Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **May/June 2025**

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.

DC (PB/SG) 344944/2

[Turn over

1 Fig. 1.1 is a diagram of part of the inner membrane of a mitochondrion.

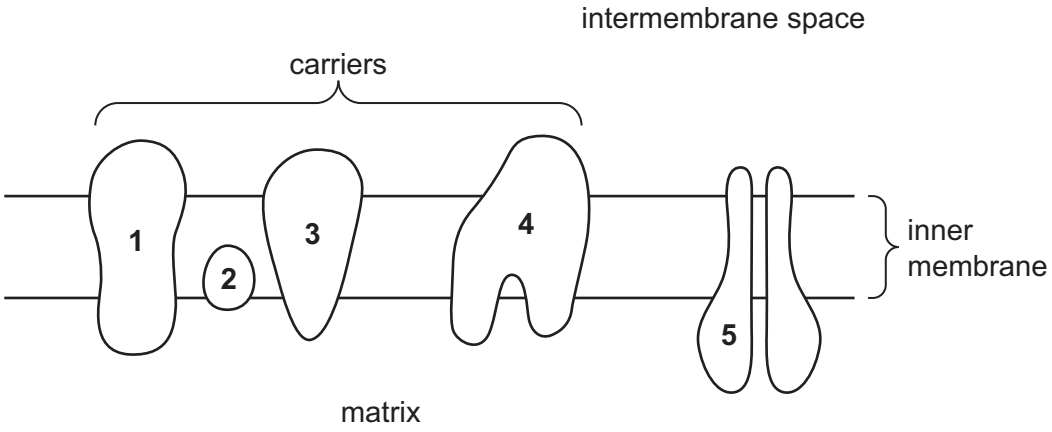

Fig. 1.1

(a) (i) The coenzymes NAD and FAD deliver hydrogen atoms to the electron transport chain (ETC).

With reference to Fig. 1.1, state which of the four carriers receives hydrogen atoms from reduced FAD.

…….. [1]

(ii) Hydrogen atoms that are delivered to the ETC by reduced NAD and reduced FAD split into protons and electrons. Energy is released as electrons pass along the ETC.

Describe the events that occur as a result of this release of energy.

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(iii) Describe how structure **5** in Fig. 1.1 is involved in oxidative phosphorylation.

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(b) Cyanide ions (CN^-) are highly toxic.

Cyanide ions bind to carrier **4** in Fig. 1.1 and inactivate the carrier.

Suggest **and** explain how the binding of cyanide ions to carrier **4** can have an effect on respiration.

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..... [4]

[Total: 10]

2 When organisms reproduce, they pass on their alleles to the next generation. There are many factors that can affect how allele frequencies change over time in a population.

Explain how genetic drift **and** the founder effect may affect allele frequencies in populations.

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[Total: 6]

3 Rice, *Oryza sativa*, is an important grain crop. A rice grain is a seed and can have a structure known as an awn, which projects from the tip of the grain.

Fig. 3.1 shows a rice grain with an awn present and a rice grain with no awn present.

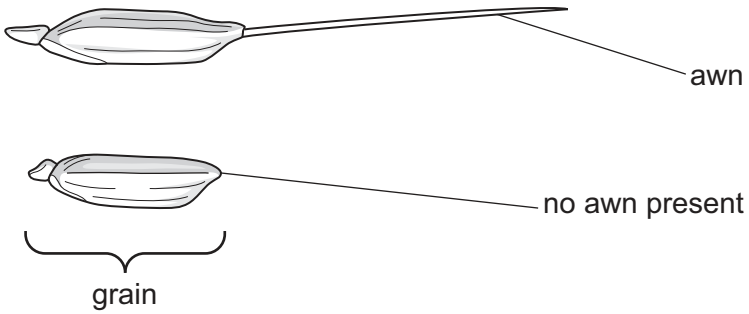

Fig. 3.1

(a) (i) The development of awns is controlled by two genes: gene **A/a** and gene **B/b**. The genes are present on different autosomes. The presence of either dominant allele **A** or dominant allele **B** results in rice plants producing grains with awns.

A cross was carried out between a rice plant that is homozygous dominant for the two genes (double homozygous dominant) and a rice plant that is homozygous recessive for the two genes (double homozygous recessive). All F1 offspring plants produced grains with awns.

Construct a genetic diagram, including a Punnett square, to show the cross that produces the F2 generation, including phenotypes.

State the ratio of the offspring phenotypes produced.

[5]

(ii) Deduce the type of inheritance shown by the ratio of the offspring phenotypes stated in **3(a)(i)**.

..... [1]

(b) It is common for wild rice plants to have grains with awns present.

Suggest a selective advantage to wild rice of having awns present on their grains.

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..... [1]

(c) One of the changes that occurred during the domestication of wild rice to cultivated rice was the loss of the awns from rice grains.

Farmers found that long awns made storing and processing rice grains more difficult.

It was also observed that rice plants that have grains with no awns have an increased grain yield.

(i) Explain the principles used by farmers to produce rice plant grains with no awns.

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..... [4]

(ii) The normal allele for the gene *An-1* codes for a transcription factor that has a role in awn development and in the number of grains of rice produced.

When the transcription factor is present there is:

- an increase in the expression of genes involved in awn development (positive regulation)
- a decrease in the expression of genes involved in the number of grains produced (negative regulation).

Suggest **and** explain how changes at the *An-1* locus can cause rice plants to have grains with no awns and an increased grain yield.

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[Total: 14]

4 Sexual reproduction in plants and animals involves:

- the formation of gametes as a result of meiosis
- the process of fertilisation.

(a) In most species of plants and animals, the cell that is formed as a result of fertilisation is diploid and contains homologous chromosomes.

Explain why the cell that is formed as a result of fertilisation is a diploid cell **and** contains homologous chromosomes.

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(b) State the name of the stage in meiosis when reduction division occurs **and** explain a reason for your choice.

stage in meiosis .....

reason .....

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..... [2]

(c) Microscope slides can be prepared for viewing with a light microscope to show the different stages of meiosis in plant cells.

In the male reproductive organ of plants, meiosis takes place in cells known as pollen mother cells.

Fig. 4.1 and Fig. 4.2 show photomicrographs of two different stages of meiosis in pollen mother cells from a lily plant, *Lilium*.

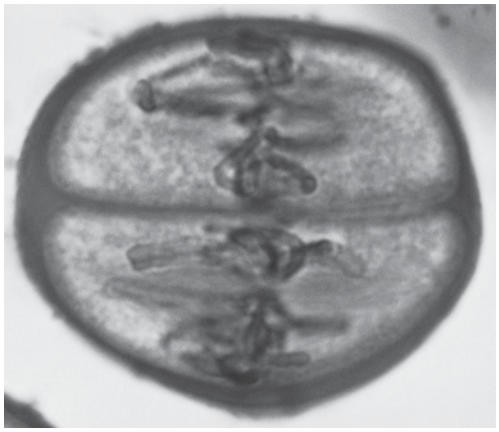

Fig. 4.1

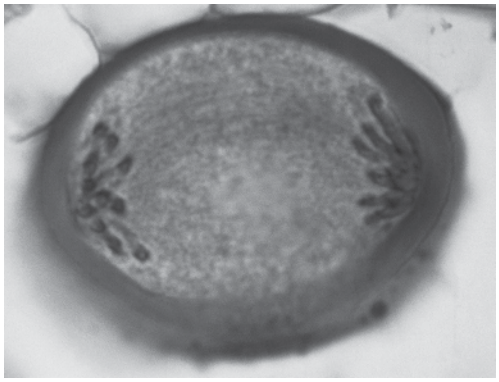

Fig. 4.2

(i) Identify the stages of meiosis shown in Fig. 4.1 **and** Fig. 4.2.

Fig. 4.1 .....

Fig. 4.2 .....

[2]

(ii) The cells formed at the end of meiosis in a *Lilium* pollen mother cell each have 12 chromosomes.

State the number of sister chromatids found in a *Lilium* pollen mother cell at the start of meiosis.

..... [1]

[Total: 8]

5 A number of diseases in humans can be treated using recombinant human proteins. These are produced by recombinant DNA technology.

(a) To produce a human protein for treatment of a disease, recombinant DNA technology needs a gene coding for the particular human protein.

Outline the different ways that can be used to obtain a gene that codes for a human protein.

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(b) Diabetes mellitus is a disease in which the blood glucose concentration cannot be controlled. Many people with diabetes mellitus use recombinant human insulin to help control their blood glucose concentration.

Before recombinant human insulin became available, animals were the main source of insulin.

Explain the advantages of using recombinant human insulin to treat diabetes.

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(c) Explain why the DNA involved in the production of recombinant human insulin is termed **recombinant** DNA.

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(d) Recombinant human insulin analogues are insulin proteins that have slightly altered amino acid sequences compared with recombinant human insulin. These analogues can be more effective than human insulin.

Synthetic genes coding for insulin analogues have been developed. The bacterium *Escherichia coli* can be used as a host for a synthetic gene for the large-scale manufacture of an analogue.

When scientists have determined the changes that are needed to produce an insulin analogue, they can obtain a synthetic gene coding for the analogue by making changes to a length of DNA using genetic engineering.

Suggest how scientists genetically engineer a synthetic gene coding for the insulin analogue **and** explain how the changes they make allow the correct analogue to be produced.

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..... [4]

[Total: 12]

6 Guard cells are located in the epidermis of the leaves of most plants. When environmental conditions change, this causes changes in guard cells that control the opening and closing of stomata.

(a) Describe the structure of guard cells.

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..... [4]

(b) Stomata have daily rhythms of opening and closing.

Fig. 6.1 shows the percentage of stomata open at different times of the day, over a period of three days, in the thale cress plant, *Arabidopsis thaliana*.

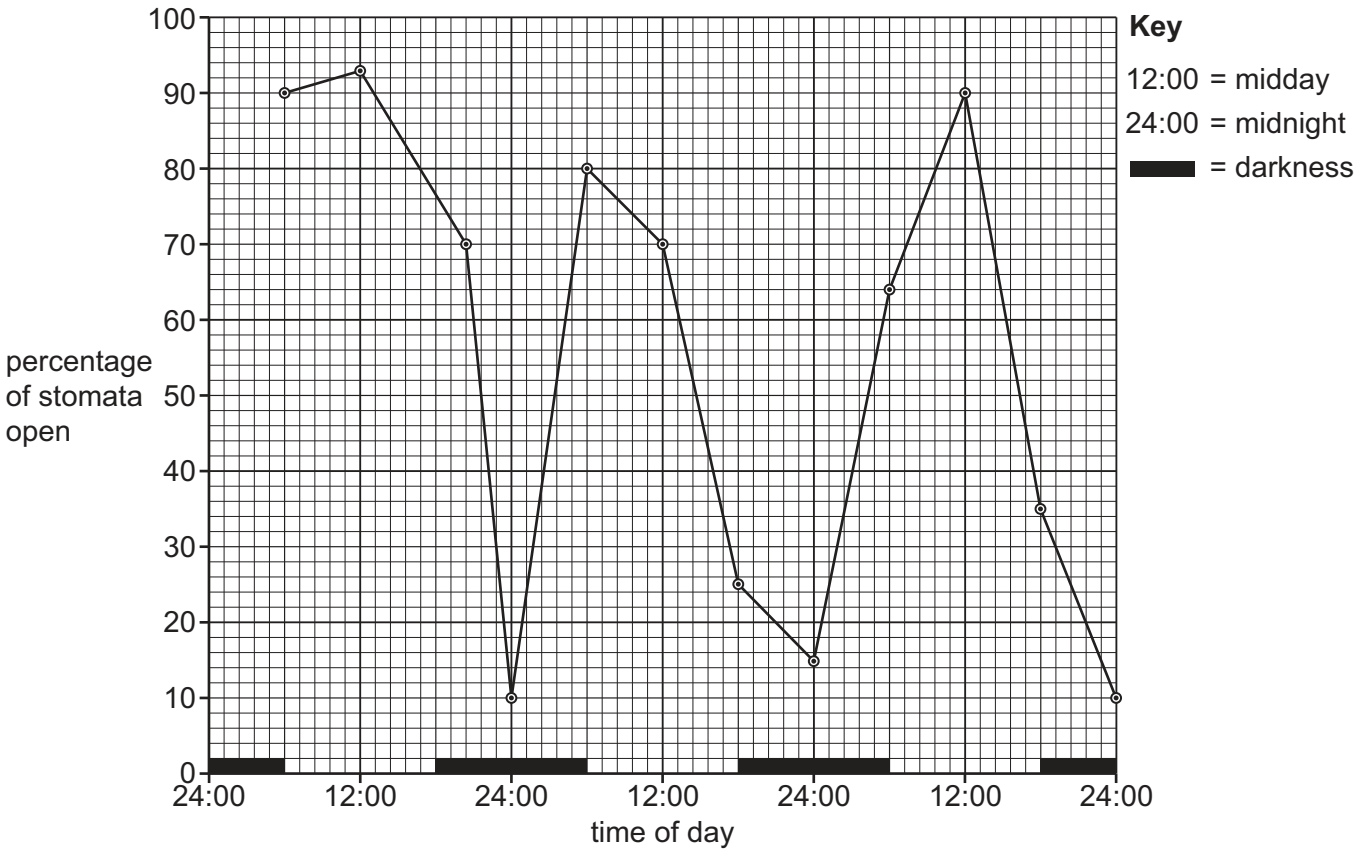

Fig. 6.1

(i) With reference to Fig. 6.1, describe the rhythm of stomatal opening and closing.

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(ii) Suggest other environmental factors, apart from the time of day, that can contribute to stomatal closure.

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..... [2]

(c) Table 6.1 shows some of the events occurring during the closure of a stoma.

The events are **not** listed in the correct order.

Table 6.1

event	description of event
A	water leaves the guard cells by osmosis
B	active transport of hydrogen ions out of the guard cells stops
C	stoma closes
D	plant is subjected to a change in environmental conditions
E	plant releases abscisic acid
F	calcium ions move into the cytoplasm of the guard cells
G	abscisic acid binds to receptors on the cell surface membrane of guard cells
H	guard cells become flaccid
I	water potential of the guard cells increases
J	potassium ions leave the guard cells

Complete Table 6.2 to show the correct order of the events shown in Table 6.1.

Three of the events have been completed for you.

Table 6.2

correct order	letter of event
1	**D**
2	.....
3	.....
4	.....
5	**F**
6	.....
7	.....
8	.....
9	.....
10	**C**

[4]

[Total: 12]

7 **(a)** An axon membrane is described as being at its resting potential when an action potential is **not** occurring.

Describe **and** explain how a resting potential of an axon membrane is maintained.

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(b) Hypokalaemia is a condition in which there is a low concentration of potassium ions (K^+) in the body. This can affect nervous coordination.

Fig. 7.1 shows a normal action potential and Fig. 7.2 shows an action potential of a person with hypokalaemia.

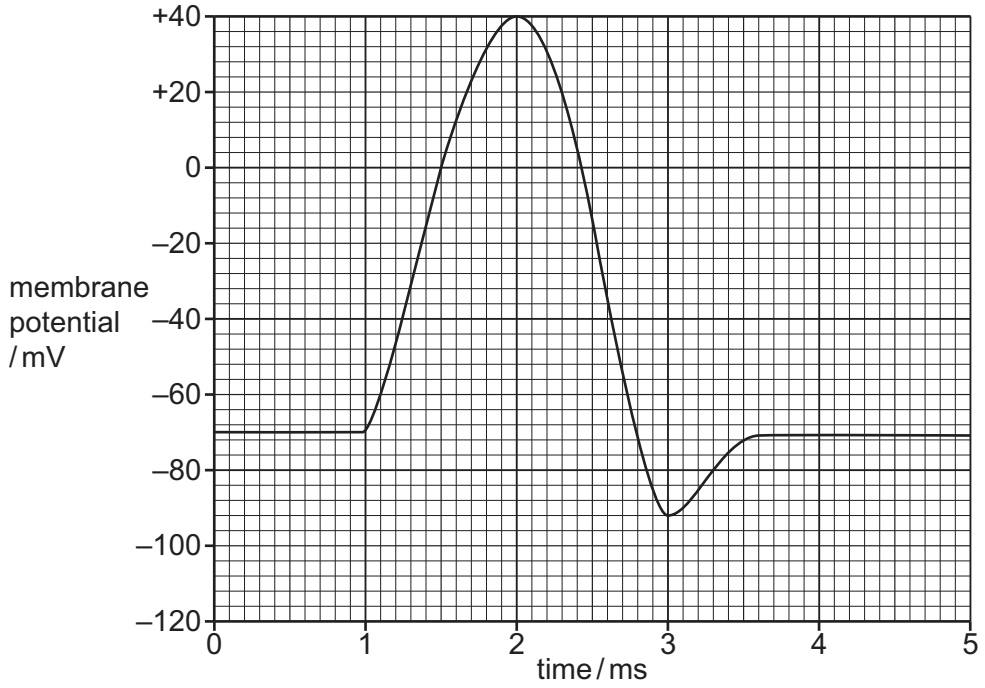

Fig. 7.1

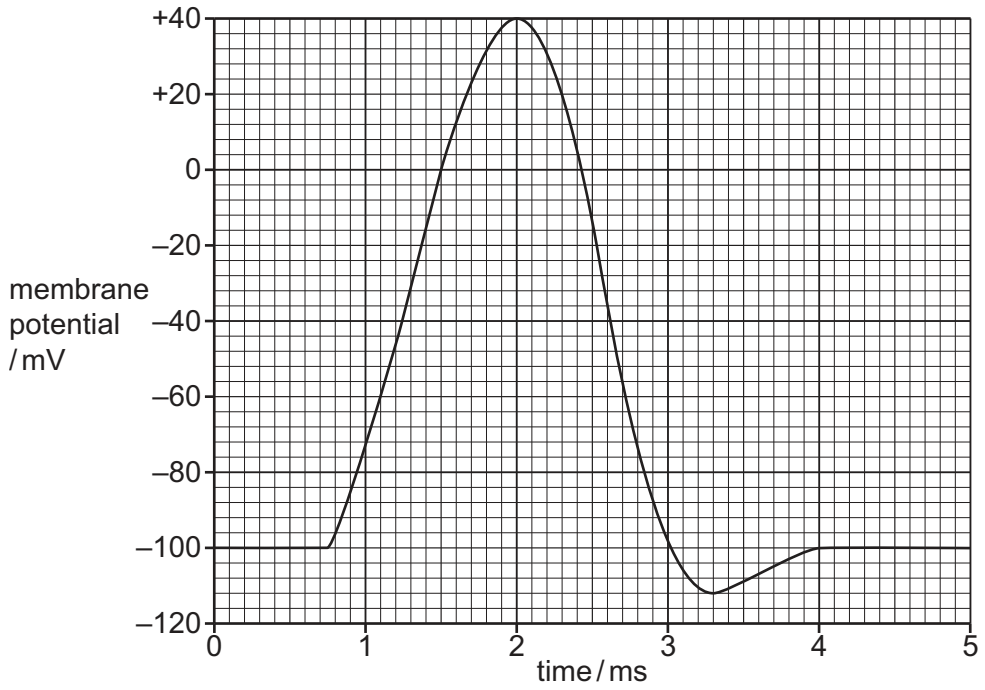

Fig. 7.2

(i) With reference to Fig. 7.1 and Fig. 7.2, describe the differences between a normal action potential and an action potential of a person with hypokalaemia.

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(ii) Suggest how hypokalaemia may affect nervous coordination.

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[Total: 11]

8 A lichen describes a mutually beneficial association of a fungus with an organism termed a photobiont. An example of a photobiont is the green alga, *Trebouxia* sp., which is a photosynthetic protoctist.

Fig. 8.1 shows lichen attached to a tree.

Fig. 8.1

(a) Outline the characteristic features of the kingdom Fungi.

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(b) Suggest how a fungus **and** a green alga benefit from the relationship shown by a lichen.

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(c) A suspension of *Trebouxia* in water was used to investigate the effect of the intensity of light on the rate of photosynthesis. The volume of oxygen released over a set period of time was used as a measure of the rate of photosynthesis at each different light intensity.

All other conditions were kept constant.

Fig. 8.2 shows how light intensity affected the volume of oxygen released by *Trebouxia*.

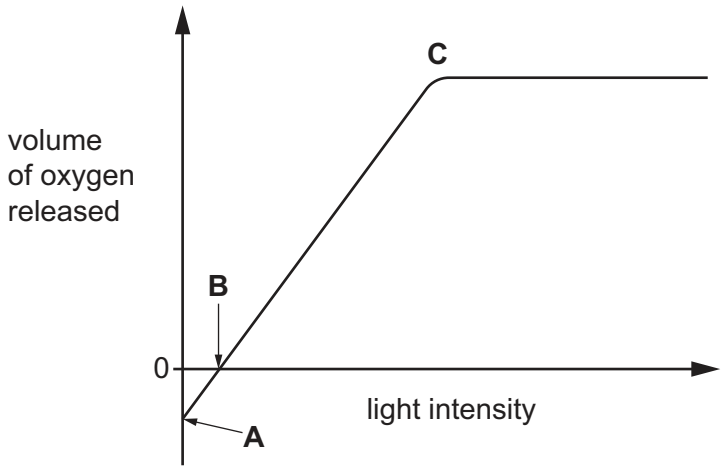

Fig. 8.2

(i) State which photosystem is involved in the release of oxygen.

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(ii) With reference to Fig. 8.2:

- explain the curve between **A** and **B**
- explain why the curve levels off after **C**.

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..... [4]

[Total: 11]

9 **(a)** The biodiversity of an area can be assessed using a variety of sampling methods.

Outline how a frame quadrat could be used to assess the biodiversity of plants in a field.

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(b) A student investigated whether the height of the soft rush plant, *Juncus effusus*, decreases with an increase in altitude on a hillside in the United Kingdom.

- 12 sites were chosen at increasing altitudes.
- The mean height of 10 plants was calculated at each altitude.

Spearman's rank correlation was used to assess the relationship between the height of the plants and altitude.

The equation for Spearman's rank correlation (r_s) is:

$$r_s = 1 - \left(\frac{6 \times \Sigma D^2}{n^3 - n}\right)$$

Key to symbols:

D = difference in rank between each pair of measurements
n = number of pairs of items in the sample

ΣD^2 was calculated to be 550.

(i) Calculate the Spearman's rank correlation for these data.

Give your answer to three decimal places.

answer ..... [3]

(ii) The null hypothesis for this investigation is: there is no correlation between the altitude and the height of the soft rush plants.

Table 9.1 shows the critical values for Spearman's rank correlation.

Table 9.1

n	***p* = 0.05**
10	0.564
12	0.504
14	0.459

Use your value of Spearman's rank correlation and Table 9.1 to state **and** explain if the null hypothesis is correct.

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..... [2]

[Total: 9]

10 (a) The grey seal, *Halichoerus grypus*, is an aquatic mammal that lives in the North Atlantic Ocean. It feeds on fish, which it hunts at depths of up to 70 metres.

Fig. 10.1 shows a grey seal.

Fig. 10.1

Diving to hunt for fish has an effect on the respiration of the grey seal.

A study was carried out to measure the blood lactate concentration of a grey seal before, during and after a dive in deep water.

Fig. 10.2 shows the results of this study.

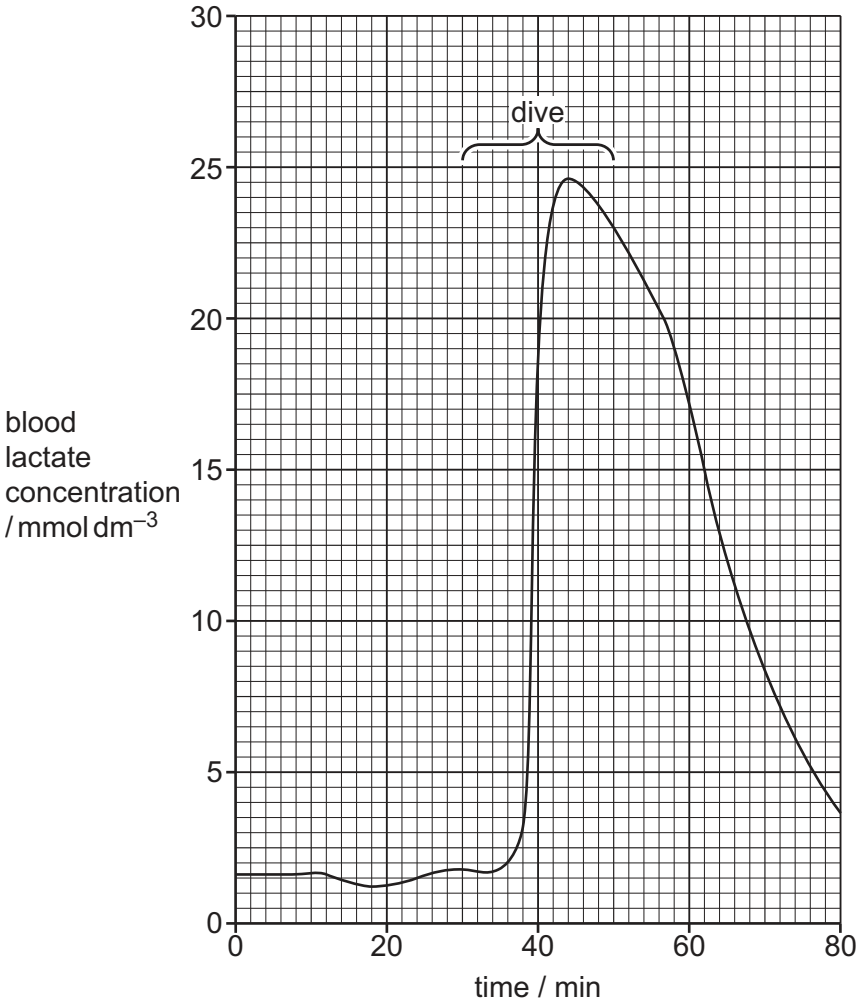

Fig. 10.2

With reference to Fig. 10.2, suggest reasons for the change in blood lactate concentration of the seal:

- during the dive
- after the dive.

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..... [4]

(b) Some seal species are classified as endangered on the IUCN Red List of Threatened Species™.

Suggest ways in which seal species may be conserved.

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..... [3]

[Total: 7]