Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1768804463

MARINE SCIENCE **9693/41**

Paper 4 A Level Data-handling and Investigative Skills **May/June 2024**

1 hour 45 minutes

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 75.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **24** pages. Any blank pages are indicated.

DC (DE/SG) 329517/5

[Turn over

Answer **all** questions.

1 Fig. 1.1 shows an electron micrograph of part of a marine algal cell, *Dunaliella* spp.

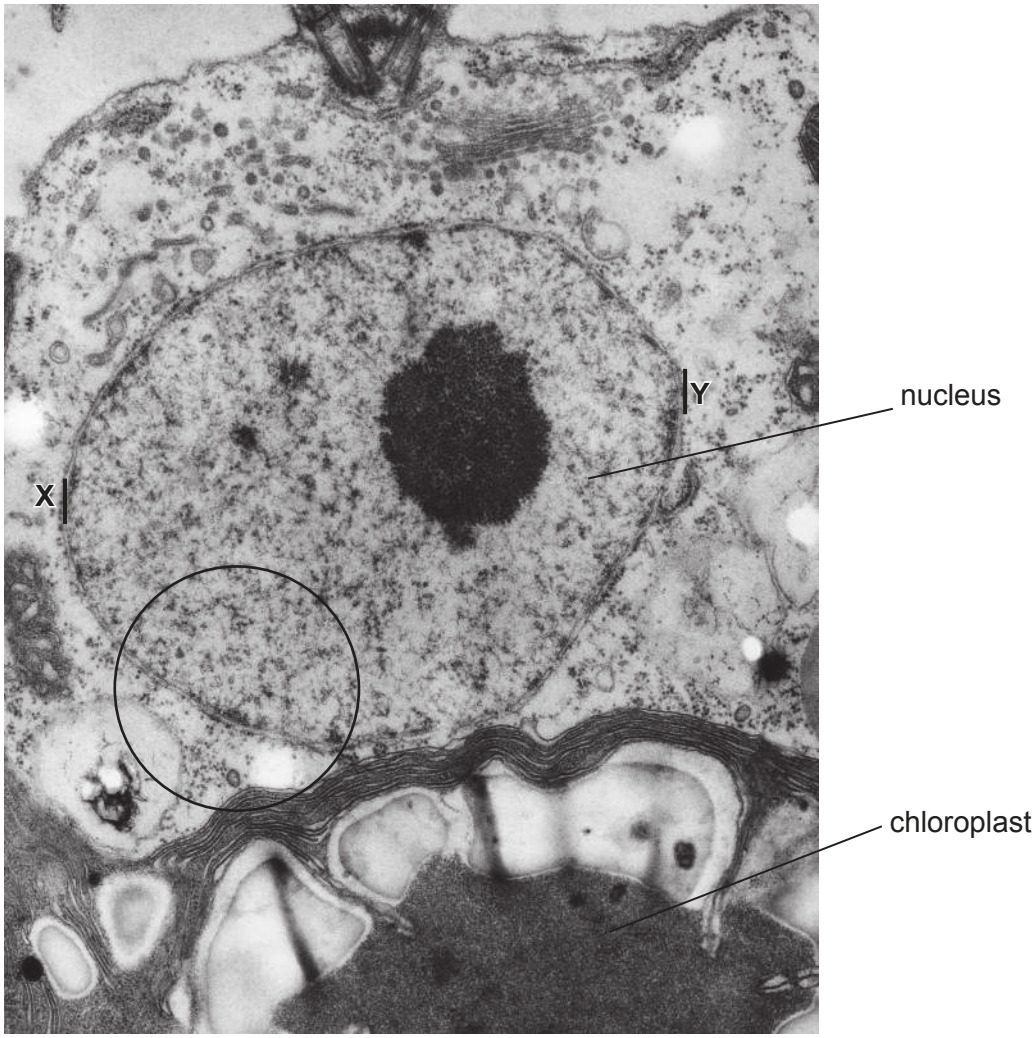

Fig. 1.1

(a) State **one** function of the cell nucleus.

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..... [1]

(b) **(i)** The magnification of the electron micrograph is ×40 000.

Calculate the actual width, from **X** to **Y**, of the nucleus.

Give your answer to **two** significant figures and in micrometres (μm).

Show your working.

..... μm [3]

(ii) Make a large drawing of the area of the cell shown in the circle in Fig. 1.1.

[4]

(c) A student investigated the effect of different colours of light on the growth of *Dunaliella* spp.

The student placed equal masses of algae into different beakers of sea water and exposed each beaker to a different colour of light for one month. This was replicated four times.

After one month, the student calculated the mean increase in the dry mass of algae that had been exposed to each colour of light.

The experiment was repeated with a second species of alga that lives in surface waters.

The results are shown in Table 1.1.

Table 1.1

colour of light	mean increase in dry mass of algae / g	
	***Dunaliella* spp.**	**surface water alga**
purple	2.50	3.15
blue	2.95	2.85
green	1.25	0.12
yellow	0.82	0.10
orange	1.85	1.65
red	2.14	2.95

(i) Compare the effect of different colours of light on the growth of *Dunaliella* spp. with the growth of the surface water alga.

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(ii) The student concluded that *Dunaliella* spp. has additional chloroplast pigments compared with the surface alga and is adapted for living in deeper water.

Discuss the student's conclusion.

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[Total: 14]

2 The giant tubeworm, *Riftia*, lives near hydrothermal vents.

Endoriftia bacteria live inside *Riftia*.

(a) (i) Outline how *Endoriftia* produces glucose by chemosynthesis.

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(ii) Explain the relationship between *Riftia* and *Endoriftia*.

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(b) Some species of chemosynthetic bacteria live in the water and substrate close to hydrothermal vents.

Scientists investigated the relationship between the population density of free-living chemosynthetic bacteria and the presence of hydrogen gas (H_2) and methane gas (CH_4). They took samples at three different hydrothermal vents and also at an area of the deep sea bed where there were no hydrothermal vents.

The results are shown in Table 2.1.

Table 2.1

factor	**location**			
	vent 1	**vent 2**	**vent 3**	**deep sea bed**
concentration of H_2 / μmol dm^{-3}	21.9	127.0	9.4	0.0
concentration of CH_4 / μmol dm^{-3}	23.7	10.1	38.4	0.0
population density of chemosynthetic bacteria / cells per cm^3 $\times$ 10^4	5.51	3.14	5.62	2.91

Suggest an explanation for the different densities of chemosynthetic bacteria at these four locations.

Use the information in Table 2.1 to support your answer.

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(c) Chemosynthetic bacteria around hydrothermal vents are important parts of the ecosystem.

Protoctists are microscopic single-celled organisms.

Species of protoctist consume the bacteria. The protoctists are then consumed by other organisms in the ecosystem.

In a further investigation, the scientists brought samples of water containing the bacteria and protoctists up to the surface. They measured the mean rates at which the protoctists consumed the bacteria in the samples of water from each vent and the deep sea bed.

The results are shown in Fig. 2.1.

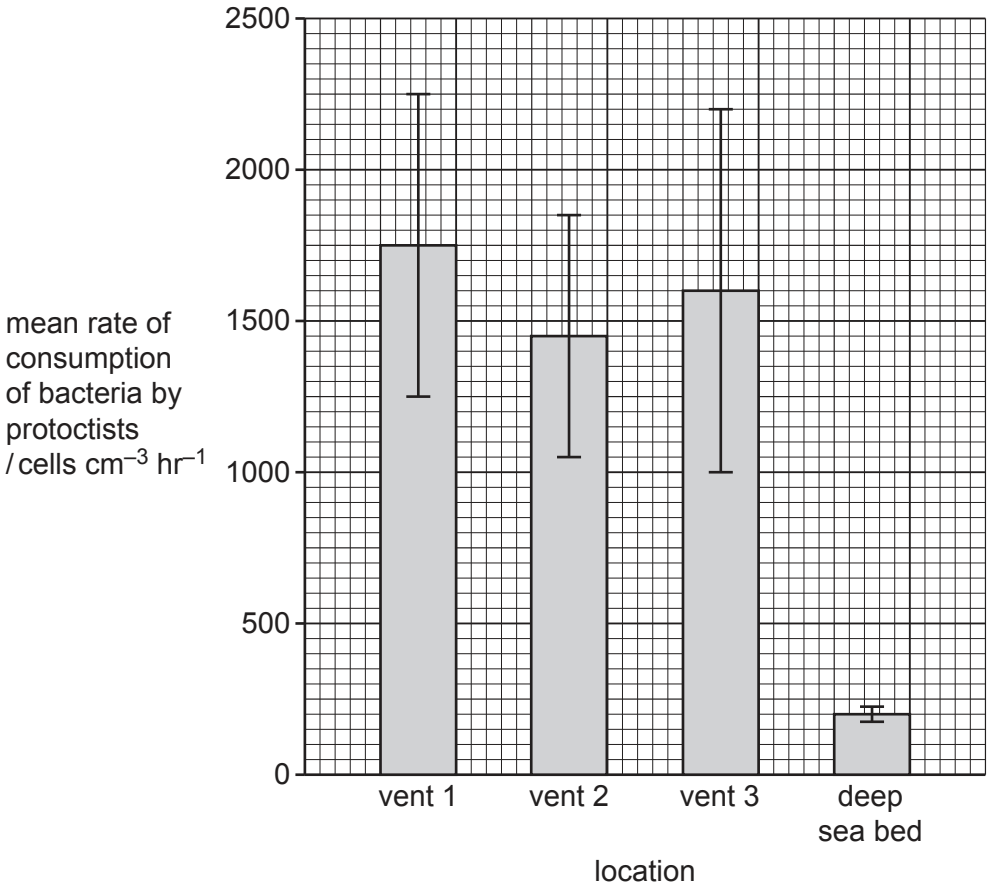

Fig. 2.1

(i) The error bars in Fig. 2.1 represent standard deviations.

Explain what the error bars in Fig. 2.1 demonstrate about the reliability of the data.

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(ii) The scientists concluded that chemosynthetic bacteria are a **more** important part of food chains on the sea bed around hydrothermal vents than in areas of the deep sea bed away from the vents.

Discuss the scientists' conclusion.

Use the data in Fig. 2.1 to support your answer.

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[Total: 12]

3 Aquaculture in coastal areas is used to produce large quantities of shrimp.

Shrimp aquaculture can cause environmental pollution.

Scientists are researching ways to make shrimp aquaculture more environmentally sustainable.

(a) (i) Outline the process for aquaculture of shrimp.

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(ii) Give **two** strategies that can be used to help ensure the long-term success of aquaculture.

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(b) Mussels are filter-feeding organisms that consume microalgae and other organic waste.

Wastewater from shrimp aquaculture sites contains large amounts of ammonium ions that pollute the sea. The ammonium ions are converted to nitrate ions by bacteria.

Scientists investigated the effects of growing mussels and adding microalgae on the removal of nitrate ions from wastewater produced by shrimp aquaculture.

- Wastewater from a shrimp aquaculture site was collected and placed into tanks.
- Different densities of mussels were added to the tanks.
- The same mass of microalgae was added to each tank.
- The nitrate ion concentration of the water was measured at the start and every day for the next six days.

The results are shown in Fig. 3.1.

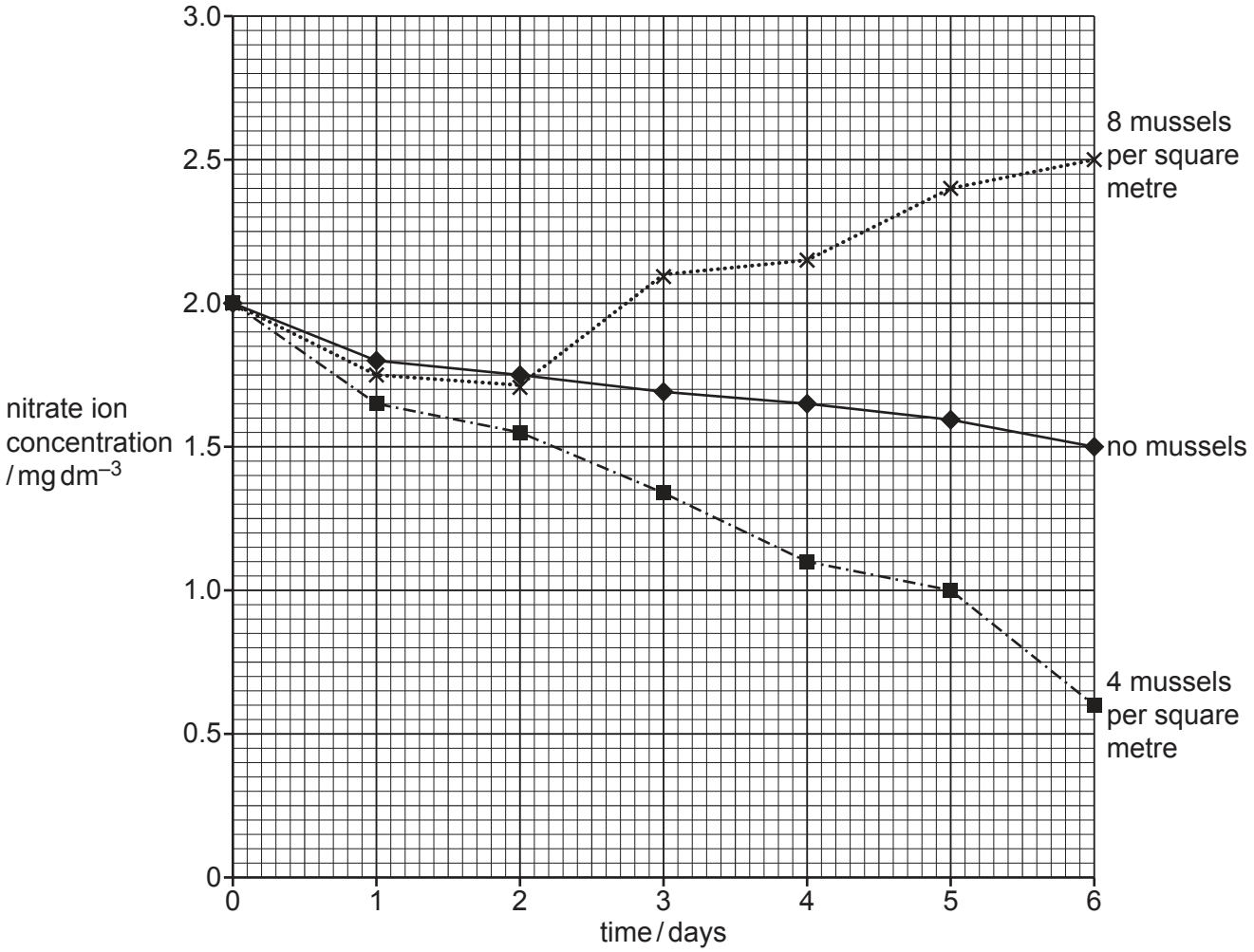

Fig. 3.1

(i) Calculate the mean rate of change of nitrate ion concentration with no mussels over the six-day period.

State the unit.

Show your working.

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(ii) Describe the effects of adding different densities of mussels on the removal of nitrate ions from the water over the six-day period.

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(c) The scientists also measured dissolved oxygen concentration in the water every day for the six days.

The results are shown in Fig. 3.2.

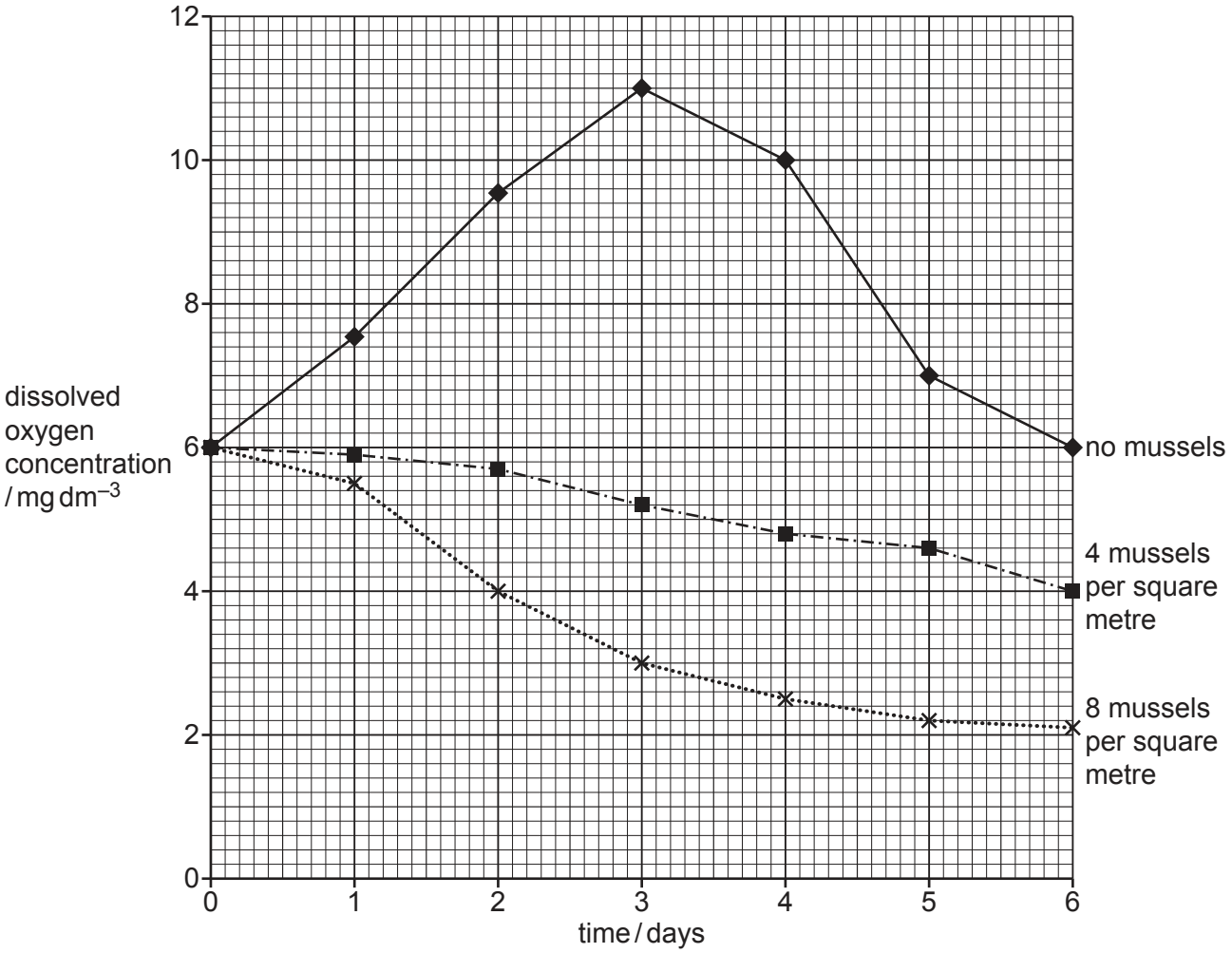

Fig. 3.2

(i) The same mass of microalgae was added to each tank at the start.

Explain the change in dissolved oxygen concentration in the water up to day three when microalgae were present with no mussels.

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(ii) Ammonium ions are converted into nitrate ions by bacteria in the water.

Nitrate ions are absorbed by algae.

Mussels consume algae.

Discuss the effects of adding different densities of mussels on the changes in concentration of oxygen and nitrate ions in the water.

Use the information in Fig. 3.1 **and** Fig. 3.2 to support your answer.

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[Total: 17]

4 Foraminifera are microscopic, single-celled marine organisms. Some species of foraminifera produce shells made from calcium carbonate.

Fig. 4.1 shows the shell of a species of foraminifera.

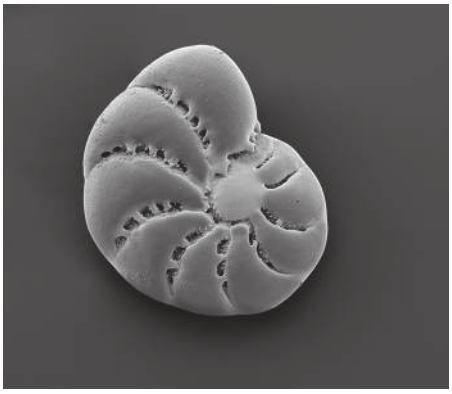


Fig. 4.1

Scientists investigated the effect of carbon dioxide concentration in the water on the length of the shells and on population growth of foraminifera.

Tanks of sea water were set up with different concentrations of carbon dioxide.

Foraminifera were added to each of the tanks.

Oxygen was bubbled into each tank and food was added daily.

The mean shell lengths of the foraminifera and the population density were determined after eight weeks.

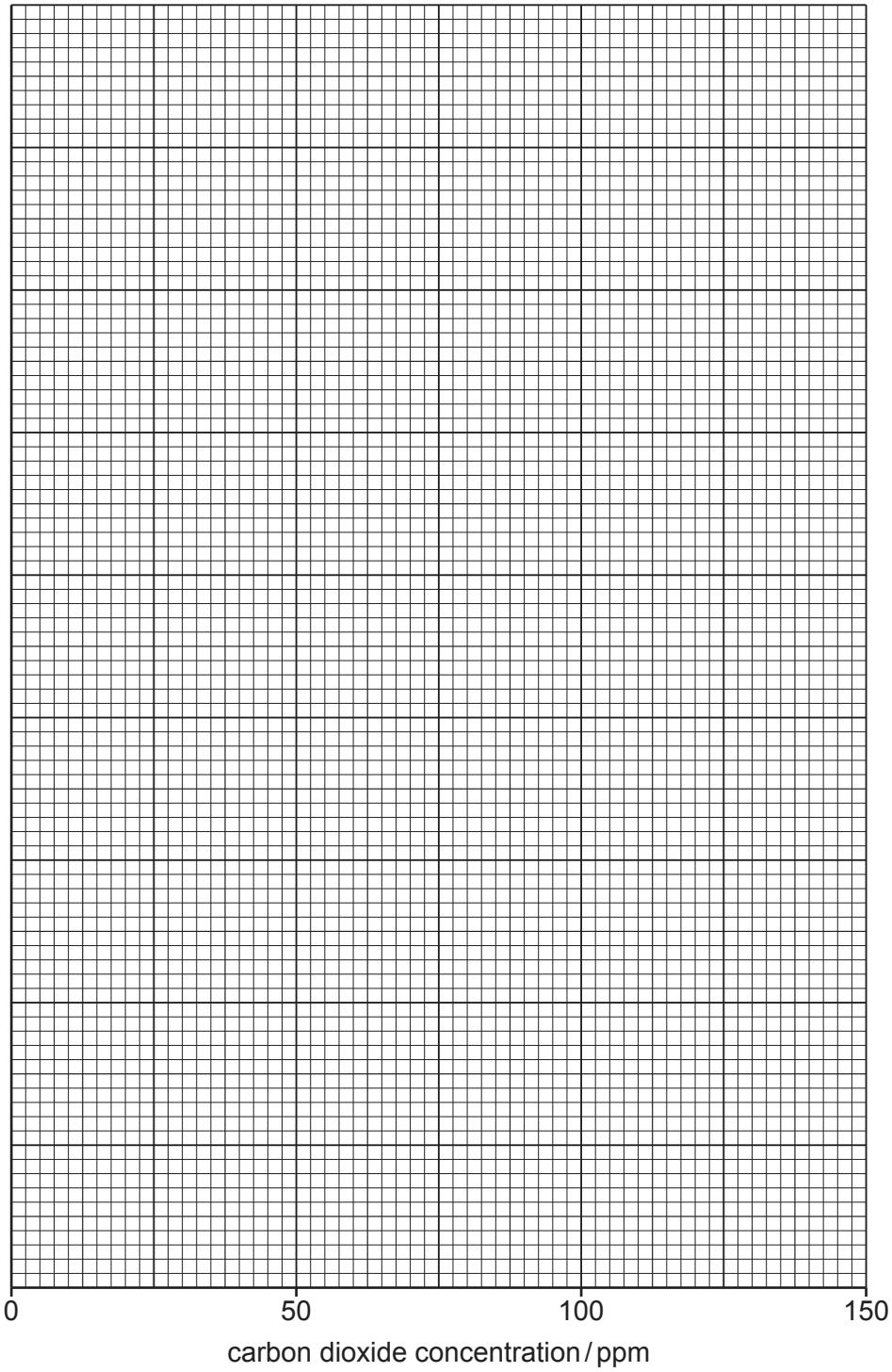
The results are shown in Table 4.1.

Table 4.1

carbon dioxide concentration / ppm	mean shell length / mm	mean population density / foraminifera per cm^3
10	0.85	1800
25	0.82	1750
50	0.84	1500
110	0.52	950
125	0.25	250

(a) Draw a line graph to show the mean shell lengths **and** mean population densities of the foraminifera at each concentration of carbon dioxide.

Join your points with ruled straight lines.



[5]

(b) The foraminifera have shells made from calcium carbonate.

Explain why increasing the carbon dioxide concentration affects the growth of the foraminifera.

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(c) There are many different species of foraminifera in areas of coral reef.

The species diversity of foraminifera is thought to be affected by factors such as temperature, carbon dioxide concentration, and calcium ion concentration.

Some scientists think that global warming will affect the species diversity of foraminifera.

Plan a **laboratory-based** investigation that you could do to investigate the effect of temperature on the species diversity of a sample of foraminifera that grows around coral.

You are provided with a mixed starter culture of 20 different species of foraminifera, sea water, microscopes, coral around which the foraminifera live, and other standard laboratory equipment.

Your plan should:

- include a clear statement of the hypothesis
- identify the independent, dependent and standardised variables
- include full details of the method so that another person can follow it
- describe how you would analyse your results
- be safe and ethical.

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[Total: 19]

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5 **(a)** Explain why international cooperation and legislation are necessary for the effective conservation of many marine species.

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(b) Cultivated salmon that have been raised in captivity are often used to rehabilitate wild stocks.

Young wild salmon naturally migrate from a river towards its estuary as part of their life cycle.

Young salmon that have been raised in captivity often swim in the wrong direction when they are released and do not reach the estuary.

Scientists investigated if acclimatising young salmon in rivers before release affects their migration behaviour.

This is the method the scientists used.

- Young salmon were raised in captivity and then separated into two groups.
- One group of the young salmon was placed into cages in the river for two weeks to acclimatise. The other group (non-acclimatised salmon) remained in the fresh-water tanks.
- Both groups of salmon were tagged with a unique identifier so they could be detected. Both groups were then released into the river.
- Sensors to detect the salmon were placed upstream and downstream of the release site.
- The number of salmon that passed each sensor each day were recorded.

The results are shown in Fig. 5.1.

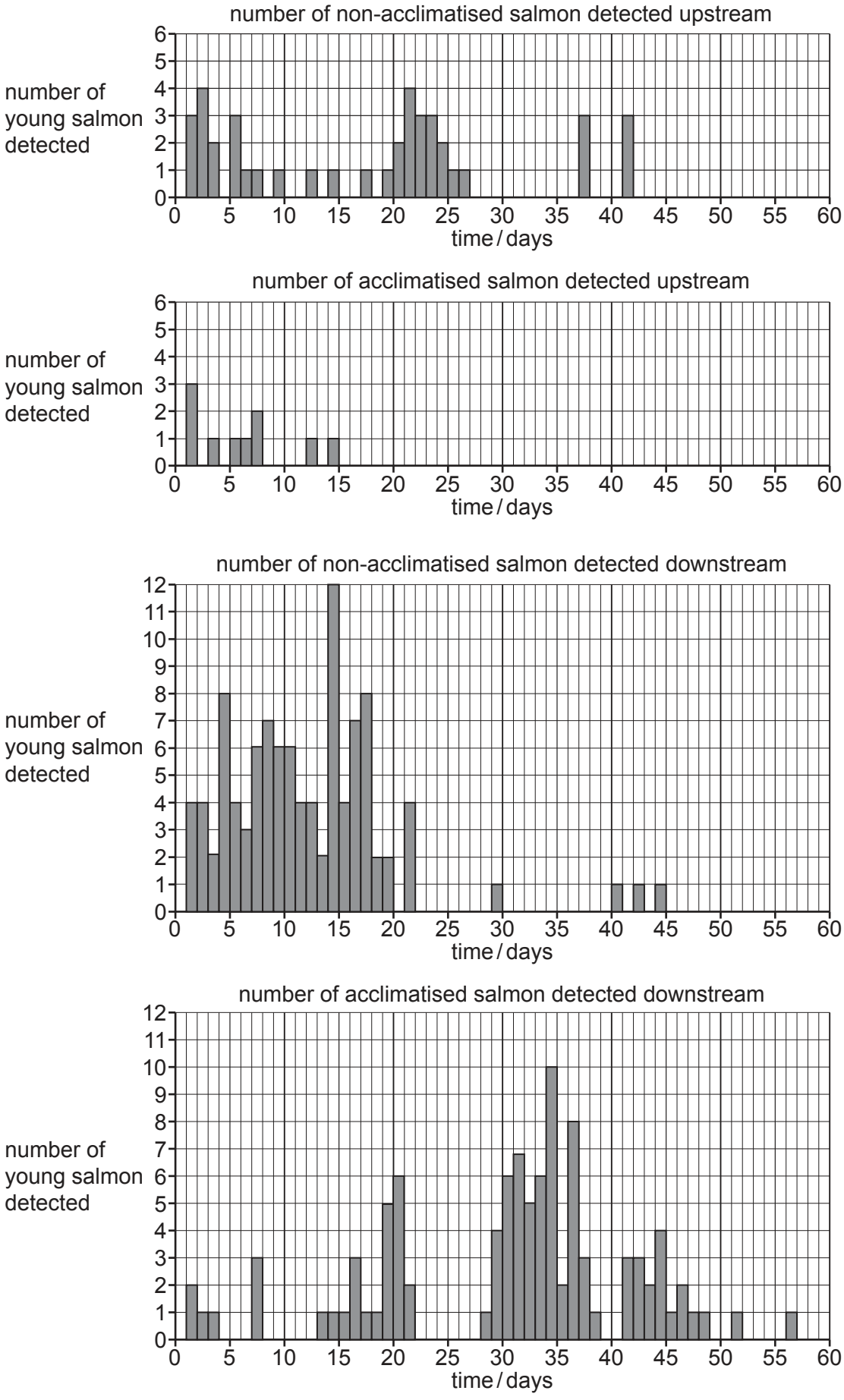

Fig. 5.1

(i) The scientists tagged 150 young salmon in each group.

Use Fig. 5.1 to calculate the percentage of acclimatised salmon that moved upstream.

Show your working.

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(ii) Discuss the effects of acclimatising the young salmon on their migration behaviour.

Use the data in Fig. 5.1 to support your answer.

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(c) The scientists carried out a chi-squared test to see if there was a significant difference between the numbers of acclimatised and non-acclimatised fish that migrated during the night or the day.

They collected data for 80 acclimatised fish and 80 non-acclimatised fish.

Their results are shown in Table 5.1.

Table 5.1

	acclimatised fish	**non-acclimatised fish**
number migrating during the night	40	65
number migrating during the day	40	15

The scientists decided to use the data for the non-acclimatised fish as the expected values as shown in Table 5.2.

Table 5.2

group	**observed number of fish (*O*)**	**expected number of fish (*E*)**	**(*O*–*E*)**	**$(O-E)^2$**	**$(O-E)^2/E$**
acclimatised fish migrating during the night	40	65	–25	625	9.6
acclimatised fish migrating during the day	40	15			

(i) Complete Table 5.2. [1]

(ii) Use the formula to calculate the chi-squared value for the results.

$$\text{chi-squared} = \Sigma\frac{(O-E)^2}{E}$$

Σ = sum of (total)

O = observed values

E = expected values

..... [1]

(iii) Table 5.3 is a critical value table for chi-squared.

Table 5.3

degrees of freedom	*p* value				
	0.900	**0.500**	**0.100**	**0.050**	**0.010**
1	0.016	0.455	2.706	3.841	6.635
2	0.211	1.386	4.605	5.991	9.210
3	0.584	2.366	6.251	7.815	11.345
4	1.064	3.357	7.779	9.488	13.277

Use your calculated value from **(c)(ii)**, **and** Table 5.3 to decide whether to accept or reject the null hypothesis.

Justify your decision.

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[Total: 13]

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