Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5141810447

BIOLOGY **9700/43**

Paper 4 A2 Structured Questions **May/June 2014**

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 in the spaces provided at the top of this page.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
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.
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.

Electronic calculators may be used.

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.

DC (NF/CGW) 91959

CAMBRIDGE International Examinations

Section A

Answer **all** the questions.

1 (a) The unicellular green alga, *Chlorella*, a photosynthetic protoctist, was originally studied for its potential as a food source. Although large-scale production proved to be uneconomic, the many health benefits provided by *Chlorella* mean that it is now mass produced and harvested for use as a health food supplement.

Fig. 1.1 shows cells of *Chlorella*.

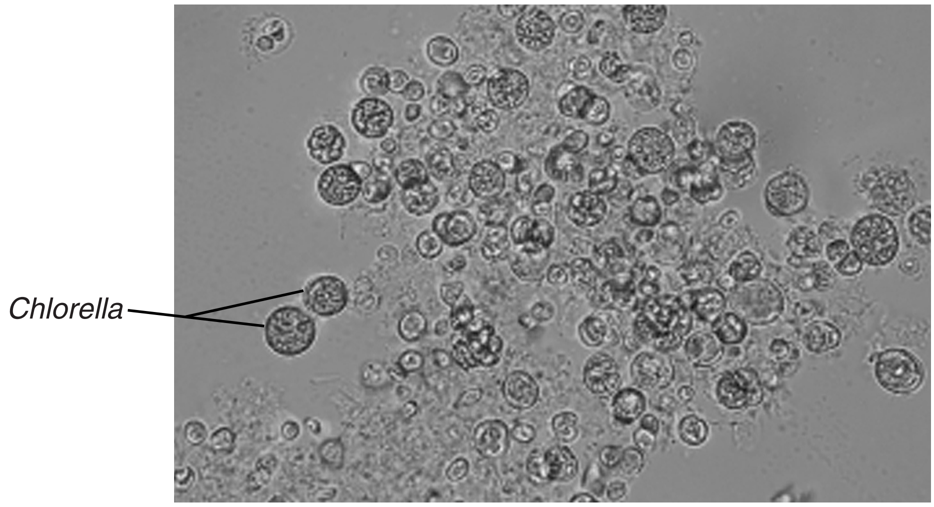

Fig. 1.1

In one study into the productivity of *Chlorella*, carbon dioxide concentration was altered to investigate its effects on the light-independent stage of photosynthesis.

- A cell suspension of *Chlorella* was illuminated using a bench lamp.
- The suspension was supplied with carbon dioxide at a concentration of 1% for 200 seconds.
- The concentration of carbon dioxide was then reduced to 0.03% for a further 200 seconds.
- The concentrations of RuBP and GP (PGA) were measured at regular intervals.
- Throughout the investigation the temperature of the suspension was maintained at 25 °C.

The results are shown in Fig. 1.2.

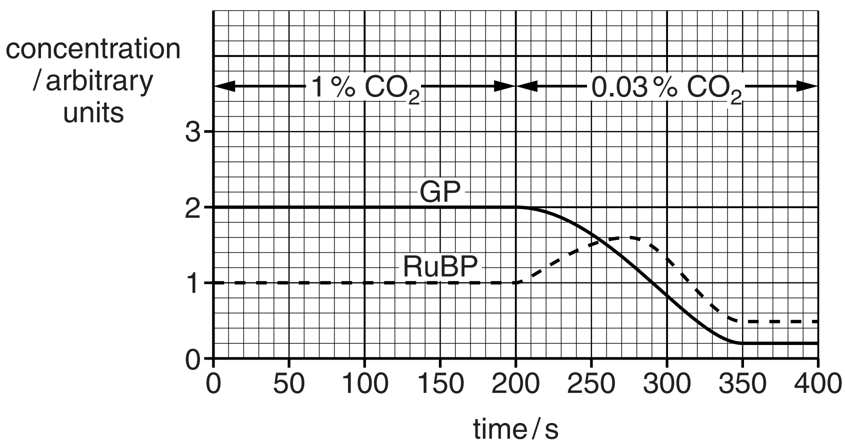

Fig. 1.2

(i) State **precisely** where in the chloroplast RuBP and GP are located.

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(ii) Explain why the concentration of RuBP changed between 200 and 275 seconds.

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....[2]

(iii) Calculate the rate of decrease per second in the concentration of GP between 200 and 350 seconds.

Show your working and give your answer to **two decimal places**.

answer .... arbitrary units per second [2]

(b) Explain how the decrease in the concentration of GP leads to a decreased harvest for commercial suppliers of *Chlorella*.

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....[2]

[Total: 7]

2 Russian scientists have discovered the fruits of a flowering plant, *Silene stenophylla*, in the food store in a burrow of a ground squirrel in frozen sediments in Siberia.

Dating techniques suggest that the fruits were stored by the ground squirrel about 32 000 years ago, shortly before the ground became permanently frozen.

Tissue samples were taken from the fruits and grown in a nutrient culture medium. After treatment with plant hormones to stimulate the growth of roots and shoots, 36 complete plants were produced.

These 'regenerated' plants, which looked identical to one another, flowered and after cross-pollination, produced seeds that were able to germinate.

(a) Explain why cross-pollination produces more genetic variation among the offspring than self-pollination.

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(b) The flowers of modern-day *S. stenophylla* look similar, but not identical, to the flowers of the 'regenerated' plants.

Outline how DNA sequencing could be used to compare the DNA of modern-day and 'regenerated' *S. stenophylla*.

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(c) Suggest a simple experiment, using plants of modern-day and 'regenerated' *S. stenophylla* to find out whether, after 32 000 years, they are still the same species.

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[Total: 9]

3 **(a)** Wheat, *Triticum aestivum*, owes its origin to hybridisation involving three different, but related, species of grass, **A**, **B** and **C**.

Each of these species had seven pairs of chromosomes (2n = 14).

The hybridisation process is shown in Fig. 3.1.

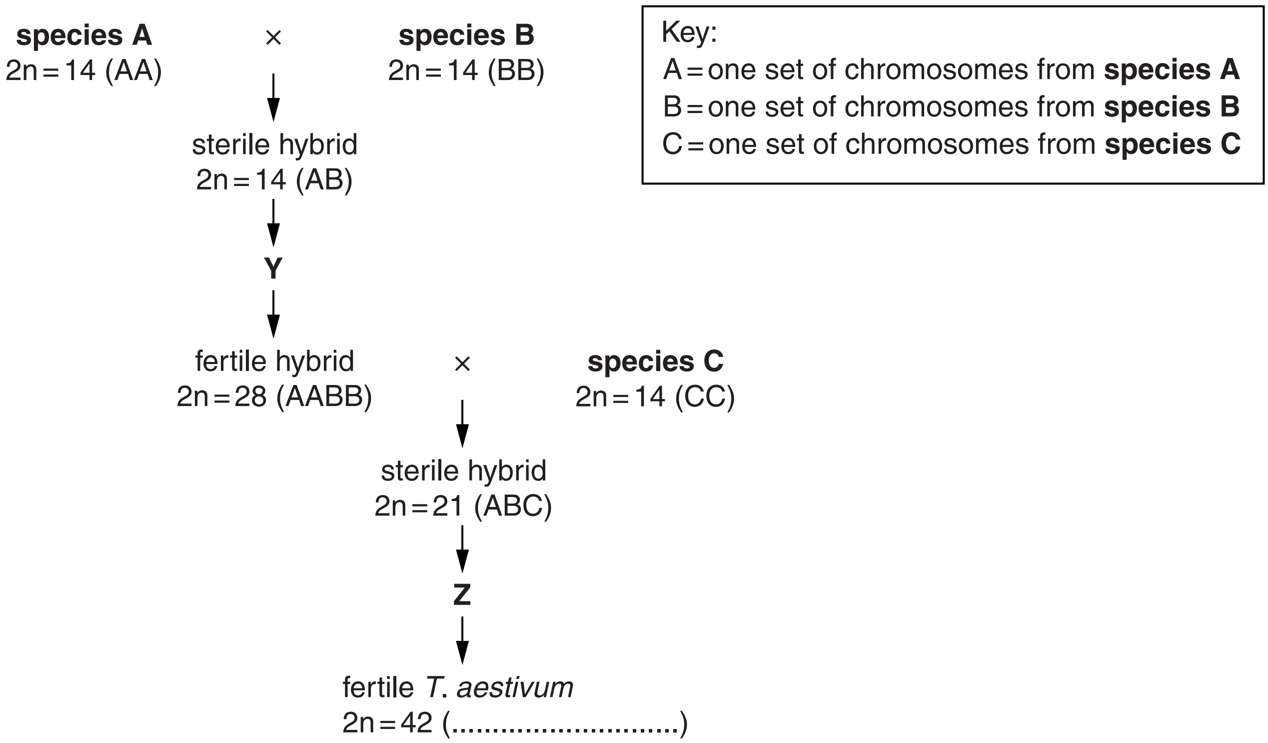

Fig. 3.1

(i) Using the symbols in the key, complete Fig. 3.1 by writing in the chromosome sets of *T. aestivum*. [1]

(ii) At the points labelled **Y** and **Z** in the hybridisation process, a fertile hybrid was produced from a sterile hybrid.

Explain why the hybrid (AB) is sterile **and** what occurred at the point labelled **Y** in Fig. 3.1.

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Question 3 continues on page 8

(b) In 2012, permission was granted for a field trial in the UK of genetically modified *T. aestivum*. The wheat carries a gene, taken from peppermint plants, that results in the wheat leaves releasing a volatile, non-toxic chemical, (E)-β-farnesene (Eβf), into the atmosphere.

Eβf is not only produced by various species of plants. It is also secreted by aphids when they are disturbed by a predator.

Two experiments have been performed into the effect of Eβf on the behaviour of aphids feeding on leaves in closed containers.

Experiment 1
Either 10 cm^3 of air from a syringe that contained plant leaves that secrete Eβf
or 10 cm^3 of air from a syringe with no such leaves
was added to the containers of feeding aphids.

Experiment 2
Either 20 cm^3 of air containing 50ng of Eβf
or 20 cm^3 of air containing no Eβf
was added to the containers of feeding aphids.

In both experiments, the number of aphids that stopped feeding and moved away from the food leaves was counted. The results are shown in Table 3.1.

Table 3.1

	Experiment 1		Experiment 2	
air added to containers of feeding aphids	10 cm^3 air that had been in contact with leaves secreting Eβf	10 cm^3 air that had not been in contact with leaves secreting Eβf	20 cm^3 air containing 50ng Eβf	20 cm^3 air containing no Eβf
number of aphids in containers	99	113	132	106
number of aphids that stopped feeding and moved away from the food leaves	54	1	111	0

(i) Discuss the extent to which the results of these experiments support the idea that Eβf is an alarm signal for aphids.

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(ii) Other experiments show that Eβf attracts predators of aphids, such as ladybirds.

Explain how growing genetically modified wheat secreting Eβf could increase the yield of wheat.

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(iii) Suggest why growing this genetically modified wheat might be acceptable to people who object to the growth of genetically modified insect-resistant maize or cotton.

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[Total: 15]

4 (a) Spermatogenesis takes place in the seminiferous tubules, in the testis. Fig. 4.1 is a diagram showing some of the cells in a small sector of a seminiferous tubule.

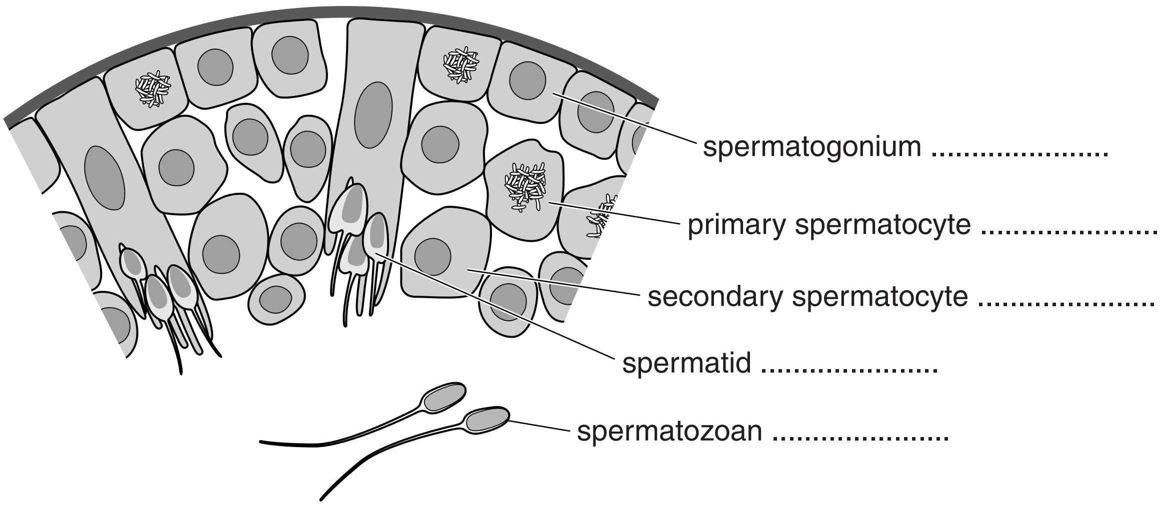

Fig. 4.1

(i) On Fig. 4.1, state whether each of the labelled cells is haploid or diploid.

Write **n** if the cell is haploid and **2n** if the cell is diploid. [2]

(ii) Spermatogenesis involves meiosis, mitosis, growth and maturation.
State which of these processes is involved in each of the following steps in spermatogenesis.

spermatogonium to primary spermatocyte

....

spermatid to spermatozoan (sperm)

....[2]

(iii) State **one** role of a Sertoli cell.

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....[1]

(b) In some men, spermatogenesis does not take place successfully and the sperm that are produced are unable to fertilise an egg. A form of IVF called intra-cytoplasmic sperm injection (ICSI) may enable them to father a child with their partner.

In ICSI, a sperm cell is inserted into a secondary oocyte using a very tiny needle.

Outline the treatment required in order to obtain mature oocytes as part of an IVF procedure.

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(c) One approach to helping an infertile man to father children is to extract immature spermatids from his testes and culture them in the laboratory, in conditions that may increase the number of them that develop into functioning sperm. These can then be used for IVF.

An investigation was carried out to see if adding reproductive hormones to a culture of immature spermatids affects their development.

Samples of spermatids were collected from men in whom the spermatids did not normally develop into functioning sperm. The spermatids were cultured in a suitable liquid medium, kept at 30 °C.

The samples were divided into four groups. No hormones were added to one group. FSH, testosterone or both were added to the other groups. The percentage of spermatids that developed into elongated cells in each group after 24 hours and 48 hours was calculated. The results are shown in Table 4.1.

Table 4.1

hormones added	**percentage of spermatids that developed into elongated cells**	
	after 24 hours	**after 48 hours**
none	20	21
FSH	32	31
testosterone	21	19
FSH and testosterone	39	44

(i) With reference to Table 4.1, describe the effects of adding reproductive hormones on the development of the spermatids **after 48 hours**.

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(ii) Suggest a reason for the apparent reduction in the percentage of elongated cells between 24 hours and 48 hours in some of the samples.

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(iii) Suggest why the culture medium was maintained at a temperature of 30 °C, and not at core body temperature (37 °C).

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....[2]

[Total: 16]

5 Deer mice, *Peromyscus maniculatus*, are small rodents that live in North America. Like all mammals, their blood contains haemoglobin which combines with oxygen in the lungs, and unloads its oxygen in respiring tissues.

Deer mice show variation in their genotypes for the genes that code for the α-polypeptide chain of haemoglobin. In most populations of deer mice, the majority of individuals have the genotype A^1A^1, while a smaller number have the genotype A^0A^0.

(a) In mice with the genotype A^1A^1, the amino acid at position 64 in the α-polypeptide chain is aspartic acid. In mice with the genotype A^0A^0, the amino acid at this position is glycine.

Suggest how the change from aspartic acid to glycine in the α-polypeptide chain could have been brought about.

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....[2]

(b) The genotypes of deer mice from three different populations, each living at a different altitude, were analysed. Fig. 5.1 shows the relative proportions of deer mice with aspartic acid (white areas) and glycine (black areas) at position 64 in the α-polypeptide of their haemoglobin.

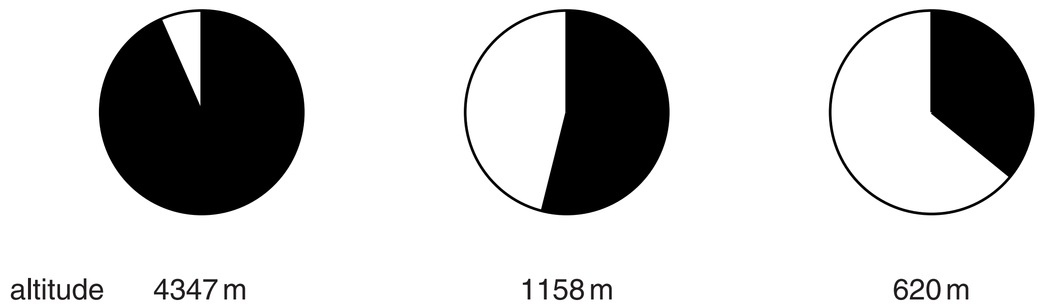

Fig. 5.1

(i) Describe the effect of altitude on the frequency of the haemoglobin alleles in these populations of deer mice.

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....[2]

(ii) The partial pressure of oxygen is relatively low at high altitudes. Haemoglobin containing glycine at position 64 in the α-polypeptide chain has a higher affinity for oxygen than haemoglobin with aspartic acid at this position.

Suggest how natural selection could account for the difference in allele frequency in deer mice living at high altitudes and low altitudes.

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[Total: 8]

6 **(a)** The passage below outlines how sensory receptors work.

Complete the passage by using the most appropriate scientific term(s).

A sensory receptor cell responds to a stimulus by opening ion .... in its cell surface membrane. Sodium ions flood into the cell causing the membrane to become .... This is called the .... potential. If this potential is large enough to reach a .... then an action potential is transmitted to the central nervous system. An increase in the strength of the stimulus will result in an increase in the .... of action potentials transmitted. [5]

(b) Describe how an action potential is **transmitted** along a sensory neurone in a mammal.

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[Total: 10]

Question 7 starts on page 18

7 Occasionally during meiosis, homologous chromosomes fail to separate at anaphase. This is known as non-disjunction. Turner's syndrome is the most common chromosome mutation in human females. It can occur due to non-disjunction in meiosis during gametogenesis. Some resulting gametes will be missing an X chromosome.

Some forms of Turner's syndrome occur when one of the pair of X chromosomes is not missing but has become damaged. The damaged X chromosome may have been broken and re-formed so that part of its structure is lost.

Fig. 7.1 is a diagram of a normal X chromosome and two forms of 'damaged' X chromosomes, X_1 and X_2.

- In X_1, a section of the 'p' arm of the chromosome is missing. This deletion leads to reduced height of the female and abnormalities such as narrowing of the aorta.
- In X_2, a section of the 'q' arm of the chromosome is missing. This deletion leads to little or no development of the ovaries.

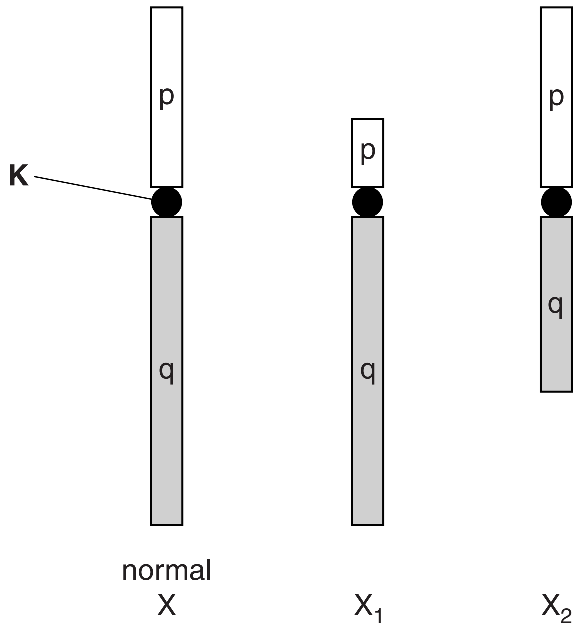

Fig. 7.1

(a) Name structure **K**.

....[1]

(b) Explain why X_1 and X_2 result in different phenotypes.

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....[2]

(c) Mothers with the X_1 form of Turner's syndrome can pass on the chromosome mutation to their daughters but not to their sons.

Complete the genetic diagram below to show how the chromosome mutation X_1 may be passed on to daughters from a mother with Turner's syndrome.

parental phenotypes	female with Turner's syndrome	normal male
parental genotypes	XX_1	
gametes		
genotypes of daughters		
phenotypes of daughters		

[4]

[Total: 7]

8 **(a)** A mitochondrion contains DNA and ribosomes and is the organelle in which aerobic respiration takes place.

Suggest the functions of the DNA and ribosomes **in a mitochondrion**.

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....[3]

(b) Oxidative phosphorylation takes place in the mitochondrion.

Different stages of oxidative phosphorylation are listed below.

They are **not** listed in the correct order.

stage	description of stage
Q	protons diffuse through the channel protein into the matrix
R	a proton gradient is set up across the crista
S	hydrogen atoms split into protons and electrons
T	protons combine with electrons and oxygen atoms to form water
U	electrons are passed from carrier to carrier
V	reduced NAD releases hydrogen atoms to cytochrome carriers
W	energy from electron transfer is used to pump protons into the intermembrane space
X	ATP synthase produces ATP

Complete Table 8.1 to show the correct order of the stages.

Two of the stages have been done for you.

Table 8.1

correct order	letter of stage
1	**V**
2	....
3	....
4	....
5	**R**
6	....
7	....
8	....

[4]

(c) ATP can be converted to ADP and inorganic phosphate by the enzyme ATPase.

State the **type** of reaction taking place.

.... [1]

(d) Some parasitic worms, such as tapeworms, live in a mammalian gut where there is no oxygen.

Suggest how a tapeworm produces ATP in this environment.

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[Total: 13]

Section B

Answer **one** question.

9 **(a)** It has been stated that the kingdom Protoctista can be described as a very diverse group of organisms that share only a few common features.

Discuss the ways in which members of the kingdom Protoctista are similar to each other and ways in which they differ. [7]

(b) With reference to any **named** species of plant or animal, explain why this species is considered to be endangered **and** outline the reasons that have caused it to become endangered. [8]

[Total: 15]

10 **(a)** Describe the action of penicillin on bacteria. [8]

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

[Total: 15]

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