Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7697970651 6

MARINE SCIENCE **9693/41**

Paper 4 A Level Data-handling and Investigative Skills **October/November 2025**

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 **20** pages. Any blank pages are indicated.

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Answer **all** questions.

1 Artificial reefs are often created by sinking old ships.

(a) Explain how artificial reefs can help to rehabilitate fish stocks.

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(b) Scientists investigated the risk of heavy metal ions leaking from artificial reefs into sea water.

Bags of mussels were placed on a sunken metal ship.

Bags of mussels were also placed at an area one kilometre from the ship as a control.

After six months, the mean concentrations of chromium ions, lead ions and zinc ions in the mussels were determined.

The results are shown in Table 1.1.

Table 1.1

heavy metal ion	concentration in mussels on ship / mg kg^{-1}		concentration in control mussels / mg kg^{-1}	
	mean	standard deviation	mean	standard deviation
chromium	1.40	0.47	0.67	0.10
lead	0.36	0.05	0.23	0.04
zinc	178.00	44.40	152.00	29.50

(i) Calculate the percentage difference in the mean concentration of chromium ions in the mussels on the ship compared with the mean concentration of chromium ions in the control mussels.

Give your answer to **two** significant figures.

Show your working.

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(ii) Describe the differences in concentrations of heavy metal ions in the mussels on the ship compared with the concentrations of heavy metal ions in the control mussels.

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(c) Fig. 1.1 shows the concentration of lead ions in the tissues of consumers that feed on mussels containing different concentrations of lead ions.

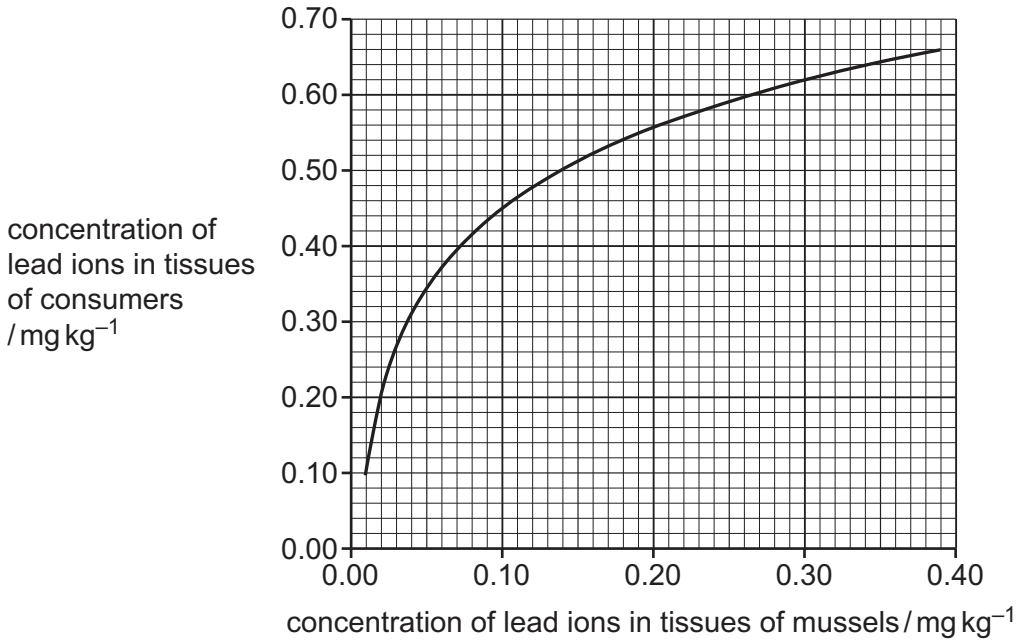

Fig. 1.1

(i) Summarise the effect of increasing concentration of lead ions in the tissues of mussels on the concentration of lead ions in the tissues of consumer organisms.

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Table 1.1

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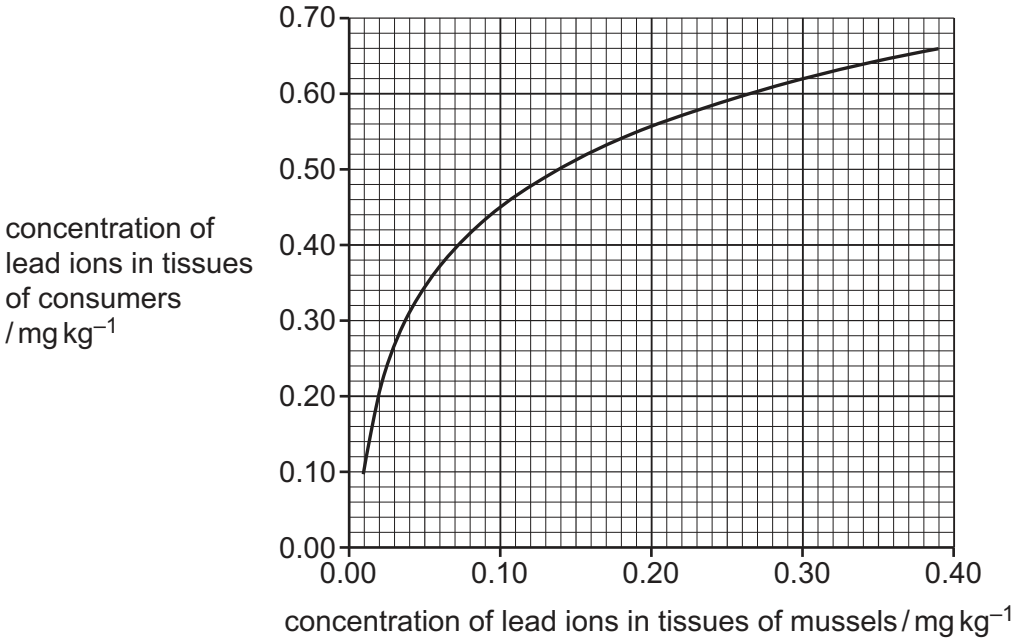

Fig. 1.1

(ii) Use the information in Table 1.1 **and** Fig. 1.1 (repeated above) to predict the mean concentration of lead ions in the tissues of consumer organisms that eat mussels from the ship.

..... mg kg^{-1} [1]

(iii) Use the information in Table 1.1 **and** Fig. 1.1 (repeated above) to explain the risks of using ships as artificial reefs.

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2 Scientists investigated the effect of temperature on the rate of photosynthesis and the rate of respiration of phytoplankton.

(a) Outline the light-dependent stage of photosynthesis.

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(b) A species of green alga that normally grows in surface water was grown in a tank.

The rate of oxygen release from algae is a measure of the rate of photosynthesis.

The algae were illuminated with light of the same intensity and wavelengths (colours) as in the surface water. The rate of oxygen release by the algae was measured at temperatures between 5 °C and 35 °C.

The experiment was repeated with light of the same intensity and wavelengths as in water at a depth of 15 m.

The effect of temperature on the rate of respiration was also determined by measuring the rate of oxygen uptake when the algae were in the dark.

The results are shown in Fig. 2.1.

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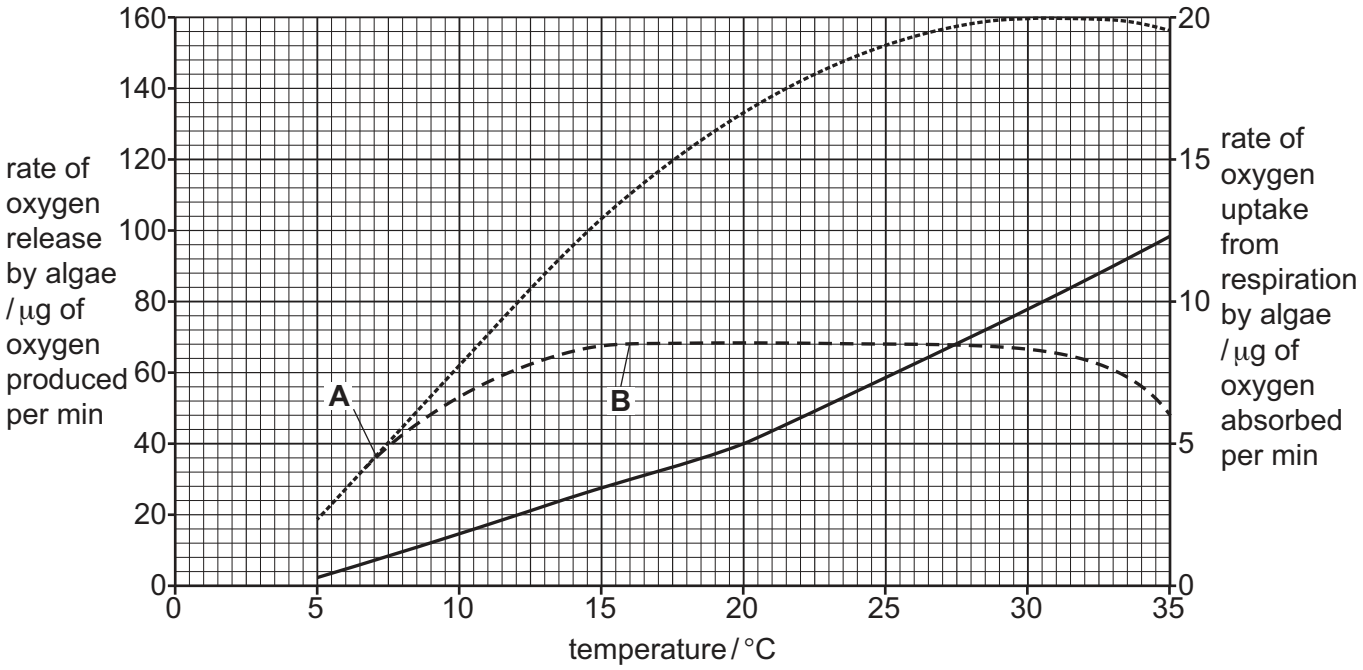

Key

····· rate of oxygen release with light of the same intensity and wavelengths as in surface water

- - - - - rate of oxygen release with light of the same intensity and wavelengths as at 15 m depth

——— rate of oxygen uptake from respiration in darkness

Fig. 2.1

(i) Describe how the light intensity and light wavelengths at a depth of 15 m will differ from the light intensity and light wavelengths at the surface.

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(ii) State the factors that are limiting the rates of photosynthesis at **A** and **B** on Fig. 2.1.

Explain your answers.

limiting factor at **A** .....

explanation .....

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limiting factor at **B** .....

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(iii) The overall rate of photosynthesis of a producer is the total amount of oxygen produced by photosynthesis. It can be calculated using the equation shown.

$$\text{overall rate of photosynthesis} = \frac{\text{rate of oxygen release}}{\text{by algae}} + \frac{\text{rate of oxygen uptake from respiration}}{\text{by algae}}$$

Use the equation **and** Fig. 2.1 to calculate the overall rate of photosynthesis for the algae at a temperature of 20 °C and a depth of 15 m.

Assume the rate of respiration is **not** affected by depth.

State the unit.

Show your working.

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(iv) Use Fig. 2.1 to discuss how global warming could affect the growth of algae at the surface **and** at 15 m depth.

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3 In 2004, purse seine fishing was banned in an Indian Ocean fishery. The impact of this ban on the mean length of grouper in the fishery was investigated.

The mean lengths of grouper caught each year from 2002 to 2014 in this area and a similar area in which purse seine fishing continued were determined.

The results are shown in Fig. 3.1.

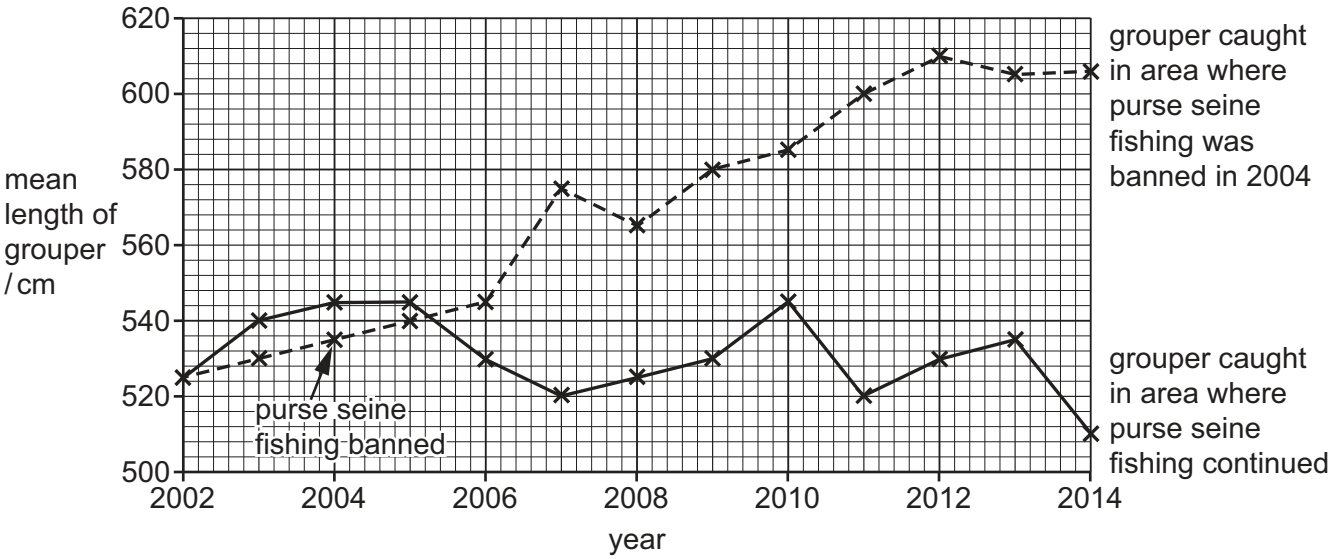

Fig. 3.1

(a) (i) Summarise the effect of the ban on purse seine fishing on the mean lengths of grouper shown in Fig. 3.1.

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(ii) Use Fig. 3.1 to explain how the ban on purse seine fishing would make fishing more sustainable.

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(b) The impact of the ban on purse seine fishing on local communities was also investigated.

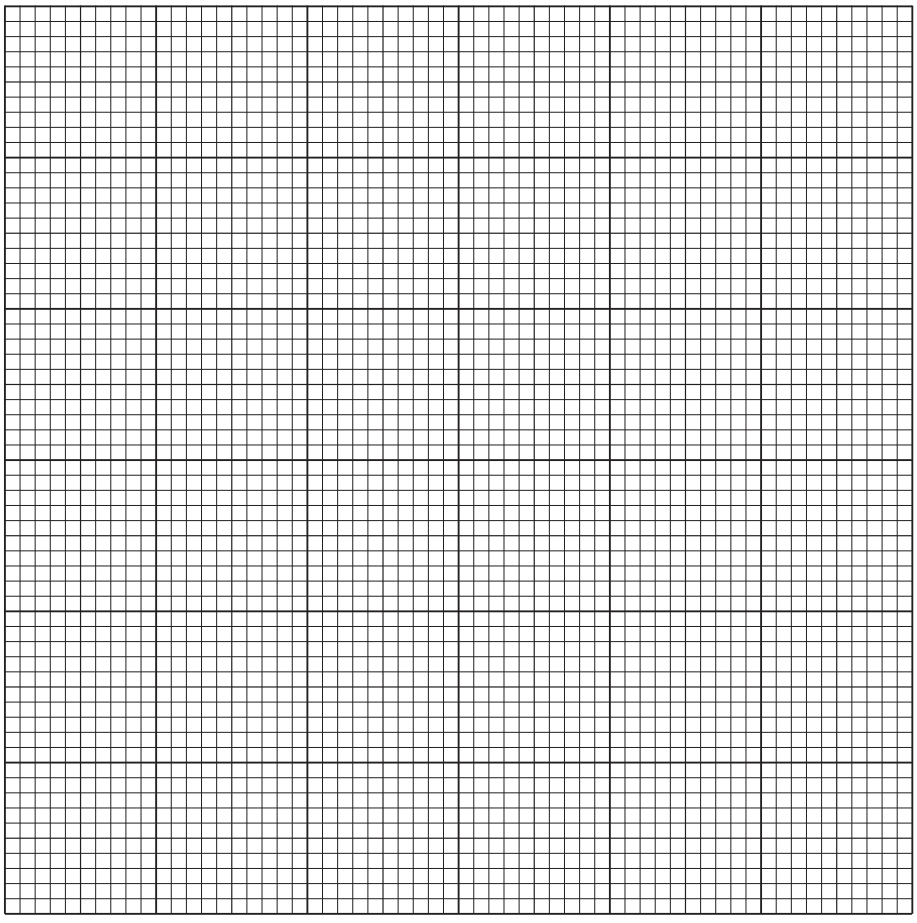
The catch per unit effort (CPUE) and the mean daily income of fishers were determined between 2002 and 2014. The data are shown in Table 3.1.

Table 3.1

year	catch per unit effort (CPUE) / kg per fisher per day	mean daily income / USD ($) per fisher per day
2002	3.6	10
2004	2.9	6
2006	3.0	8
2008	3.2	8
2010	3.6	10
2012	4.2	14
2014	4.2	16

(i) Draw a line graph to show the CPUE and mean daily income of fishers between 2002 and 2014.

Join your points with ruled, straight lines.



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(ii) Use Table 3.1 **and** your graph in **(b)(i)** to discuss the effect on the local community of the 2004 ban on purse seine fishing.

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(iii) Give **one** way in which the ban on purse seine fishing can be monitored.

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4 Environmental groups have warned that increasing ocean acidification is causing the shells of marine molluscs to become thinner.

Fig. 4.1 shows a photograph of the shell of a marine mollusc species called *Neptunea contraria*.

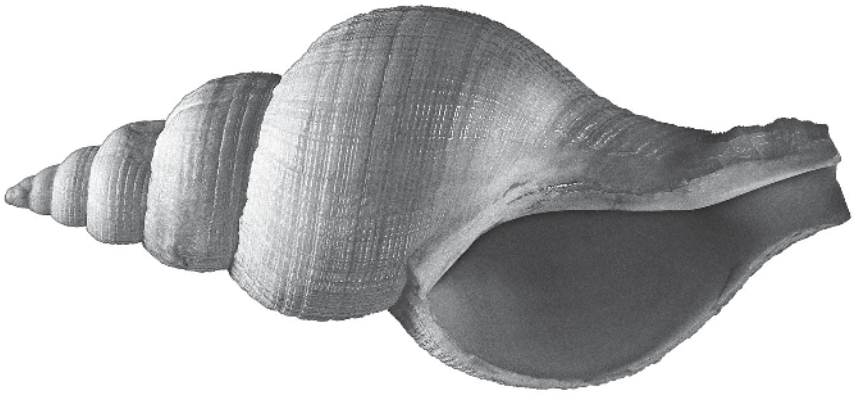

Fig. 4.1

(a) Make a large drawing of the shell of *Neptunea contraria* shown in Fig. 4.1.

Do **not** include the markings on the shell.

Do **not** label your drawing.

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(b) (i) Describe how carbon dioxide reacts with water to affect the pH.

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(ii) Explain why excess atmospheric carbon dioxide can cause the shells of marine molluscs to become thinner.

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(c) The temperature of water may affect the speed at which mollusc shells are damaged by acidity.

Plan a **laboratory-based** investigation that you could do to determine the effect of temperature on the loss of mass of mollusc shells due to acidic water.

You are provided with standard laboratory apparatus and materials.

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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5 Pacific salmon are euryhaline fish that spend part of their life cycle in the sea and part of their life cycle in rivers.

(a) State what is meant by the term euryhaline.

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(b) Scientists investigated the effect of placing salmon into water of different salinities.

Salmon were first kept in water with a salinity of 35 ppt for two weeks.

Five of these salmon were selected and each one was placed into a separate tank of water with a salinity of 15 ppt.

The decrease in oxygen concentration of the water in each of the tanks was determined over a period of one hour.

This was repeated twice. In the first repeat, five different salmon were selected and each one placed into separate tanks with a salinity of 35 ppt. In the second repeat, five different salmon were selected and each one placed into separate tanks with a salinity of 47 ppt.

Table 5.1 shows the results.

Table 5.1

salinity / ppt	number of salmon (n)	mean decrease in oxygen concentration / mg dm^{-3} kg^{-1}	standard deviation / mg dm^{-3} kg^{-1}	standard error	2 × standard error
15	5	2.3	0.50	0.22	0.44
35	5	2.1	0.20	0.09	0.18
47	5	3.8	0.40		

(i) Calculate the standard error for the mean decrease in oxygen concentration of the water with a salinity of 47 ppt.

Use the equation:

$$\text{standard error, SE} = \frac{s}{\sqrt{n}}$$

s = standard deviation

n = sample size (number of observations)

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(ii) Use your answer to **(b)(i)** to calculate the 95% confidence interval for the mean decrease in oxygen concentration of the water with a salinity of 47 ppt.

Use the equation:

$$95\%\ \text{confidence interval (95\% CI)} = \bar{x} \pm (2 \times \text{SE})$$

$\bar{x}$ = mean

SE = standard error

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(iii) Assess whether placing the salmon into water with salinities of 15 ppt and 47 ppt resulted in significant differences in the mean decrease in oxygen concentration of the water compared with the results at 35 ppt.

Use the information in Table 5.1 **and** your answer to **(b)(ii)** to support your answer.

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(iv) Explain why placing the salmon into the water with a salinity of 47 ppt caused a decrease in the oxygen concentration.

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