheles* mosquito in rural India. A number of different insecticides have been used.

Malathion was the main insecticide used for many years. In 2005 the newer insecticide, deltamethrin, was used instead and the use of malathion was discontinued.

A laboratory study was carried out using mosquitoes collected from two sites in India. The percentage of mosquitoes killed by malathion and deltamethrin was estimated.

The results of the study are shown in Table 4.1

Table 4.1

site	year	percentage of mosquitoes killed by	
		malathion	deltamethrin
Jamnagar	2005	76	100
	2007	95	90
Bikaner	2005	66	100
	2007	77	100

(a) With reference to Table 4.1, describe the difference in effectiveness of the two insecticides.

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(b) The researchers concluded that at Jamnagar, the mosquitoes had evolved resistance to deltamethrin.

Explain how the mosquitoes evolved resistance.

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(c) Explain how the data in Table 4.1 show evidence that the use of malathion was discontinued after 2005.

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(d) The resistance of mosquitoes to malathion was found to be due to a difference in the shape of **one** enzyme.

Name the type of variation controlling malathion resistance in the mosquito population.

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(e) Some students suggested that resistance to malathion could be due to a gene with two alleles. They proposed that the allele for resistance to malathion would be dominant to the allele for non-resistance.

Using this assumption, the data in Table 4.1 can be used to calculate the frequency of resistant mosquitoes and the frequency of the allele for resistance in a mosquito population.

Use the Hardy-Weinberg principle to calculate the frequency, *p*, of the allele for resistance in Jamnagar in 2005.

[3]

[Total: 13]

5 The land area of Italy is composed of forest, grasslands (including agricultural fields), built-up areas (for example towns and cities) and inland water bodies like lakes and rivers.

Table 5.1 shows changes in the area covered by these environments over a fifteen year period.

Table 5.1

environment	**area / thousand hectares**		
	1990	**2000**	**2005**
forest	8 791	9 564	9 951
agricultural fields and towns	20 620	19 847	19 460
inland water bodies	723	723	723
total	30 134	30 134	30 134

(a) (i) Explain why none of the three environments listed in Table 5.1 can be referred to as an ecosystem.

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(ii) The increase in area covered by forest in Italy has occurred because farmers have cultivated less of their land or have abandoned their farms altogether.

Describe how this change in land use may affect biodiversity. You should consider the three different levels of biodiversity in your answer.

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(b) Two large mammals native to Italy are the grey wolf and the lynx. Fig. 5.1 shows a grey wolf and Fig. 5.2 shows a lynx.

Fig. 5.1

Fig. 5.2

Some facts relevant to the survival of these large mammals in Italy are listed below.

In 1971:
- there were fewer than 100 wolves in Italy
- lynx were extinct in Italy
- wolves received protected status in Italy
- lynx were successfully re-introduced to Switzerland, which shares a border with Italy.

In 1973:
- lynx were successfully re-introduced to Slovenia, which also shares a border with Italy.

In 2014:
- the number of wolves in Italy was estimated at 800
- the number of lynx in Italy was estimated at around 25.

Suggest what actions may have been necessary at **local**, **national** and **global** levels to contribute to the successful conservation of biodiversity of Italy's large mammals.

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[Total: 10]

6 **(a)** Fig. 6.1 shows the concentration of four hormones in a woman's blood during one menstrual cycle.

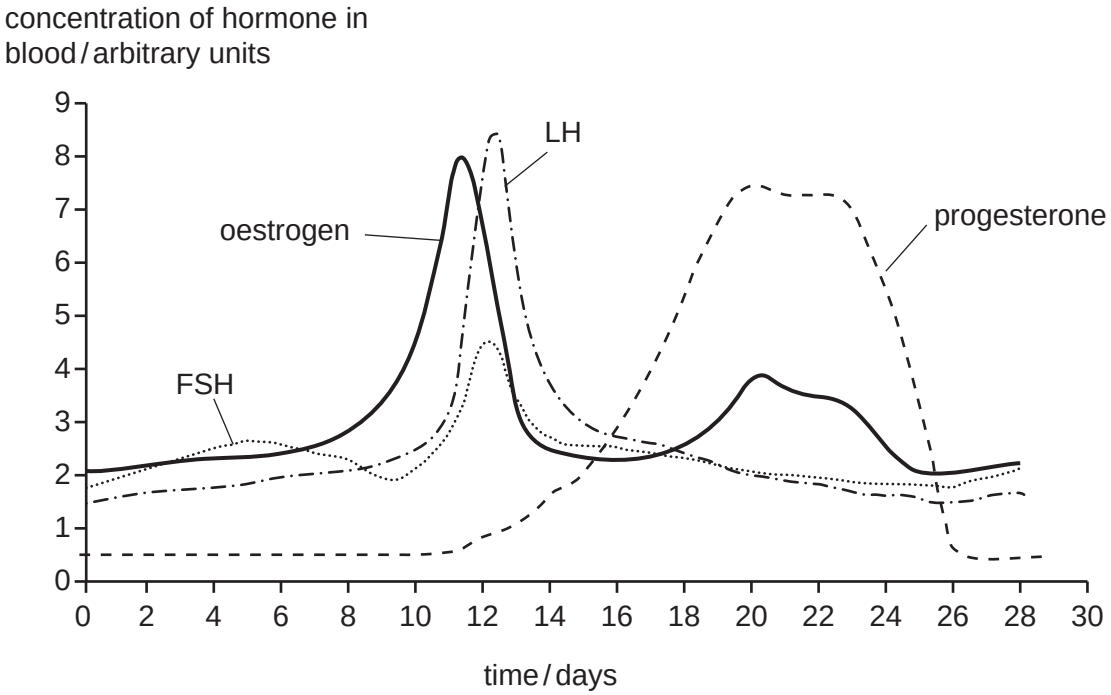

Fig. 6.1

(i) With reference to Fig. 6.1, explain why there is a large increase in LH at around day 12.

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.....[1]

(ii) State how Fig. 6.1 shows that the woman did not become pregnant during this cycle.

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.....[1]

(b) The combined oral contraceptive pill contains oestrogen and progesterone.

(i) Explain how this combined contraceptive pill works to prevent pregnancy.

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(ii) Suggest why some women take the combined contraceptive pill for just the first 21 days of their cycles.

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(iii) Some women have a contraceptive device inserted under the skin. This releases hormones into the blood and can last for up to three years.

Suggest **one** advantage of using such a device rather than taking contraceptive pills.

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[Total: 8]

7 Fig. 7.1 shows a mammalian neuromuscular junction.

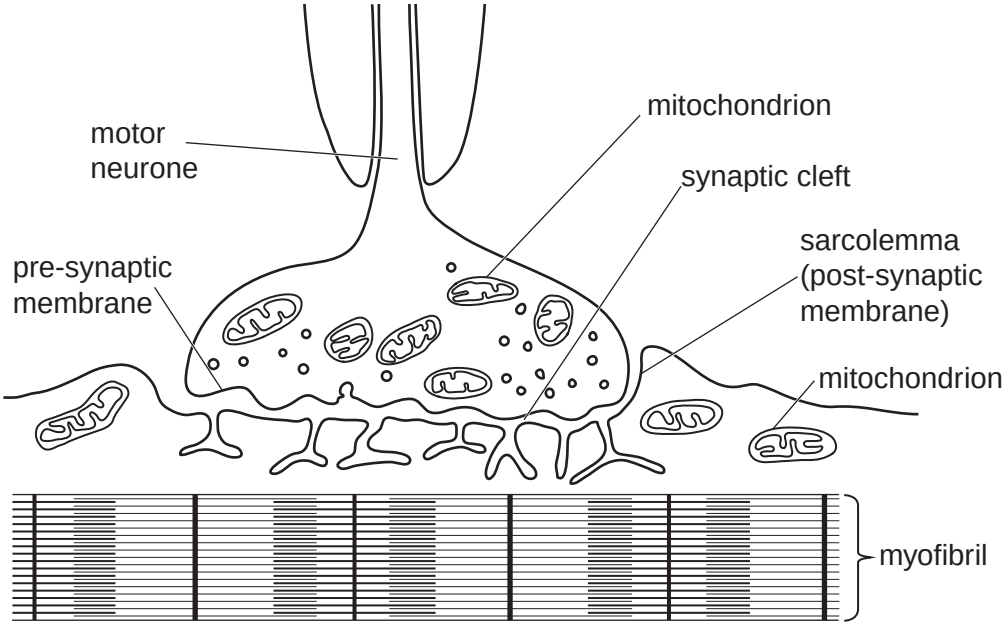

Fig. 7.1

(a) (i) On Fig. 7.1, use label lines and letters to label each of the following parts:

A – a region containing only actin
B – a region containing both actin and myosin. [2]

(ii) Outline how an action potential arriving at this neuromuscular junction can result in depolarisation of the sarcolemma.

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(b) Table 7.1 shows some of the events occurring during muscle contraction. They are **not** listed in the correct order.

Table 7.1

event	description of event
Q	Ca^{2+} ions diffuse out of sarcoplasmic reticulum
R	myosin heads bind to actin
S	sarcolemma depolarised
T	sarcomere shortens
U	Ca^{2+} ions bind to troponin
V	transverse tubules depolarised
W	binding sites on actin exposed
X	myosin heads tilt
Y	tropomyosin moves
Z	troponin changes shape

Complete Table 7.2 to show the **correct** order of the events.
Two of the events have been completed for you.

Table 7.2

correct order	letter of event
1	.....
2	.....
3	.....
4	.....
5	**Z**
6	.....
7	.....
8	.....
9	.....
10	**T**

[4]

[Total: 10]

8 **(a)** When a dormant seed absorbs water it will start to germinate and its rate of respiration will increase.

Name the plant growth regulator involved in the initiation of germination of seeds.

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(b) A respirometer can be used to measure the rate of respiration of germinating seeds.

Fig. 8.1 shows a respirometer.

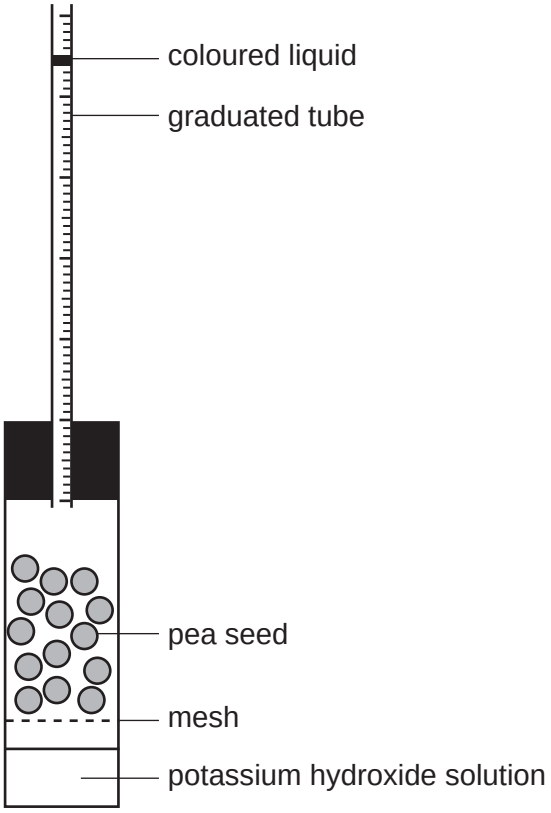

Fig. 8.1

(i) State the role of potassium hydroxide solution in the use of a respirometer.

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(ii) As respiration takes place, oxygen is used by the seeds and the coloured liquid moves down the tube.

Describe the role of oxygen in aerobic respiration.

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(c) Respirometers, as shown in Fig. 8.1, were used to investigate the effect of temperature on the rate of respiration of germinating pea seeds.

Four respirometers, **A**, **B**, **C** and **D** were set up:

- **A** and **B** in a water-bath maintained at 10 °C.
- **C** and **D** in a water-bath maintained at 25 °C.
- **A** and **C** each contained 30 germinating pea seeds.
- **B** and **D** each contained glass beads with a total volume equivalent to 30 pea seeds.

- The respirometers were left in the water-baths for 10 minutes.
- In each respirometer the position of the coloured liquid in the graduated tube was then marked (time 0 minutes).
- After 5 minutes the distance moved by the coloured liquid was measured.
- The volume of oxygen taken up was calculated for each respirometer.
- This was repeated after 10, 15 and 20 minutes.

Fig. 8.2 shows the results of the experiment.

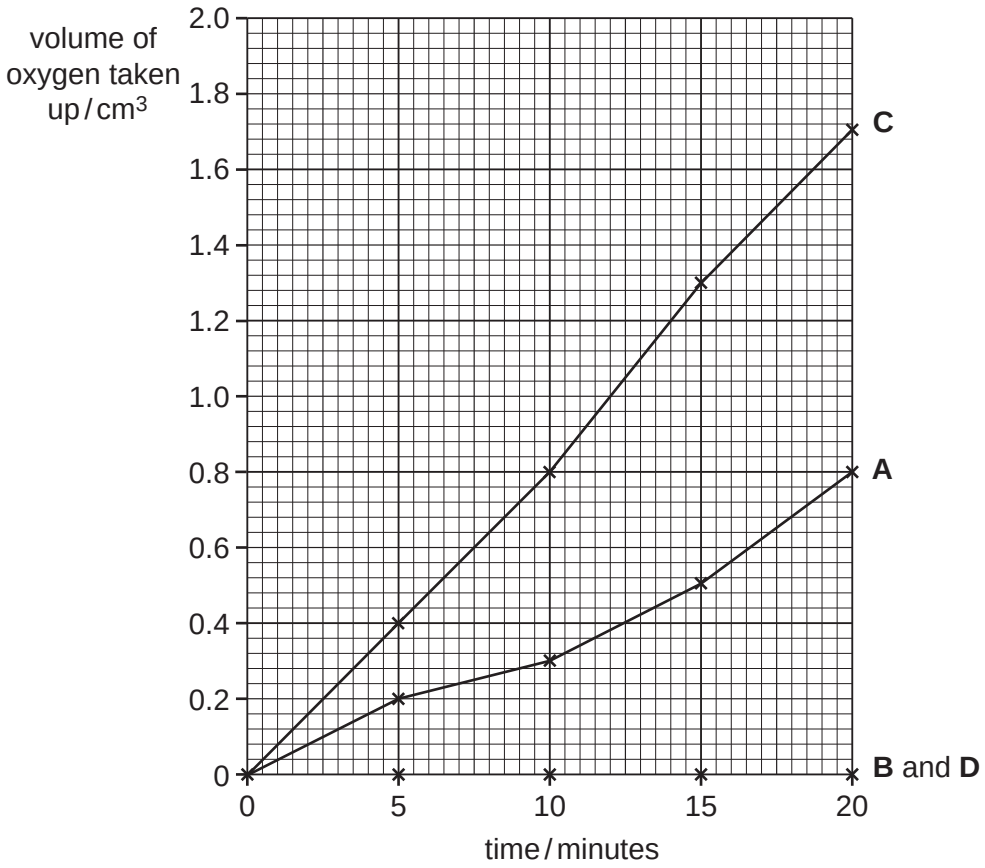

Fig. 8.2

(i) Suggest why the respirometers were left for 10 minutes before measurements were made.

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(ii) Suggest why respirometers **B** and **D** were used in this investigation.

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(iii) Calculate the rate of oxygen uptake in cm^3 per minute for respirometer **C** between 5 and 20 minutes.

Give your answer to two significant figures.

Show your working.

answer ..... $cm^3\ min^{-1}$ [2]

(iv) Explain why there is an increased rate of respiration of germinating pea seeds between 10 °C and 25 °C.

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(v) Suggest why carrying out the experiment with germinating seeds at 50 °C could result in a lower rate of respiration than at 25 °C.

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[Total: 14]

Section B

Answer **one** question.

9 **(a)** Using examples, outline the importance of homeostasis in a mammal. [7]

(b) Describe the main stages of cell signalling in the control of blood glucose concentration by adrenaline. [8]

[Total: 15]

10 **(a)** Explain the role of auxin in cell elongation in plants. [7]

(b) Describe the role of abscisic acid in the closure of stomata. [8]

[Total: 15]

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