Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7360030883

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2024**

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. Any blank pages are indicated.

1 Fig. 1.1 outlines the effect of antidiuretic hormone (ADH) on the cells of the collecting duct. The cell-signalling mechanism of ADH is similar to that of glucagon on liver cells.

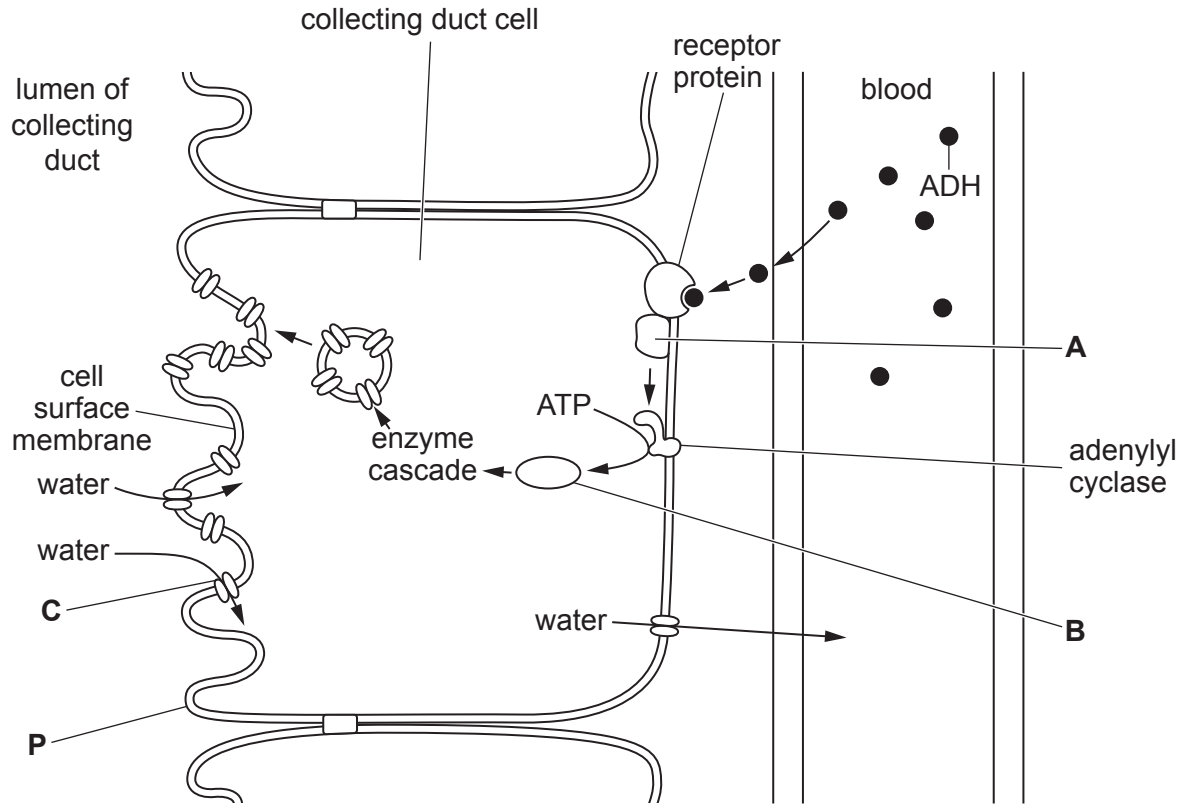

Fig. 1.1

(a) Name structures **A**, **B** and **C**.

A .....

B .....

C .....

[3]

(b) ADH is secreted by the posterior pituitary gland when the water potential of the blood decreases.

Suggest reasons why the water potential of the blood may decrease.

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(c) Diabetes insipidus is a condition affecting osmoregulation by the kidney. One form of diabetes insipidus is caused by a tumour in the pituitary gland, which results in a decreased secretion of ADH.

Suggest the symptoms that would occur in a person with diabetes insipidus.

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(d) Neurogenic diabetes insipidus (NDI) is another form of diabetes insipidus. In NDI, ADH molecules cannot bind to the receptor proteins located in the cell surface membranes of the cells of the collecting duct.

With reference to Fig. 1.1, explain the effect on the cell surface membrane labelled **P** if ADH cannot bind to the receptor proteins.

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..... [2]

(e) NDI is caused by a recessive allele of the gene coding for the receptor protein. The gene is located on the X chromosome.

Explain why a man with NDI could **not** have inherited the condition from his father.

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..... [2]

[Total: 12]

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2 Phenotypic variation exists in many forms.

(a) Some examples of phenotypic variation in plants and animals are described in Table 2.1.

Complete Table 2.1 by stating whether the cause of variation for each described example is likely to be due to:

- genetic factors, V_G
- environmental factors, V_E
- a combination of genetic and environmental factors, $V_G + V_E$.

Table 2.1

description of phenotypic variation	cause of variation
Tomato plants grown in a glasshouse and grown outside vary in the yield of tomatoes they produce. Seventeen genes associated with tomato yield have been identified.	
New strawberry plants from the variety called Sweet Ann are made by asexual reproduction. The new plants grow to different sizes and produce different numbers of fruit.	
The domestic cat has a blood group system with three possible blood types: A, B and AB. The blood types are determined by antigens present on the cell surface membrane of red blood cells.	
Over 50 genes have variants that are associated with excessive weight gain in humans. Other risk factors for excessive weight gain include diet and exercise.	
Resting heart rate in humans varies between different individuals. Some factors that influence resting heart rate include: biological sex, family history of heart disease, number of cigarettes smoked, medication taken.	

[3]

(b) Name a spontaneous, random event occurring in cells that can be a source of phenotypic variation.

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(c) Other than the event named in **(b)**, describe the features of sexual reproduction that contribute to the production of genetically different offspring.

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[Total: 7]

[Turn over

3 In plants and humans, the phenotype of an organism is determined by the genotype and the environment.

(a) Plants from the genus *Primula* have different petal colours. The presence of the pigment malvidin results in blue petals.

The metabolic pathway for malvidin synthesis is controlled by gene ***T***/***t***. The presence of the dominant allele **T** results in blue petals.

Another gene, gene ***D***/***d***, at a different locus, also influences the malvidin synthesis pathway. When the dominant allele **D** is present, its gene product suppresses the malvidin synthesis pathway. This is summarised in Fig. 3.1.

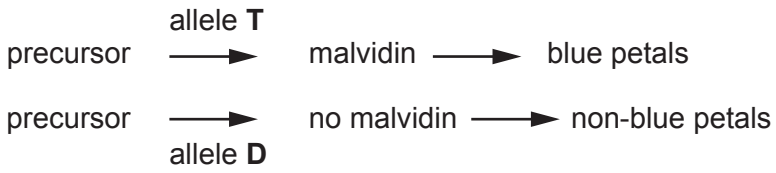

Fig. 3.1

A genetic cross was carried out between two plants heterozygous at both gene loci. The resulting offspring genotypes are shown in a Punnett square in Fig. 3.2.

	TD	**Td**	**tD**	**td**
TD	TTDD	TTDd	TtDD	TtDd
Td	TTDd	TTdd	TtDd	Ttdd
tD	TtDD	TtDd	ttDD	ttDd
td	TtDd	Ttdd	ttDd	ttdd

Fig. 3.2

(i) State which of the genotypes shown in Fig. 3.2 have blue petals.

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..... [1]

(ii) State the ratio of non-blue to blue petals for the cross shown in Fig. 3.2.

..... [1]

(iii) Name the type of gene interaction that has caused the offspring ratio you have stated in **(a)(ii)**.

..... [1]

(iv) Gene ***T***/***t*** and gene ***D***/***d*** code for proteins that are involved in the control of the production of malvidin.

Discuss the possible roles of the proteins coded for by gene ***T***/***t*** and gene ***D***/***d*** in the control of the production of malvidin.

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(b) Some humans have the inherited condition haemophilia.

Explain the relationship between the ***F8*** gene, factor VIII and the condition haemophilia.

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[Total: 12]

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4 Genetic engineering is a technique used to modify the genetic material of a specific organism to change a characteristic.

(a) (i) Genetic engineering uses specific enzymes and commonly involves the use of plasmids for the transfer of genes into an organism.

Four enzymes that are used in genetic engineering techniques involving plasmids are:

- restriction endonuclease
- DNA ligase
- DNA polymerase
- reverse transcriptase.

Outline the role of these enzymes in genetic engineering involving plasmids.

restriction endonuclease .....

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DNA ligase .....

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DNA polymerase .....

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reverse transcriptase .....

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[4]

(ii) Explain why a promoter, as well as the desired gene, is often transferred into an organism.

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(b) The production of insulin by genetic engineering involves the use of plasmids and the bacterium *Escherichia coli*.

Multiple copies of a gene that codes for an insulin polypeptide are mixed with cut plasmids.

During the process, only some of the plasmids that are taken up by host bacteria will lead to the expression of insulin polypeptides.

Fig. 4.1 shows:

- a cut plasmid and the gene coding for the insulin polypeptide
- three different plasmids that have been formed as part of the genetic engineering process.

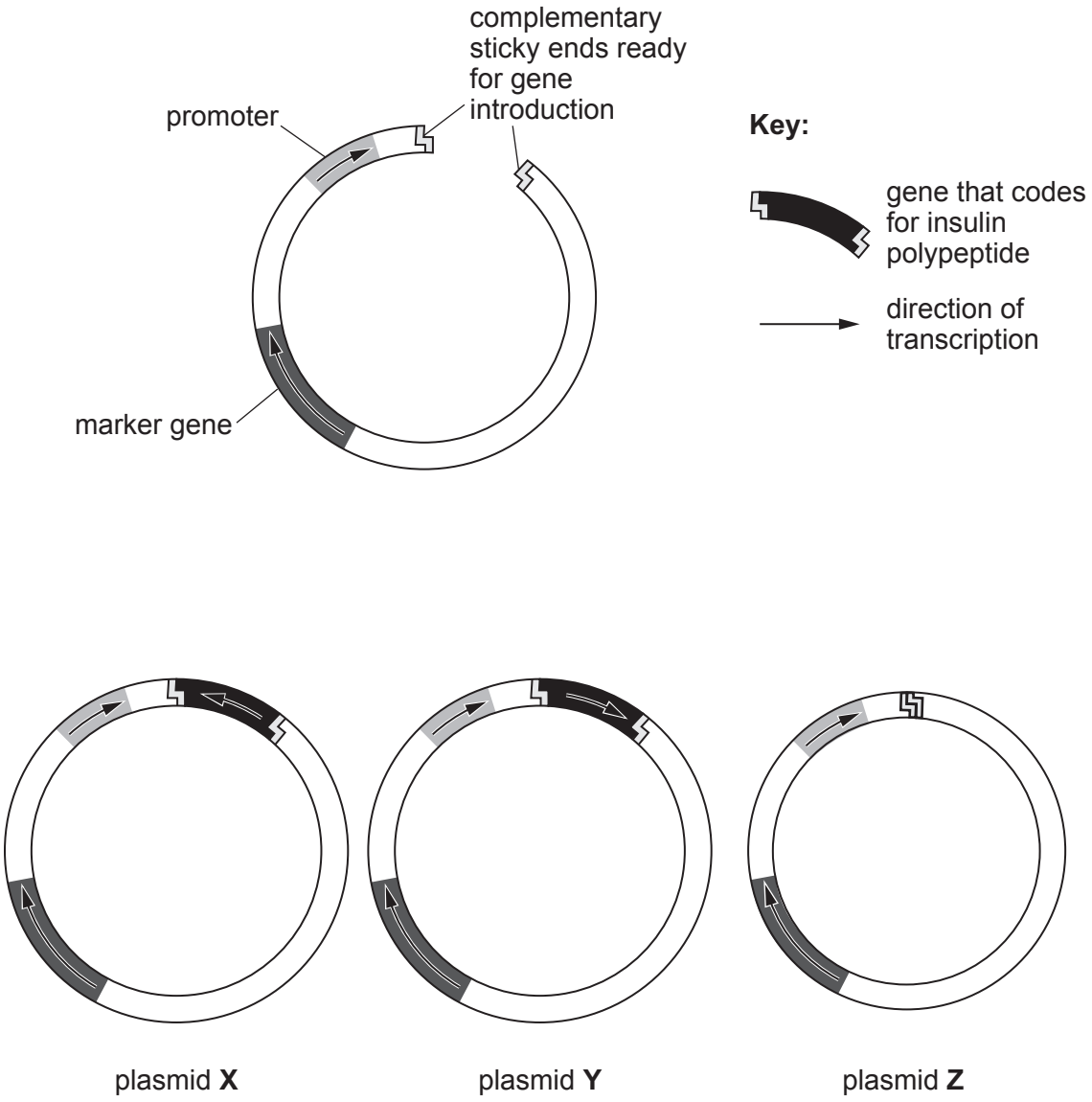

Fig. 4.1

Comment on whether a bacterium will produce the insulin polypeptide if it has either plasmid **X** or plasmid **Y** or plasmid **Z and** explain the reason for your choice.

plasmid **X** .....

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plasmid **Y** .....

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plasmid **Z** .....

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[3]

[Total: 10]

5 *BRCA2* is a tumour-suppressor gene. Its gene product, BRCA2, is involved in DNA repair. If the DNA cannot be repaired, BRCA2 has a role in causing the cell to die. BRCA2 is found in cells of breast tissue.

When a mutation occurs in *BRCA2*, damaged DNA may not be repaired and this increases the risk of breast cancer.

When a double-stranded piece of DNA breaks, BRCA2 binds to the damaged DNA directly and interacts with the enzyme RAD51 to repair the damage.

Repairing DNA prevents other mutations and gene rearrangements from occurring which could otherwise lead to breast cancer.

(a) Double-stranded DNA breaks occur naturally during meiosis.

State the event that is initiated as a result of double-stranded breaks during meiosis.

..... [1]

(b) Scientists have identified hundreds of mutations in *BRCA2*, but not all of these mutations will increase the risk of cancer. One specific mutation in *BRCA2*, known as 999del5, is found in 0.6% of the general global population.

Iceland is an island country in the North Atlantic Ocean. The ancestors of most of the current population are people who arrived to settle in Iceland in AD 874.

In the Icelandic population, mutation 999del5 is the cause of 7–8% of breast cancer cases in women and 40% of breast cancer cases in men. This is much higher than the percentage of breast cancer cases in the general global population.

(i) Suggest **and** explain how mutation 999del5 accounts for a very high percentage of breast cancer cases in Iceland compared with the general global population.

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(ii) One of the largest global genetic screening programmes for breast cancer involves identifying people with mutations in *BRCA2*.

Outline the advantages of genetic screening for mutations in *BRCA2*.

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..... [3]

(iii) Suggest **one** advantage to a country of a genetic screening programme for breast cancer that screens for specific mutations in *BRCA2* in the population.

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..... [1]

(c) *Lipocalin 2* (*Lcn2*) is a cancer-promoting gene (oncogene). When *Lcn2* is expressed, it can result in breast cancer.

Research is being carried out to see if gene editing of *Lcn2* could be used to treat breast cancer.

Gene editing was used to treat human cancer cells that had been implanted into mice to form a tumour. The treatment stopped *Lcn2* from being expressed in the cancer cells and resulted in a significant reduction in the growth of the tumour. There was no negative effect in normal tissues.

(i) Suggest how DNA editing stopped *Lcn2* from being expressed in cancer cells.

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(ii) Suggest why the expression of **only** *Lcn2* was affected.

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[Total: 11]

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6 **(a)** In plants, stomata open and close in response to changes in environmental conditions.

Explain why stomata need to open and close according to environmental conditions.

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(b) Describe the mechanism occurring in guard cells that leads to the opening of a stoma.

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[Total: 9]

7 **(a)** Experiments were carried out to determine the effect of light intensity on the rate of photosynthesis of a species of the unicellular protoctist, *Chlorella*. A cell suspension of *Chlorella* was used.

Carbon dioxide uptake was used as a measure of the rate of photosynthesis.

- The suspension of *Chlorella* was illuminated at a light intensity of 3 lux for 20 seconds.
- The carbon dioxide uptake by *Chlorella* was measured at the end of the 20 second period of illumination.
- The experiment was repeated at 6 lux, 9 lux, 12 lux and in a dark room.
- The suspension was maintained at a temperature of 20 °C.

Table 7.1 shows the results of the experiments.

Table 7.1

light intensity / lux	**total CO_2 uptake after 20 seconds / μmol**	**rate of photosynthesis / μmol s^{-1}**
0	0	0.0
3	20	1.0
6	44	.....
9	72	3.6
12	80	4.0

(i) Use Table 7.1 to calculate the rate of photosynthesis at a light intensity of 6 lux.

Complete Table 7.1 by writing your calculated value in the space provided. [1]

(ii) Plot a graph of the data in Table 7.1 on the grid in Fig. 7.1 to show the effect of light intensity on the rate of photosynthesis.

Draw a curve **and** extend your curve to show what would happen to the rate of photosynthesis if the experiment is carried out at 18 lux.

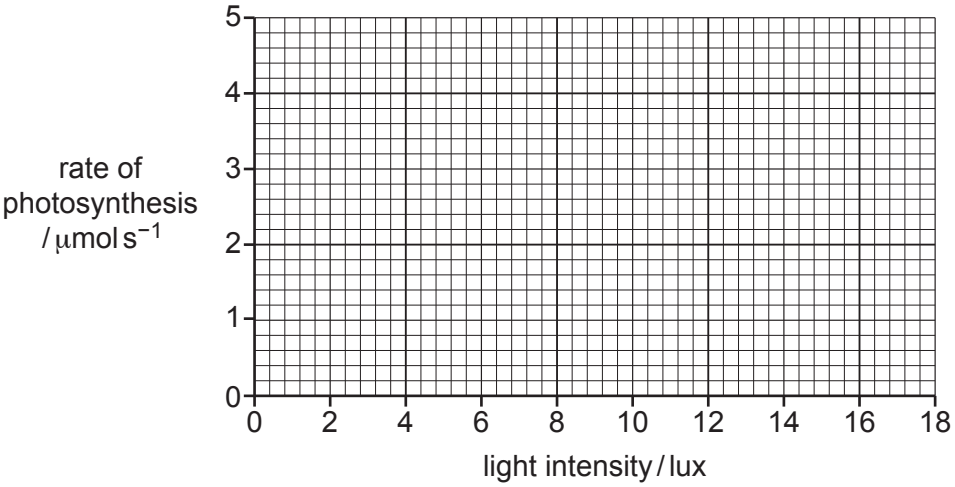

Fig. 7.1

[3]

(iii) Suggest an explanation for the shape of your curve from 12 lux to 18 lux.

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(b) In photophosphorylation, photoactivation of chlorophyll results in the synthesis of ATP.

Describe how photoactivation of chlorophyll results in the synthesis of ATP in photophosphorylation.

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[Total: 10]

8 **(a)** Fig. 8.1 is a diagram of a mitochondrion.

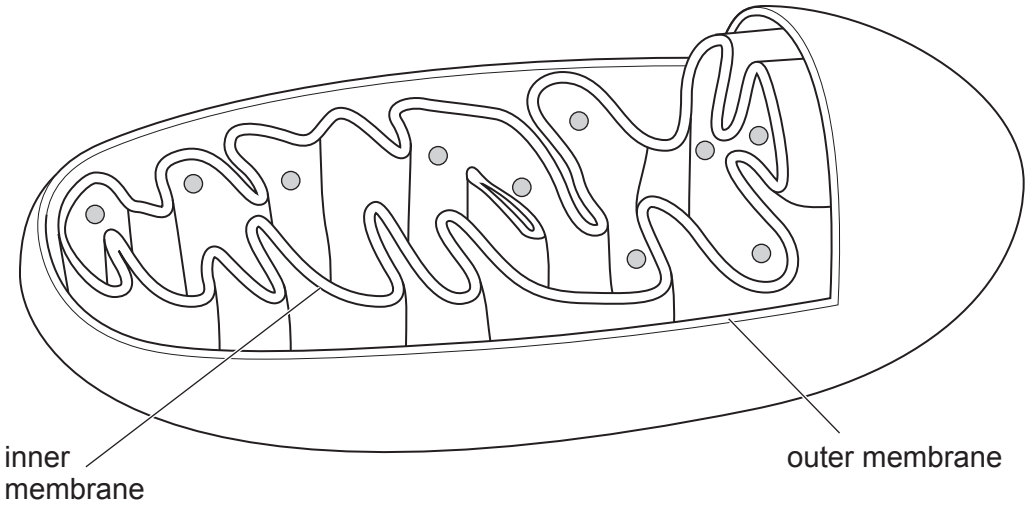

Fig. 8.1

Outline the roles played by the mitochondrial membranes in respiration.

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(b) The shapes and numbers of mitochondria are continually changing due to fission. Fission occurs when one mitochondrion splits to form two mitochondria.

(i) Suggest reasons why mitochondria carry out fission.

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..... [2]

(ii) Guanosine triphosphate (GTP) is a molecule that is used as a source of energy in some reactions, instead of ATP. Guanosine is composed of a purine, similar to adenine, and ribose.

Suggest why GTP can be a suitable source of energy in some reactions.

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..... [1]

(c) Old or damaged mitochondria reduce the ability of a cell to carry out aerobic respiration and produce the ATP needed for the metabolic processes of the cell.

Suggest what occurs to these mitochondria to allow the cell to maintain the same overall rate of respiration and ATP production.

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[Total: 9]

9 **(a)** Fig. 9.1 shows how the mean global atmospheric carbon dioxide concentration has changed over the 800 000 (800×10^3) years leading up to the year 2020.

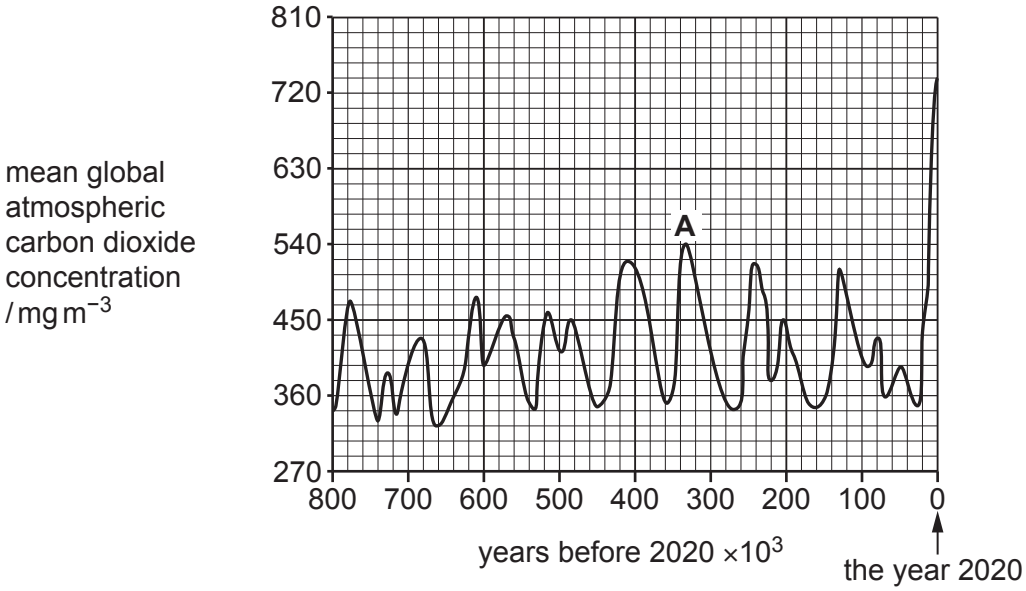

Fig. 9.1

(i) Calculate the percentage increase in carbon dioxide concentration between point **A** and the year 2020.

Show your working. Write your answer to one decimal place.

percentage increase = ...% [2]

(ii) Suggest how the changes in carbon dioxide concentration between **A** and the year 2020 may have affected the environment and biodiversity.

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(b) Outline reasons for maintaining **plant** biodiversity.

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[Total: 10]

10 **(a)** Fig. 10.1 is a diagram of part of a neurone membrane while the resting potential is maintained.

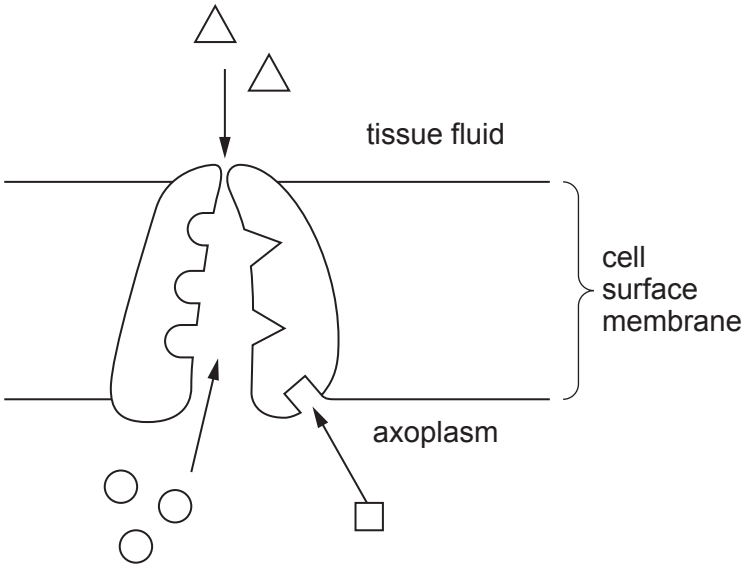

Fig. 10.1

On Fig. 10.1, use label lines and letters to label:

K – potassium ions

A – ATP.

[2]

(b) Describe the sequence of events that occur during an action potential.

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(c) Table 10.1 shows the axon diameter, myelination and transmission speed of impulses of motor neurones for three animals: squid, cockroach and cat.

Table 10.1

animal	axon diameter / mm	myelination	transmission speed / $m s^{-1}$
squid	1.5	no	30
cockroach	0.05	no	10
cat	0.02	yes	100

Describe **and** suggest explanations for the results shown in Table 10.1.

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[Total: 10]