Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0796397395

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2023**

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 **28** pages. Any blank pages are indicated.

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[Turn over

1 **(a)** The Krebs cycle was named after the biochemist Sir Hans Krebs, who worked out the sequence in 1937.

Fig. 1.1 is an outline of the Krebs cycle.

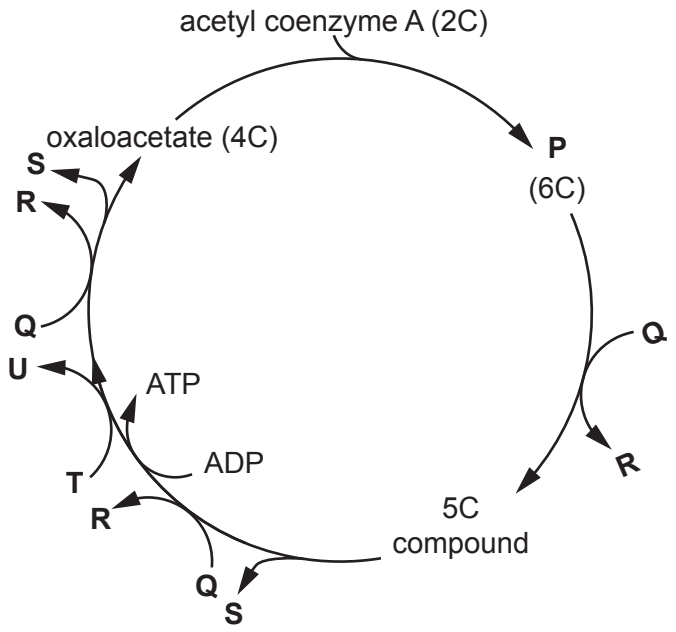


Fig. 1.1

Identify substances **P**–**U**.

P .....

Q .....

R .....

S .....

T .....

U .....

[3]

(b) Describe how ATP is produced from ADP in the Krebs cycle.

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(c) Describe **and** explain the features of ATP that make it suitable as the universal energy currency.

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[Total: 9]

2 Humans use antibiotics to treat bacterial infections. The increased use of antibiotics has led to an increase in the number of strains of bacteria that are resistant to antibiotics.

The evolution of antibiotic resistance in bacteria has resulted from natural selection.

Outline how bacteria become resistant to antibiotics.

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[Total: 7]

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3 Gene expression in a cell is controlled. When a gene is expressed (switched on), the gene is transcribed. When a gene is **not** expressed (switched off), the gene is **not** transcribed.

Environmental changes can cause some genes to be switched on or switched off.

(a) An example of control of gene expression in prokaryotes is regulation in the *lac* operon.

The *lac* operon is a length of DNA that is made up of different parts.

Fig. 3.1 shows a simple diagram representing the *lacI* (regulatory) gene and the *lac* operon.



Fig. 3.1

(i) Outline the main features of the *lac* operon.

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(ii) Explain the role of the *lacI* gene in the regulation of the *lac* operon.

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(b) The *lac* operon codes for inducible enzymes. Repressible operons code for repressible enzymes.

Suggest **and** explain why it is an advantage to a prokaryote to have a repressible operon.

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[Total: 10]

4 One cause of the genetic disease severe combined immunodeficiency (SCID) is a mutation in the *ADA* gene. This mutation results in a deficiency of the enzyme adenosine deaminase (ADA).

Although ADA is found throughout the body, it is especially active in lymphocytes. The absence of functional ADA causes the build-up of toxic metabolites that kill lymphocytes and damage organs.

Babies are often diagnosed with SCID by six months old. Treatment can greatly improve the life expectancy of children with SCID.

Some treatment options are available.

- Enzyme replacement therapy with recombinant human ADA made by genetically modified (GM) *Escherichia coli*. Weekly intra-muscular injections are given.
- Bone marrow transplant if a well-matched donor, such as a close relative, can be found.
- Gene therapy.

(a) Suggest **and** explain why it may be more appropriate to use enzyme replacement therapy to treat SCID instead of a bone marrow transplant.

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(b) Outline the procedure used for gene therapy treatment of a person with SCID.

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(c) Suggest the social and ethical implications of gene therapy for SCID that need to be considered before treatment is carried out.

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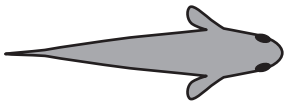
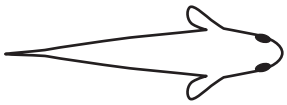
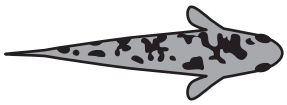
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[Total: 10]

5 A freshwater fish species, *Oryzias latipes*, has individuals with four body colour patterns, as shown in Table 5.1.

Table 5.1

phenotype	body colour pattern
red	
white	
red with black spots	
white with black spots	

Two unlinked genes determine the body colour patterns shown in Table 5.1.

One gene controls whether the body colour is red or white:
- dominant allele **R** = red
- recessive allele **r** = white.

The other gene controls whether black spots are present or **not** present:
- dominant allele **B** = with black spots
- recessive allele **b** = without black spots.

A fish that is homozygous recessive at both loci is white.

Genetic crosses were carried out to investigate the inheritance of the four different body colour patterns.

Males that were red with black spots, and homozygous at both loci, were crossed with females that were white. The F1 offspring were all red with black spots.

These F1 offspring were then crossed to produce the F2 generation.

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(a) Table 5.2 shows the observed numbers obtained of each of the four different phenotypes for the F2 generation.

Table 5.2

phenotype	**observed**	**expected**	***O–E***	$(O–E)^2$	$\frac{(O–E)^2}{E}$
red with black spots	279	281.25			
white with black spots	95	93.75	1.25	1.5625	0.017
red	96	93.75	2.25	5.0625	0.054
white	30	31.25			
				χ^2 = ...	

Table 5.2 compares the observed numbers with the numbers that would be expected in the F2 generation for a normal dihybrid ratio.

Calculate χ^2 for the F2 generation by completing Table 5.2.

The formula for χ^2 is:

$$\chi^2 = \sum \frac{(O–E)^2}{E}$$

[3]

(b) The critical value at $p = 0.05$ and 3 degrees of freedom is 7.815.

Comment on whether the null hypothesis should be accepted or rejected.

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Further analysis of the results from the F2 generation in Table 5.2 showed that there were no white males or white males with black spots.

In *O. latipes*, females have two **X** chromosomes and males have an **X** and a **Y** chromosome.

It was deduced that, in *O. latipes*:

- the gene that controls body colour is located on the **X** chromosome **and** the **Y** chromosome
- the gene that controls whether black spots are present or **not** is located on an autosome.

(c) To produce the F2 generation, red males with black spots, $\mathbf{X^rY^RBb}$, were crossed with red females with black spots, $\mathbf{X^RX^rBb}$.

Complete the Punnett square in Fig. 5.1 to show the genotypes and phenotypes of the F2 generation.

- Use the symbols $\mathbf{X^R}$, $\mathbf{X^r}$ and $\mathbf{Y^R}$ for the alleles of the gene that controls body colour.
- Use the symbols **B** and **b** for the alleles of the gene that controls whether black spots are present or **not**.

Some of Fig. 5.1 has been completed for you.

	female gametes			
male gametes	$\mathbf{X^RB}$	$\mathbf{X^rB}$	$\mathbf{X^Rb}$	$\mathbf{X^rb}$
$\mathbf{X^rB}$	$\mathbf{X^RX^rBB}$		$\mathbf{X^RX^rBb}$	$\mathbf{X^rX^rBb}$
	female		female	female
	red + black spots		red + black spots	white + black spots
$\mathbf{Y^RB}$	$\mathbf{X^RY^RBB}$	$\mathbf{X^rY^RBB}$	$\mathbf{X^RY^RBb}$	$\mathbf{X^rY^RBb}$
	male	male	male	male
	red + black spots	red + black spots	red + black spots	red + black spots
$\mathbf{X^rb}$	$\mathbf{X^RX^rBb}$	$\mathbf{X^rX^rBb}$	$\mathbf{X^RX^rbb}$	
	female	female	female	
	red + black spots	white + black spots	red + no spots	
$\mathbf{Y^Rb}$		$\mathbf{X^rY^RBb}$		$\mathbf{X^rY^Rbb}$
		male		male
		red + black spots		red + no spots

Fig. 5.1 [4]

(d) Explain why there are no white males or males that are white with black spots in the F2 generation.

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(e) In another cross, red males with the genotype $\mathbf{X^rY^Rbb}$ were mated with white females with the genotype $\mathbf{X^rX^rbb}$. All the male offspring were expected to be red and all the female offspring were expected to be white.

The observed results showed that the offspring included two red females out of 253 and one white male out of 198.

Suggest an explanation for this unexpected result.

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[Total: 13]

6 **(a)** Fig. 6.1 shows part of the Bowman's capsule of a kidney nephron.

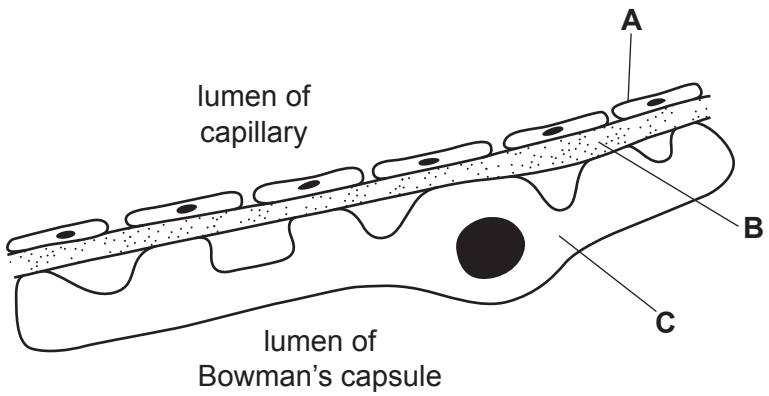


Fig. 6.1

Name structures **A**, **B** and **C**.

A .....

B .....

C .....

[3]

(b) Fluid is forced into the Bowman's capsule by ultrafiltration to form the glomerular filtrate.

Describe the role of structure **B** in ultrafiltration.

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(c) The main component of the glomerular filtrate formed in the Bowman's capsule is water. Most of this water is reabsorbed as the filtrate passes along the nephron.

- 180 dm^3 of water forms part of the glomerular filtrate each day.
- 1.4 dm^3 of water leaves the body in urine each day.

Calculate the percentage of water in the glomerular filtrate that is reabsorbed as the glomerular filtrate passes along the nephron.

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

answer ..... % [2]

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(d) Describe how the action of antidiuretic hormone (ADH) on the cells of the collecting duct leads to the reabsorption of water in the glomerular filtrate.

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[Total: 14]

7 **(a)** Sarcomeres are the functioning units of the myofibrils of the muscle fibres (muscle cells) of striated muscle.

The arrival of an action potential at the sarcoplasmic reticulum of a striated muscle fibre can lead to the shortening of a sarcomere. This shortening occurs by the sliding filament model.

Outline the sequence of events occurring after stimulation of the sarcoplasmic reticulum that results in the shortening of a sarcomere.

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(b) Scientists compared the diameter of samples of striated muscle fibres taken from young mice and adult mice.

The results are shown in Fig. 7.1.

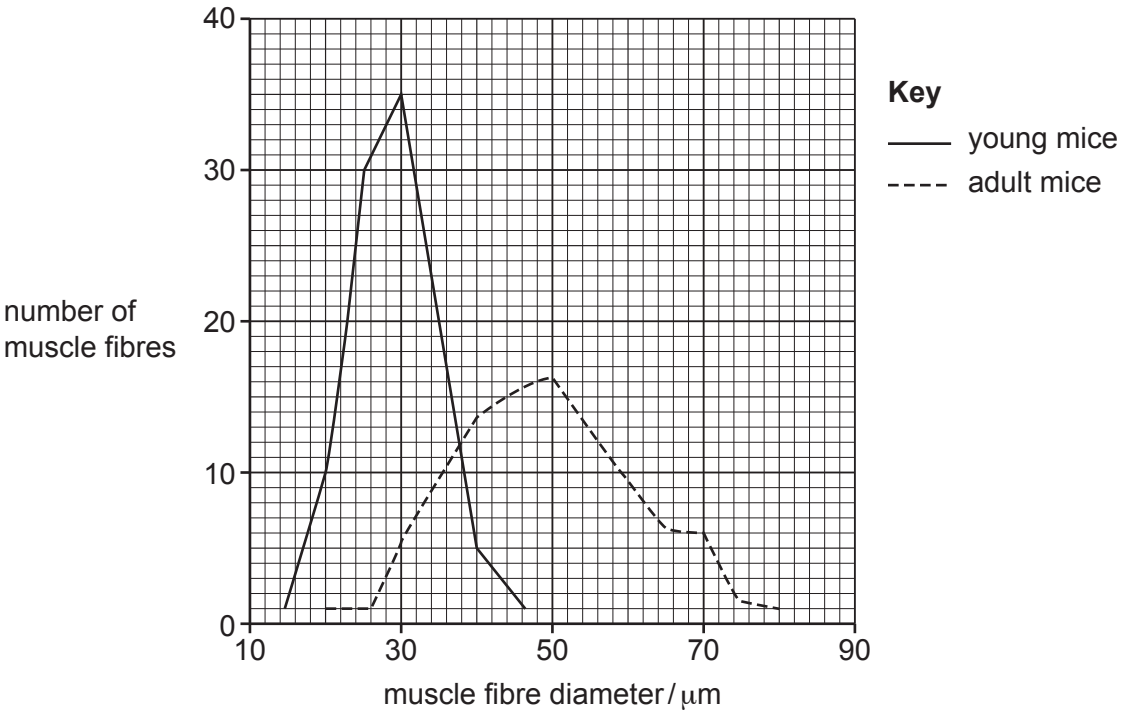


Fig. 7.1

With reference to Fig. 7.1:

- describe **two** differences between the muscle fibres of young mice and adult mice
- suggest how these differences may affect the sliding filament model.

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[Total: 8]

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

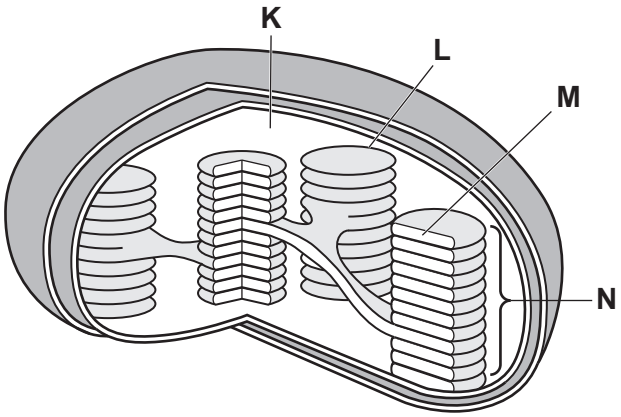


Fig. 8.1

Using the letters **K**–**N**, complete Table 8.1.

Each letter may be used once, more than once, or not at all.

Table 8.1

	letter
high concentration of protons	.....
location of photosynthetic pigments	.....
site of light-independent stage	.....
site of light-dependent stage	.....

[4]

(b) Chlorophyll *a* is the main photosynthetic pigment in plants.

Describe the role of other photosynthetic pigments found in plant chloroplasts.

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(c) The absorption of different wavelengths of light by chloroplast pigments can be represented by an absorption spectrum.

Fig. 8.2 is an absorption spectrum of an extract of chloroplast pigments and an absorption spectrum of whole chloroplasts.

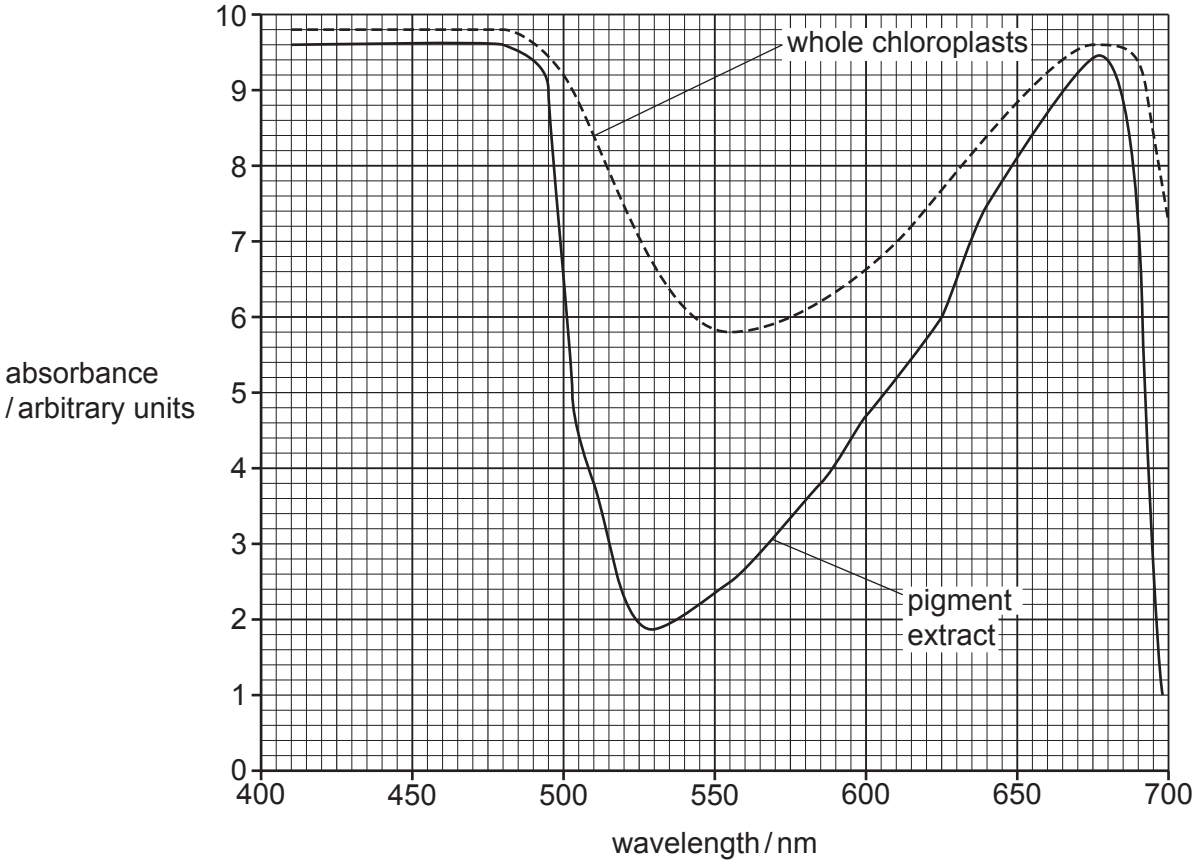


Fig. 8.2

With reference to Fig. 8.2, describe the differences between the two spectra **and** suggest explanations for the differences.

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[Total: 12]

9 **(a)** Dopamine is a neurotransmitter released in some synapses in the brain. The release and action of dopamine is similar to that of acetylcholine.

Fig. 9.1 is a diagram of a brain synapse where dopamine is the neurotransmitter.

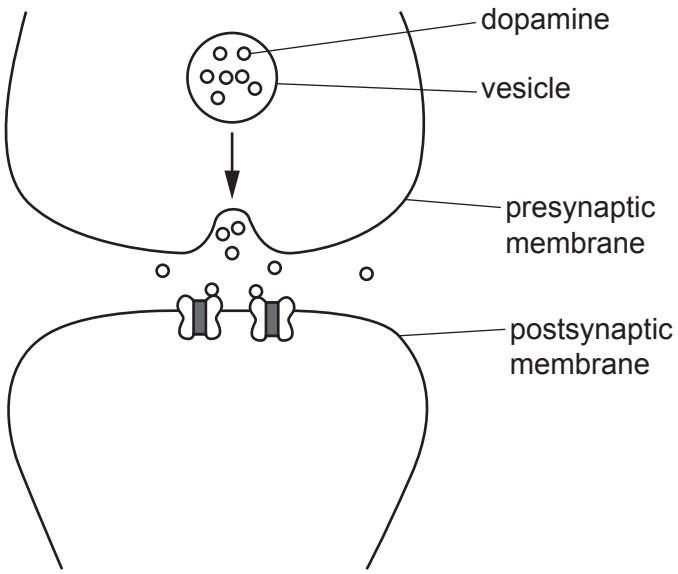


Fig. 9.1

(i) Describe how the release of dopamine from the presynaptic neurone can lead to an action potential in the postsynaptic neurone.

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(ii) In brain cells, the amino acid tyrosine is changed into DOPA, which then is converted to dopamine.

Name another compound in the body produced from DOPA.

..... [1]

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(b) In some brain synapses, the neurotransmitter gamma-aminobutyric acid (GABA) is released. This results in an influx of chloride ions into the postsynaptic neurone.

Suggest **and** explain whether an action potential would be generated in the postsynaptic neurone if GABA is released into a brain synapse.

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[Total: 8]

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10 (a) The moose, *Alces alces*, is a large member of the deer family. It lives in temperate forests in North America and northern Europe, where snow is present for large parts of the year.

Fig. 10.1 shows an adult male moose feeding in a lake.



Fig. 10.1

The moose feeds on a plant in the lake called watermilfoil, *Myriophyllum aquaticum*.

The moose and the watermilfoil belong to the domain Eukarya, which includes the kingdoms Animalia and Plantae.

Describe the main differences between the kingdom Animalia and the kingdom Plantae.

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..... [4]

(b) Measurements of the surface temperature of land and oceans can be taken from locations around the world. The mean global surface temperature for land and ocean combined can be calculated for a fixed time period.

Scientists calculated:

- the mean global temperature for the twentieth century
- the mean global temperature for each decade (ten years) from 1880 to 2020.

The mean temperature for each decade was compared to the mean for the twentieth century. For each decade, the difference in temperature was calculated.

The calculated differences are shown in Fig. 10.2.

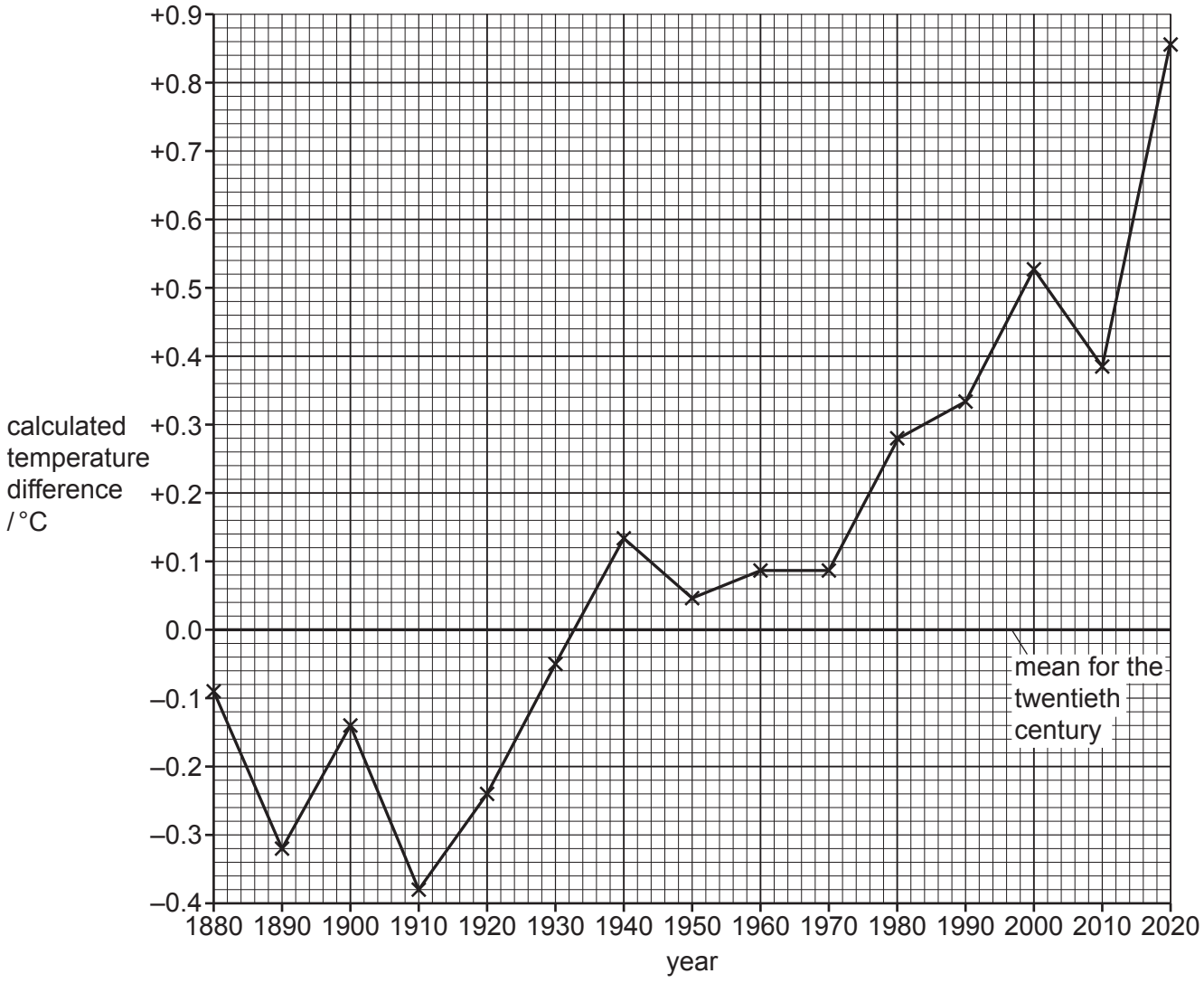


Fig. 10.2

(i) Calculate the rate of increase in temperature per **decade** between 1980 and 2020.

Show your working.

Write your answer to **two** decimal places.

answer ..... °C per decade [2]

(ii) Moose populations have decreased in North America since 1980.

Suggest **and** explain reasons for the decrease in moose populations.

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[Total: 9]

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