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MARINE SCIENCE**9693/23**

Paper 2 AS Level Data-handling and Investigative Skills

May/June 2026**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. Do **not** use correction fluid or tape.
- 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.

Answer **all** questions.

- 1 Figure 1.1 shows a horseshoe crab.

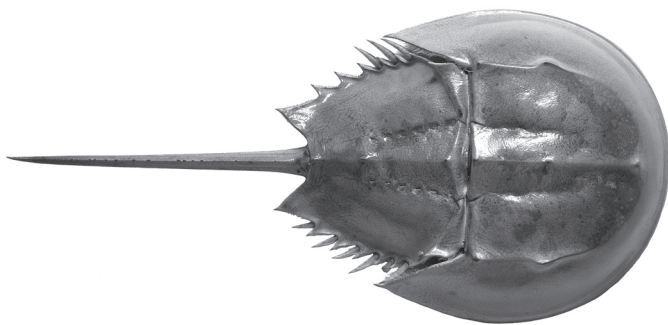


Figure 1.1

- (a) Make a large drawing of the horseshoe crab in Figure 1.1.

[4]

- (b) Horseshoe crabs are **not** classified as crustaceans.

Table 1.1 shows some body features of organisms.

The features present in horseshoe crabs have been identified.

Table 1.1

feature	horseshoe crab	typical crustacean
two pairs of antennae	<i>x</i>	
carapace	✓	
operculum	<i>x</i>	

- (i) Complete Table 1.1 to identify if each feature is present (✓) or **not** present (*x*) in a typical crustacean. [1]

- (ii) State **one** other feature found in a typical crustacean. [1]

.....

- (c) Horseshoe crabs are grown in captivity to study their development.

As they develop, their larvae go through various growth stages.

Scientists investigated the growth of horseshoe crab larvae in the first seven stages.

They measured the body width (in mm) and body mass (in mg) of the larvae.

The mean body width and mean body mass were calculated for the first seven stages, as shown in Table 1.2.

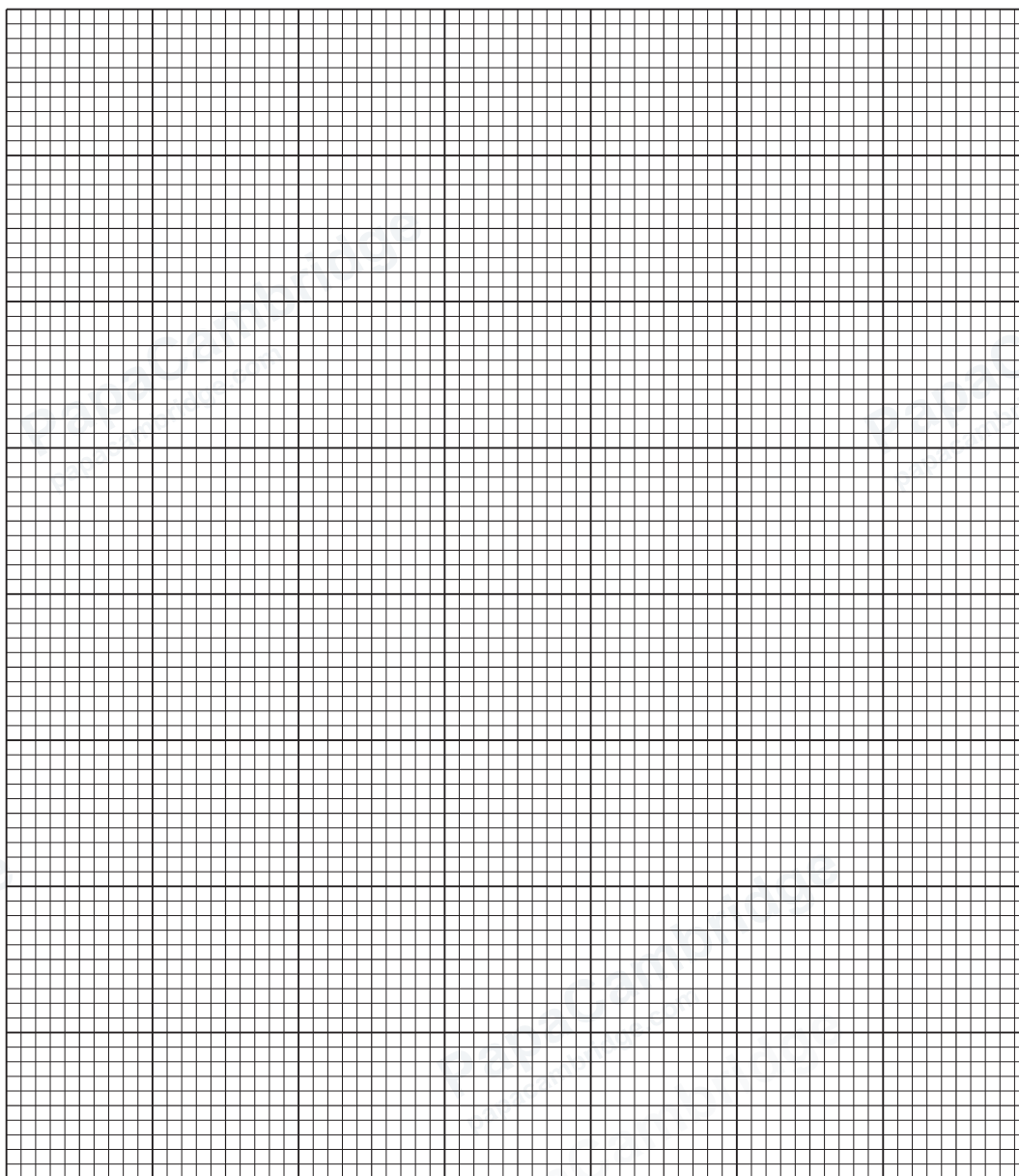
Table 1.2

growth stage	mean body width/mm	mean body mass/mg
1	3.7	7
2	5.0	12
3	6.9	31
4	9.4	77
5	12.6	169
6	17.1	374
7	26.4	792



- (i) Plot a graph of mean body width against mean body mass.

Include a line of best fit.



[4]

- (ii) Describe the relationship between mean body width and mean body mass for the first seven growth stages.

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..... [2]

(iii) Scientists also studied the food preferences of the larvae at each growth stage.

Figure 1.2 shows the food preferences at each growth stage.

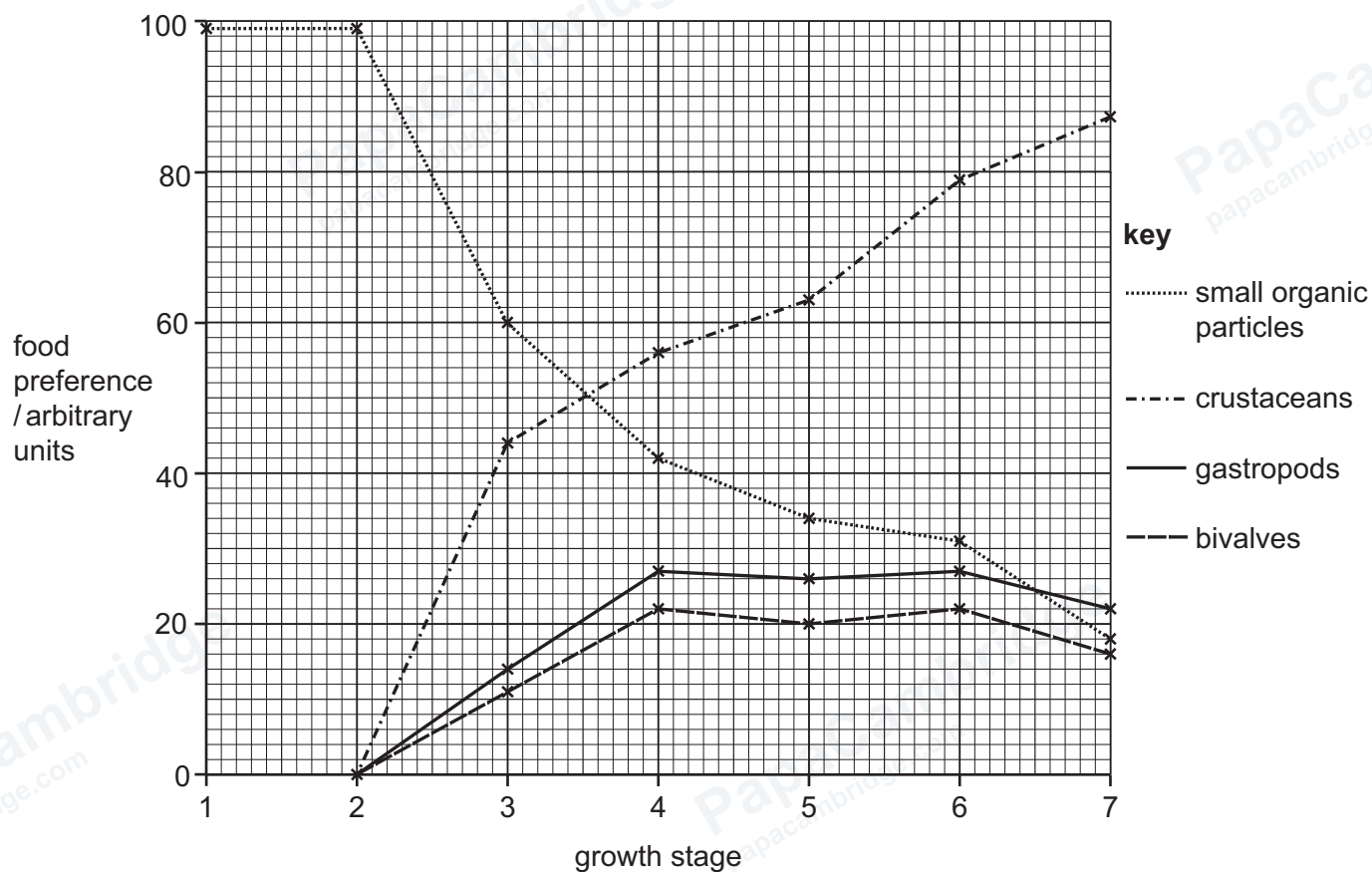


Figure 1.2

Use Figure 1.2 to suggest how the food provided for horseshoe crabs grown in captivity needs to change as they grow.

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[3]

[Total: 15]

- 2 (a) Figure 2.1 shows a fluted giant clam, *Tridacna squamosa*, living in a coral reef ecosystem.



Figure 2.1

- (i) Identify the position in the taxonomic hierarchy for each part of the binomial name of the fluted giant clam.

Tridacna

squamosa

[2]

- (ii) Some giant clams live for over 100 years and grow to 1.2m wide.

Giant clams have large numbers of zooxanthellae living in their tissues.

Suggest ways in which coral reef ecosystems can benefit from giant clams living in the reef.

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[4]

- (b) A smaller clam species is harvested as a food resource in the Northern hemisphere. They do **not** have zooxanthellae living in their tissues.

Scientists investigated the effect of latitude and mean sea surface temperature on the mean shell thickness and mean shell mass of the clams.

Samples were taken from sites at 11 different latitudes.

At each sample site the sea surface temperature was recorded, and 40 clams of the same length were collected. The mean shell thickness and mean shell mass were calculated for each sample site.

Table 2.1 shows the mean data for each latitude.

Table 2.1

latitude / degrees N	mean sea surface temperature / °C	mean shell thickness / mm	mean shell mass / g
46.0	16.88	1.77	2.22
45.7	16.96	1.60	2.15
45.2	16.47	1.33	1.66
44.8	16.54	1.26	1.59
44.2	17.05	1.17	1.57
43.6	17.81	1.20	1.60
43.4	17.63	1.16	1.55
43.1	17.90	1.14	1.52
42.5	18.11	1.09	1.44
42.3	18.08	1.11	1.45
41.9	18.60	1.06	1.41

Spearman's rank correlation was used to analyse the relationship between mean sea surface temperature and mean shell mass.



The formula for Spearman's rank correlation (r_s) is given below:

$$r_s = 1 - \left(\frac{6 \times \sum D^2}{n^3 - n} \right)$$

where

Σ = sum of (total)

n = number of pairs of items in the sample

D = difference in rank between each pair of measurements

Table 2.2 shows part of the calculation of r_s when comparing mean sea surface temperature with mean shell mass.

Table 2.2

latitude/ degrees N	mean sea surface temperature/°C	rank	mean shell mass/g	rank	D	D^2
46.0	16.88	9	2.22	1	8	64
45.7	16.96	8	2.15	2	6	36
45.2	16.47	11	1.66	3	8	64
44.8	16.54	10	1.59	5	5	25
44.2	17.05	7	1.57	6	1	1
43.6	17.81	5	1.60	4	1	1
43.4	17.63	6	1.55	7	1	1
43.1	17.90	4	1.52	8	4	16
42.5	18.11	2	1.44	10	8	64
42.3	18.08	3	1.45	9	6	36
41.9	18.60	1	1.41	11	10	100

(i) Calculate $\sum D^2$ for the data in Table 2.2.

..... [1]

(ii) Use your answer to **2(b)(i)** to calculate r_s .

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

..... [3]



- (iii) Use your answer to **2(b)(ii)** to describe the relationship between mean sea surface temperature and mean shell mass.

Justify your answer.

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.....

.....

..... [2]

- (iv) Explain **two** other factors that could affect the shell thickness and shell mass of the clams.

1

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2

.....

[2]

[Total: 14]



- 3 Density of sea water can be measured using a floating instrument called a hydrometer.

A student used a hydrometer to investigate the effect of temperature on the density of sea water.

500 cm³ of sea water was placed in a large measuring cylinder.

The measuring cylinder was then placed in a water-bath set to the required temperature and left for 15 minutes.

A hydrometer was then added and a density reading taken from the scale as shown in Figure 3.1.

This process was then repeated with sea-water samples for a range of increasing temperatures.

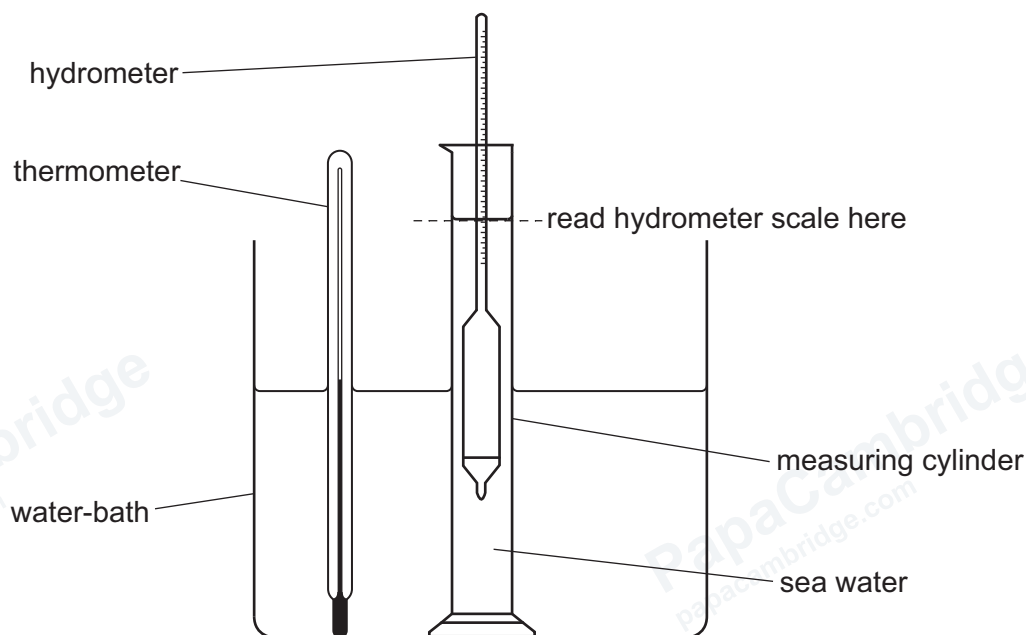


Figure 3.1

- (a) (i) Suggest why the measuring cylinder was left in the water-bath for 15 minutes before adding the hydrometer.

.....
 [1]

- (ii) Suggest why the student did not place the sea water and the hydrometer directly into the water-bath and adjust the temperature.

.....
 [1]



(b) (i) Draw a table that could be used by the student to record their results.

Include suitable units but do **not** include any data.

[2]

(ii) Use the axes below to predict the relationship that the student would find between sea-water temperature and density.



[2]

(c) Explain why increasing temperature will affect the density of water.

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.....

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..... [2]



- (d) Many marine mammals have a layer of lipid-rich tissue underneath their skin called blubber. Blubber has a lower density than sea water.

- (i) Suggest why the lower density of blubber may be useful for marine mammals.

.....
..... [1]

- (ii) Lipids are large molecules that are made from smaller molecules.

Name the **two** smaller molecules that lipids are made from.

..... and [1]

- (iii) Name **three** elements that all lipids are composed of.

.....
..... [1]

- (iv) Lipids also make good insulators as they have low thermal conductivity.

Thermal conductivity is the ability of a substance to transfer thermal energy.

Different lipids have different thermal conductivity.

Table 3.1 shows information about two species of marine mammal that are of similar size.

Table 3.1

mammal	region of ocean	blubber thermal conductivity / arbitrary units	percentage blubber lipid content
harbour porpoise	temperate	0.09	81.6
spotted dolphin	tropical	0.21	54.9

Explain the differences in blubber found in harbour porpoises and spotted dolphins.

Use your own knowledge **and** the information provided in Table 3.1 to support your answer.

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..... [3]

[Total: 14]

- 4 Figure 4.1 shows four locations around a delta, J, K, L and M.

Samples of water and sediment were taken from each location.

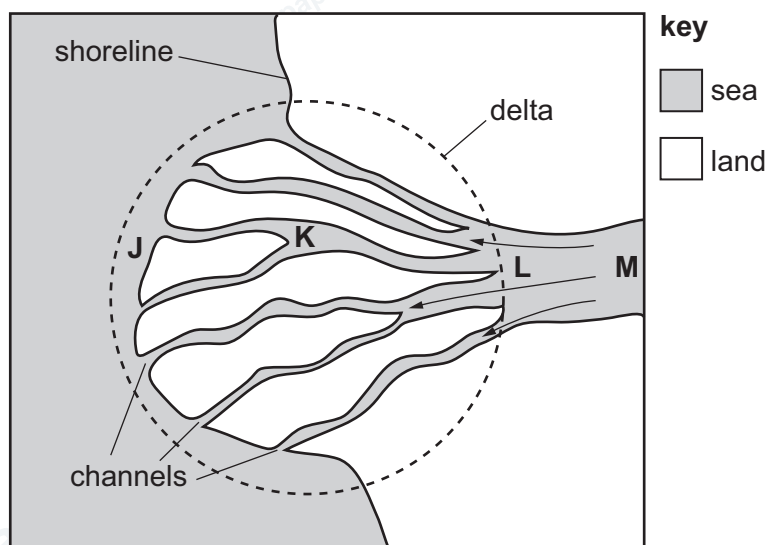


Figure 4.1

- (a) Describe how a delta forms.

.....

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..... [2]

- (b) Each water sample was tested for pH using three different methods: litmus indicator, universal indicator and a pH probe.

The results are shown in Table 4.1.

Table 4.1

sample site tested	result for each test method		
	litmus indicator	universal indicator	pH probe
J	blue	blue-green	8.1
K	blue	blue-green	7.5
L	blue	green	7.3
M	blue	green	7.2



(i) State how universal indicator could be used to find the pH of the sample.

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..... [1]

(ii) Evaluate the results for each test method shown in Table 4.1.

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..... [3]

(c) A student suggested the following hypothesis:

The higher the salinity the higher the pH of water.

(i) Describe a method the student could use to create solutions of different salinity in the laboratory.

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..... [3]

(ii) Discuss if the information in Figure 4.1 **and** Table 4.1 supports the student's hypothesis.

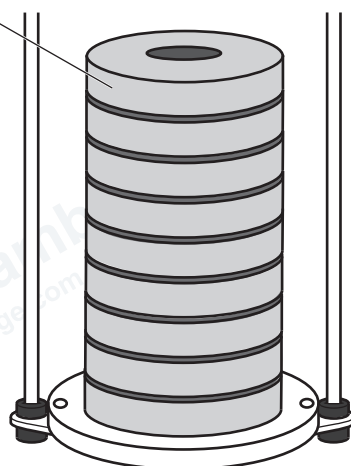
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..... [3]



- (d) The student performed a sediment analysis on samples taken from sites **K** and **L** at the delta.

A known mass of dry sediment from site **K** was passed through a set of mechanical sieves (1–9) with different-sized holes, to separate sediment particles of different sizes as shown in Figure 4.2.

top sieve where
sediment is added



stack of sieves with
different-sized holes:
largest particles collect at top,
smallest particles collect at bottom

Figure 4.2

The percentage composition of each size was then calculated.

This was then repeated for a sample from site **L**.

Table 4.2 shows the results of the sediment analysis.

Table 4.2

sieve	percentage composition of sample	
	sample site K	sample site L
1 (largest)	0.11	3.57
2	0.85	16.43
3	8.17	27.32
4	12.31	21.72
5	7.78	15.65
6	7.87	4.98
7	11.41	1.49
8	12.87	0.57
9 (smallest)	38.63	8.27

- (i) The mass of particles in sieve 9 at sample site **K** was 193.15 g.

Calculate the total mass of the sediment sample from site **K**.

.....g [1]

- (ii) Use Table 4.2 to compare the percentage compositions for the different sediment particle sizes found at sample sites **K** and **L**.

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..... [3]



- (iii) Suggest reasons for the differences in the percentage composition for the different sediment particle sizes found at sample sites **K** and **L**.

Use Figure 4.1 to explain your answer.

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..... [3]

[Total: 19]

- 5 Macroalgae can be used to obtain seaweed extract, which may be of benefit to humans.

Scientists investigated four seaweed extracts (1, 2, 3 and 4) to find if they had any benefit as disinfectants. Disinfectants are useful as they can kill microorganisms such as bacteria.

- (a) State **two** features of a typical macroalga.

1

2 [2]

- (b) Four different species of bacteria (**A**, **B**, **C** and **D**) were investigated.

Each species was grown on a separate Petri dish containing nutrient-rich medium.

Paper discs soaked in each seaweed extract were placed on the medium and incubated in a warm oven.

After 24 hours each Petri dish was examined, and any clear area around each paper disc was measured and recorded as a 'zone of inhibition', as shown in Figure 5.1.

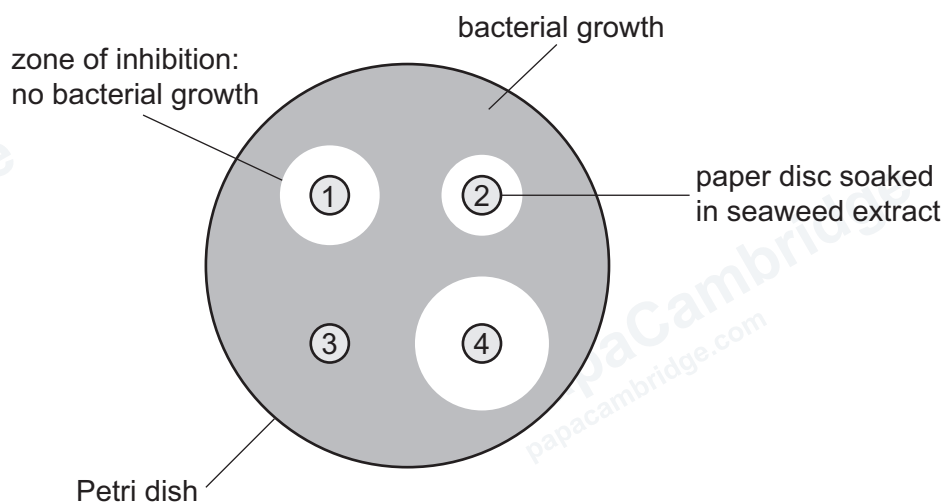


Figure 5.1

Figure 5.2 shows the results for each species of bacterium when exposed to each type of seaweed extract.

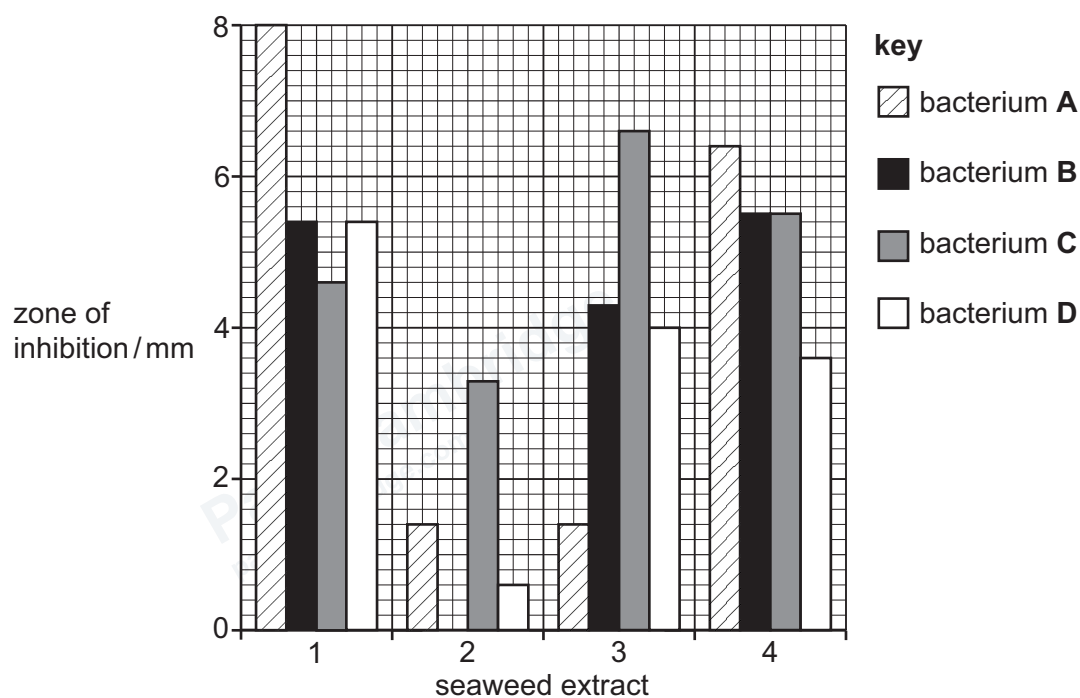


Figure 5.2

(i) State **two** variables that would need to be standardised during this investigation.

- 1
- 2

[2]

- (ii) The scientists concluded that seaweed extract **1** would be most effective to use as a disinfectant.

Evaluate the extent to which the results in Figure 5.2 support this conclusion.

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..... [4]

- (c) Each seaweed extract was analysed to find the mass of four types of metal ion.

Table 5.1 shows the mass of each metal ion in each seaweed extract.

Table 5.1

metal ion	mass of element in each seaweed extract / mg kg^{-1}			
	extract 1	extract 2	extract 3	extract 4
calcium	8853	6002	8184	4670
arsenic	76	23	27	66
aluminium	21	46	274	56
magnesium	5553	9545	9838	5116

- (i) Suggest which metal ion could be inhibiting the growth of bacterium **A**.

Use Table 5.1 **and** Figure 5.2 to explain your answer.

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..... [2]

- (ii) Suggest which extract contained the most chlorophyll.

Give a reason for your answer.

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..... [1]

- (d) Extracts from keyhole limpets are used for human medical purposes.

State the name **and** medical use of a chemical extracted from keyhole limpets.

name

.....

medical use

..... [2]

[Total: 13]



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