UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/42**

Paper 4 A2 Structured Questions **May/June 2013**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

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 ink.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in Section A and **one** question from Section B.
Circle the number of the Section B question you have answered in the grid below.

Electronic calculators may be used.

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	
Section B	
9 or 10	
Total	

This document consists of **22** printed pages and **2** lined pages.

Section A

Answer **all** the questions.

For Examiner's Use

1 **(a)** A student investigated the effects of temperature and light intensity on the rate of photosynthesis of an aquatic plant.

Fig. 1.1 shows the results of the investigation.

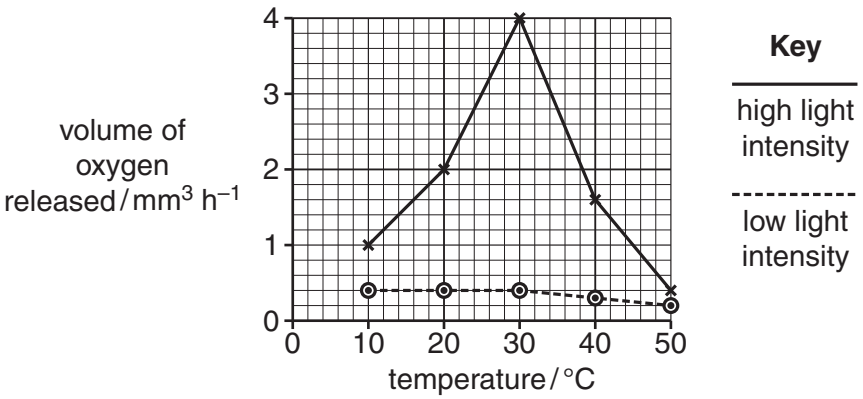

Fig. 1.1

With reference to Fig. 1.1:

(i) describe the results of the investigation

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(ii) suggest explanations for the results for high light intensity **above 30 °C**.

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(b) (i) Name the process in the light-dependent stage of photosynthesis that produces oxygen.

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(ii) Name the photosystem involved in the production of oxygen in the light-dependent stage.

..... [1]

(iii) Explain why the volume of oxygen released from the plant does not give a true rate of photosynthesis.

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..... [1]

[Total: 8]

2 The pink bollworm moth, *Pectinophora gossypiella*, is a pest of cotton crops. The size of its population can be reduced by releasing large numbers of sterile male moths into cotton fields. The sterile male moths mate with wild females from the cotton fields, but no offspring are produced.

For Examiner's Use

Over a period of three years, 20 million genetically modified (GM) sterile male moths were released in the USA. Each insect contained a gene coding for a red fluorescent protein (DsRed) taken from a species of reef coral. The added DNA also included a promoter.

(a) Explain why, in gene technology:

(i) genes for fluorescent proteins such as DsRed are now more commonly used as markers than are genes for antibiotic resistance

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(ii) a promoter needs to be included when transferring a gene from a coral into an insect.

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(b) DsRed is visible at all stages of the life cycle of the moth, but the presence of the gene in a particular individual can be confirmed by genetic fingerprinting, using gel electrophoresis.

(i) Outline the principles of gel electrophoresis.

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(ii) Explain how the presence of the gene for DsRed in a moth can be confirmed once electrophoresis is complete.

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(c) DsRed allows sterile male moths to be distinguished from wild moths when caught in an insect trap in a field of cotton plants.

Suggest why it is important to be sure whether a moth caught in such a trap is a released sterile male or a wild insect.

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..... [2]

(d) The United States Department of Agriculture has ruled that the release of sterile males to control insect pest numbers is environmentally preferable to all other alternatives.

For Examiner's Use

Suggest what information would be needed to determine whether the release of the sterile male moths, carrying the gene for DsRed, has a damaging effect on the environment.

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..... [2]

[Total: 15]

Question 3 starts on page 8

3 The filamentous fungus, *Fusarium venenatum*, is grown in continuous culture in large fermenters to provide mycoprotein for human consumption.

(a) Explain what is meant by the term *continuous culture*.

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(b) In an investigation into the growth of the fungus in culture, several factors were varied including:

- temperature
- concentration of the carbon source
- concentration of the nitrogen source.

Some of the results are shown in Table 3.1.

Table 3.1

temperature /°C	concentration of carbon source / g dm^{-3}	concentration of nitrogen source / g dm^{-3}	dry mass of fungus / g dm^{-3}
25	7.0	2.9	3.1
25	14.0	3.5	4.3
30	7.0	3.5	4.8
30	14.0	2.9	4.2

(i) Describe the effect of temperature on the growth of the fungus at the different concentrations of the carbon source.

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(ii) Explain why the fungus needs sources of carbon and nitrogen.

For Examiner's Use

carbon .....

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nitrogen .....

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..... [3]

[Total: 8]

4 **(a)** The production of ATP by oxidative phosphorylation takes place in the electron transport chain in a mitochondrion.

(i) State the part of the mitochondrion in which the electron transport chain is found.

..... [1]

(ii) Describe briefly where the electrons that are passed along the electron transport chain come from.

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..... [3]

(iii) Describe the role of oxygen in the process of oxidative phosphorylation.

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(b) The brain depends on a constant supply of oxygen for aerobic respiration. Anaerobic respiration is not sufficient to keep neurones in the brain alive. This is because neurones require especially large amounts of ATP. Up to 80% of the ATP is used to provide energy for the Na^+/K^+ pump.

For Examiner's Use

When a person suffers a stroke, blood flow to part of the brain is stopped, so some neurones receive no oxygen. ATP production by oxidative phosphorylation stops. Fig. 4.1 shows some of the ways in which the lack of ATP affects a neurone in the brain.

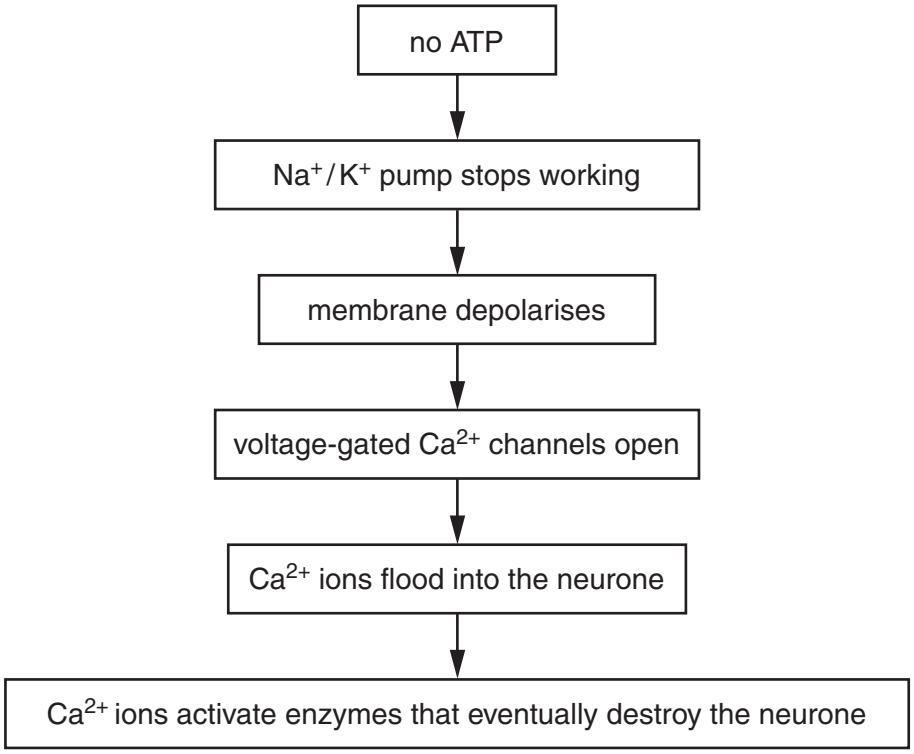

Fig. 4.1

(i) Explain why the membrane of the neurone depolarises when the Na^+/K^+ pump stops working.

For Examiner's Use

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(ii) Suggest why calcium ions flood into the neurone when the Na^+/K^+ pump stops working.

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(c) The freshwater turtle, *Trachemys scripta*, is able to survive for long periods in conditions of very low oxygen concentration. As in humans, the rate of activity of the Na^+/K^+ pump in the neurones in its brain falls sharply. However, in turtles this does not result in damage to these cells.

For Examiner's Use

A better understanding of how the neurones in the turtle's brain survive in these conditions could lead to new treatments for people who have suffered a stroke.

Experiments show that, in turtle brain neurones, in conditions of low oxygen availability:

- most ion channels in the cell surface membranes immediately close
- after about four hours, the quantity of mRNA involved in the synthesis of proteins used to build ion channels, falls to less than one fifth of normal concentrations.

(i) Suggest how the closure of ion channels in the neurones of the turtle in very low oxygen concentrations could allow the cells to survive.

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(ii) Suggest what causes the quantity of mRNA for protein channels to fall.

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[Total: 16]

Question 5 starts on page 14

5 Fig. 5.1 shows some of the steps involved in in-vitro fertilisation (IVF).

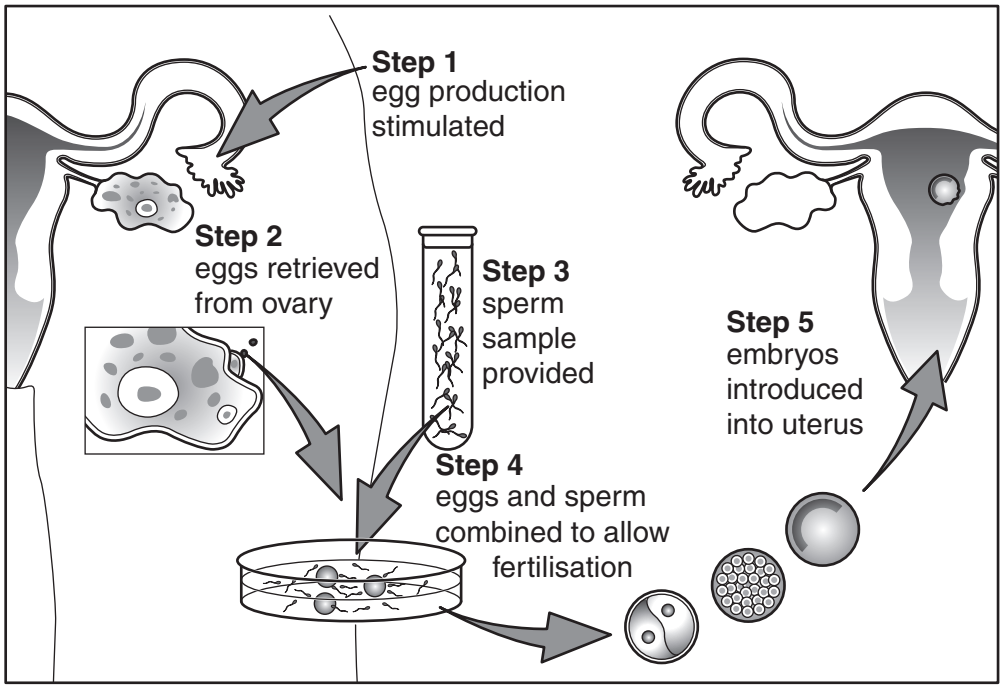

Fig. 5.1

(a) Explain how egg production is stimulated at **step 1**.

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..... [2]

(b) Following **step 3** in Fig. 5.1, the sperm sample is placed in a solution containing various nutrients and other substances, for up to one hour, before being added to the eggs.

For Examiner's Use

Explain why this is done.

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..... [2]

(c) In 2010, researchers found that they could predict with 93% certainty which embryos produced by in-vitro fertilisation would develop into healthy babies when implanted into the uterus.

Their technique involved the use of time-lapse microscopy. The successful embryos met three criteria:

- the first cytokinesis lasted between 0 and 33 minutes
- the time interval between the first and second cell division was between 7.8 and 14.3 hours
- the time interval between the second and third cell division was between 0 and 5.8 hours.

(i) Suggest **one** advantage of the use of this new technique in the IVF procedure.

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..... [2]

(ii) Suggest **one** disadvantage of the use of this technique.

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..... [2]

[Total: 8]

For Examiner's Use

6 **(a)** The human kidneys process 1200 cm^3 of blood every minute. This 1200 cm^3 of blood contains 700 cm^3 of plasma. As blood passes through the glomeruli of the kidneys, 125 cm^3 of fluid passes into the renal capsules (Bowman's capsules). This fluid is called the glomerular filtrate and is produced by a process called ultrafiltration.

(i) Calculate the percentage of plasma that passes into the renal capsules.

Show your working and **give your answer to one decimal place**.

answer .....% [2]

(ii) Explain how the **structures** of the glomerular capillaries and the podocytes are adapted for ultrafiltration.

glomerular capillaries .....

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podocytes .....

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..... [4]

(b) The glomerular filtrate then passes through the proximal convoluted tubule.

For Examiner's Use

Fig. 6.1 is a transverse section through part of the proximal convoluted tubule.

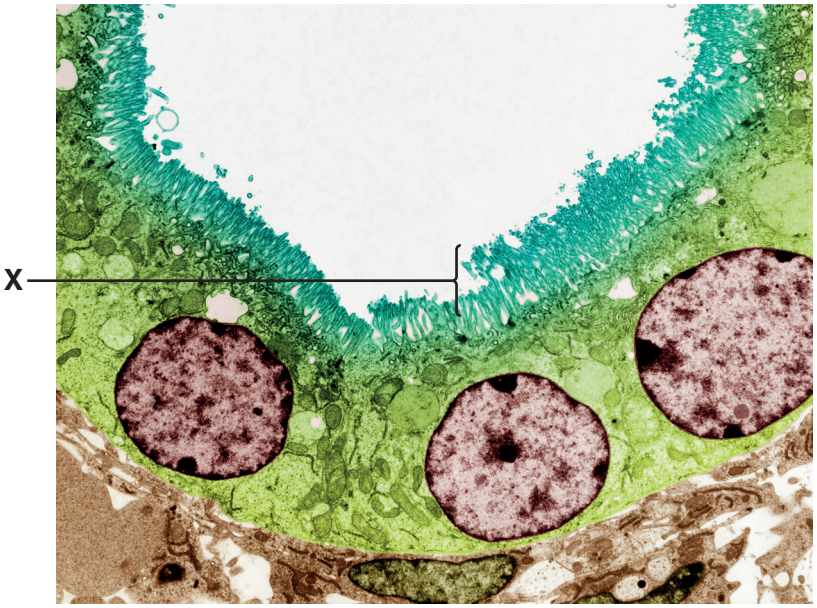

Fig. 6.1

(i) Name the structures labelled **X**.

..... [1]

(ii) Explain why the epithelial cells of the proximal convoluted tubule have many mitochondria in them.

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(iii) Of the 125 cm^3 of glomerular filtrate that enters the renal capsules each minute, only 45 cm^3 reaches the loops of Henlé.

Name **two** substances that are reabsorbed into the blood from the proximal convoluted tubule, **apart from water**.

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..... [2]

[Total: 11]

7 Resistance to the poison warfarin is now extremely common in rats. Warfarin inhibits an enzyme in the liver, vitamin K epoxide reductase, that is necessary for the recycling of vitamin K. This vitamin is involved in the production of substances required for blood clotting.

- Rats susceptible to warfarin die of internal bleeding.
- Rats that are homozygous for resistance to warfarin do not suffer from internal bleeding when their diet provides more than 70 μg of vitamin K per kg body mass per day.
- Heterozygous rats are resistant to warfarin when their diet provides about 10 μg of vitamin K per kg body mass per day.

(a) Using appropriate symbols, complete the genetic diagram to show how two resistant rats can produce warfarin-susceptible offspring.

key to symbols

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parental phenotypes	resistant male	resistant female
parental genotypes		
gametes		
offspring genotypes		
offspring phenotypes		

[3]

(b) Rats that are homozygous for warfarin resistance have a low survival rate in the wild. Suggest why this is so.

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..... [1]

(c) Warfarin can be safely given to humans who are at risk of unwanted blood clots. The clotting time of the blood is measured regularly and the warfarin dose is varied accordingly.

For Examiner's Use

Suggest, giving a reason, the type of inhibition warfarin has on the enzyme vitamin K epoxide reductase.

type of inhibition .....

reason .....

..... [2]

(d) The allele for warfarin resistance may have originated by a single base substitution and resulted in a modified vitamin K epoxide reductase.

Explain how a single base substitution may affect the phenotype of an organism.

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[Total: 9]

8 The Death Valley region of Nevada in the USA used to have an extensive lake system. Approximately 20 000 years ago the lakes started to dry up and now consist of isolated small pools. Four different species of the desert pupfish have been found living in these pools. Evidence indicates that over 20 000 years ago there was only one species of pupfish living in the lake system.

Fig. 8.1 shows a desert pupfish.

Fig. 8.1

(a) Explain how the change from an extensive lake system to just a few pools could have resulted in the evolution of four new species of desert pupfish.

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(b) State how environmental factors can act as stabilising forces of natural selection in an isolated pool, after the initial evolution of a new species of desert pupfish.

For Examiner's Use

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(c) Suggest what may happen to the desert pupfish if water levels rise and the pools once more form an extensive lake system.

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[Total: 10]

[Turn over

Section B

Answer **one** question.

For Examiner's Use

9 **(a)** Bacteria are members of the kingdom *Prokaryota*. Describe the main features of a bacterial cell. [8]

(b) Outline the use of bacteria in the extraction of metals from ores. [7]

[Total:15]

10 **(a)** Describe the structure of a chloroplast. [7]

(b) Explain how rice is adapted to growing in flooded fields. [8]

[Total:15]

For Examiner's Use

For Examiner's Use