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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5388820991

BIOLOGY **9700/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2024**

1 hour 15 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 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

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1 Algae are a diverse group of photosynthetic eukaryotes in the kingdom Protoctista.

Rhodomonas salina and *Skeletonema costatum* are two species of alga that live in seawater.

Fig. 1.1 shows a scanning electron micrograph of *R. salina*, which is a unicellular organism. *R. salina* is red in colour.



Fig. 1.1

Fig. 1.2 shows a scanning electron micrograph of *S. costatum*, which is also a unicellular organism. The individual cells can group together in a chain. *S. costatum* is yellow-brown in colour.

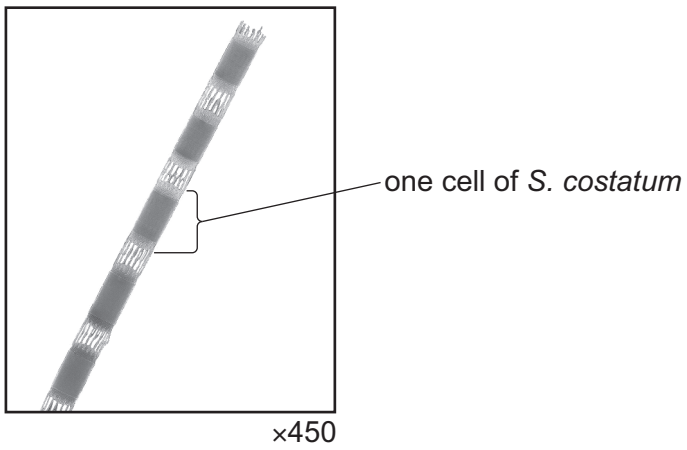


Fig. 1.2

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(a) A student prepared extracts of the photosynthetic pigments from *R. salina* and *S. costatum*. The student carried out chromatography to identify and compare the pigments in the two species.

The chromatograms are shown in Fig. 1.3.

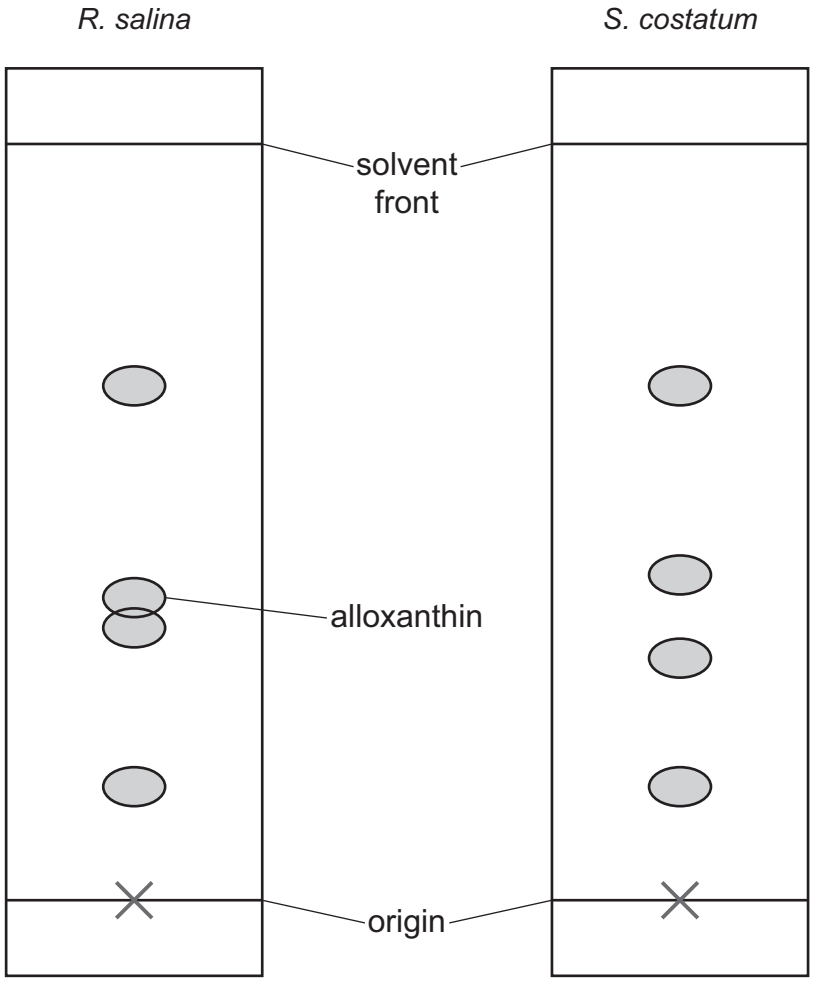


Fig. 1.3

(i) Use Fig. 1.3 to calculate the R_f value of alloxanthin from *R. salina*.

R_f of alloxanthin = ... [1]

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(ii) Table 1.1 shows the R_f values of some photosynthetic pigments.

Table 1.1

photosynthetic pigment	R_f value
β-carotene	0.94
chlorophyll a	0.68
chlorophyll b	0.54
chlorophyll c	0.15
diadinoxanthin	0.32
fucoxanthin	0.43
phycocyanin	0.35

R. salina lacks two photosynthetic pigments that are present in *S. costatum*.

Use Fig. 1.3 and Table 1.1 to identify the **two** photosynthetic pigments that are present in **only** *S. costatum*.

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(b) The extract of the photosynthetic pigments from each of the two species was used to obtain absorption spectra as shown in Fig. 1.4.

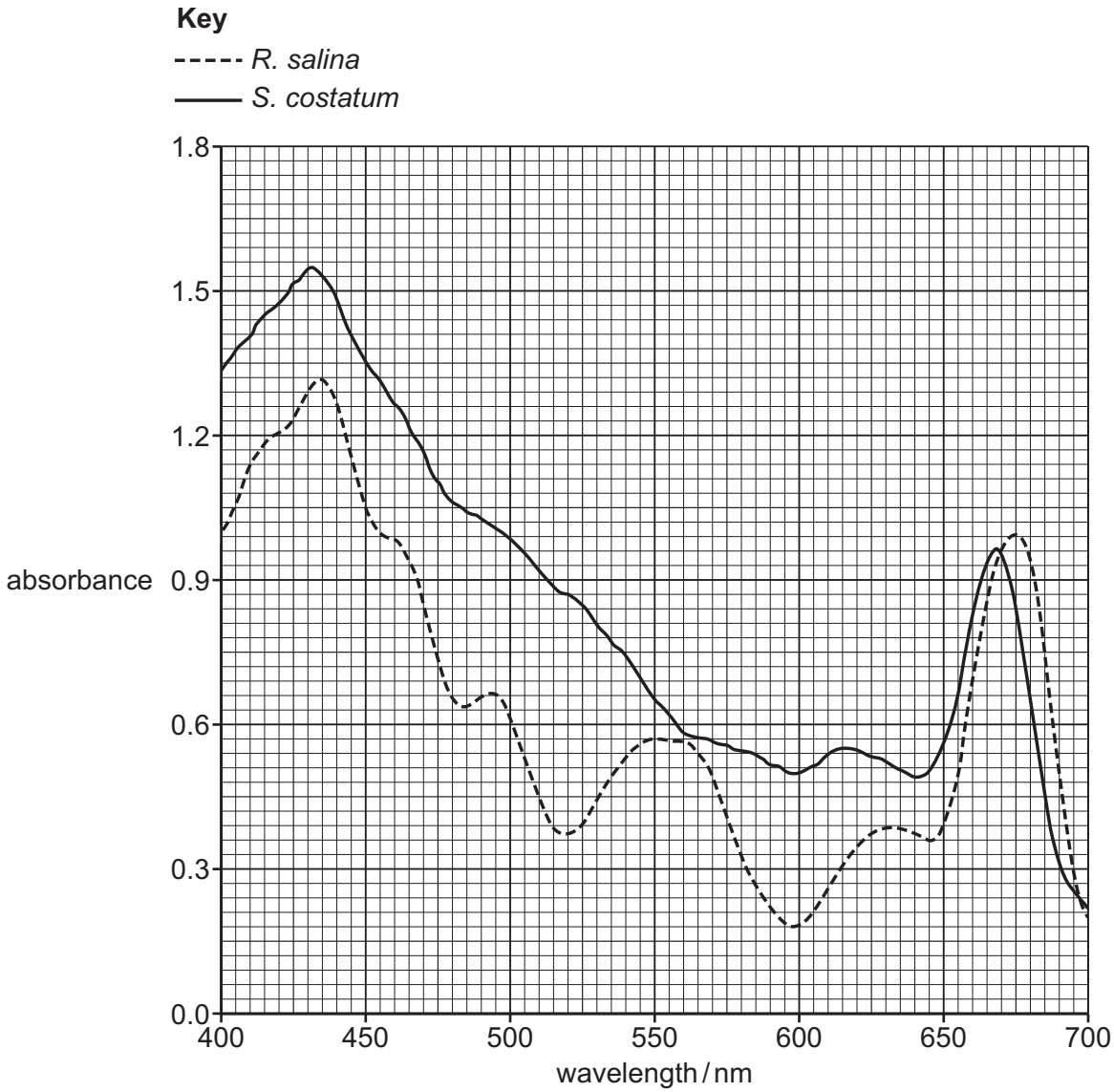


Fig. 1.4

The student planned to investigate the effect of light wavelength on the rate of photosynthesis in *R. salina* and *S. costatum*.

The student planned to determine the rate of photosynthesis in the two species when they were exposed to three different colours of light:

- blue light, peak wavelength of 455 nm
- green light, peak wavelength of 550 nm
- red light, peak wavelength of 670 nm.

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Use Fig. 1.4 to compare the expected rates of photosynthesis for the two species in blue, green and red light.

blue light .....

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green light .....

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red light .....

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[3]

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(c) In the investigation, the student used three different filters, blue, green and red, to expose the two species to the three different colours of light.

The student immobilised the algae in sodium alginate to form two sets of algal beads, one set for *R. salina* and one set for *S. costatum*.

The algal beads were the same size. Photosynthesis of the algae is **not** affected when they are immobilised in the beads.

The student placed the algal beads in small bottles for the experiment as shown in Fig. 1.5.

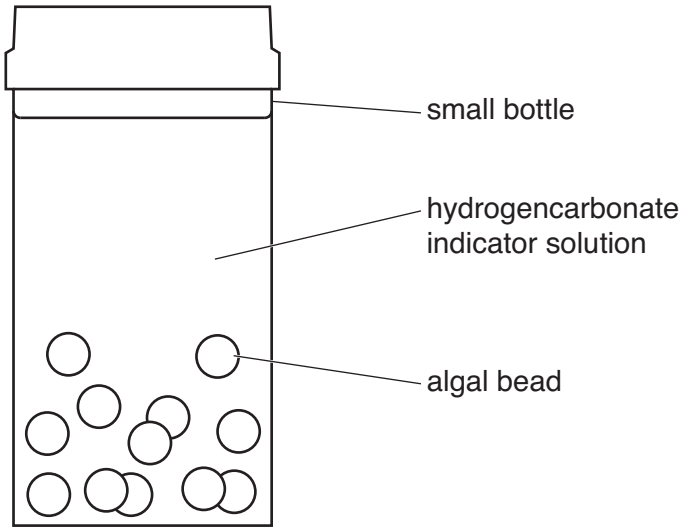


Fig. 1.5

The student used hydrogencarbonate indicator solution to estimate the rate of photosynthesis when the algal beads were exposed to each colour of light. The indicator solution changes colour with pH as shown in Table 1.2.

Table 1.2

colour of indicator solution	pH	CO_2 concentration	rate of photosynthesis
yellow	7.6	↑ increasing concentration	↓ increasing rate
yellow-orange	7.8		
orange	8.0		
orange-red	8.2		
red	8.4	atmospheric concentration (0.04%)	
red-magenta	8.6	↓ decreasing concentration	
magenta	8.8		
magenta-purple	9.0		
purple	9.2		

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The student used pH change as an indirect measure of the rate of photosynthesis. A greater decrease in CO_2 concentration indicates a higher rate of photosynthesis.

For each bottle tested, the student:

- added algal beads to a small bottle containing indicator solution
- removed a sample of the indicator solution from the small bottle after some time
- used a colorimeter to measure the absorbance of the sample of the indicator solution.

The student used a calibration curve to estimate the pH of the samples of the indicator solution.

(i) Suggest **one** reason why using algal beads, instead of placing the algal cells directly into the indicator solution in the bottles, improves the validity of the investigation.

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(ii) Identify the **two independent** variables and the **dependent** variable in this investigation.

independent variable 1 .....

independent variable 2 .....

dependent variable .....

[3]

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(iii) In addition to the colour filters, algal beads, small bottles, indicator solution and a colorimeter, the student had access to standard laboratory equipment.

The student carried out the investigation in a temperature-controlled room.

Describe a method the student could use to collect sufficient data so that the rates of photosynthesis of both species of alga in the three colours of light can be compared.

The description of your method should be set out in a logical way and be detailed enough for another person to follow.

You should **not** include a risk assessment or details of how to prepare the algal beads.

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(iv) Identify a hazard in this investigation **and** state a risk associated with the hazard **and** state one precaution that the student should take.

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(d) For each colour of light, the student carried out a statistical test to compare the pH of the samples taken from the small bottles that contained *R. salina* and *S. costatum*.

The student decided that a *t*-test was the most appropriate test to use for these data.

(i) Suggest **one** reason why a *t*-test was the most appropriate test to use for these data.

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(ii) State a null hypothesis for this test.

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2 A group of ecologists investigated the biodiversity of two peat bog ecosystems, **A** and **B**.

Peat bogs are wetland ecosystems that often contain rare species.

Fig. 2.1 shows an example of a peat bog.



Fig. 2.1

(a) The ecologists sampled the plant species in peat bog **A** and peat bog **B**.

The ecologists decided to use two suitable indices of biodiversity:

- Simpson's index of diversity
- Shannon diversity index.

The ecologists had read that the two indices can lead to different conclusions.

The Shannon diversity index gives values in the range 1.5–3.5, where 1.5 is low biodiversity and 3.5 is high biodiversity.

The results are shown in Table 2.1.

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Table 2.1

peat bog A		peat bog B	
species	number of individuals	species	number of individuals
L	34	L	30
M	10	M	15
N	11	N	18
O	15	O	24
P	8	P	16
Q	7	Q	8
R	4	R	20
S	1	S	4
T	3	T	0
U	3	U	0
V	2	V	0
W	1	W	0
Simpson's index (*D*) = **0.82**		Simpson's index (*D*) = **0.85**	
Shannon index = **2.03**		Shannon index = **1.96**	

The ecologists concluded that one index indicated peat bog **A** had more biodiversity, but the other index indicated peat bog **B** had more biodiversity.

Suggest how the differences in the data in the two samples, shown in Table 2.1, may have led to the different conclusions.

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(b) The ecologists sampled the invertebrate species in peat bogs **A** and **B** and calculated invertebrate biodiversity using Simpson's index of diversity.

(i) The ecologists sampled invertebrate species in peat bog **A**:

- between 13:00 and 16:00 on three different days within a 30-day period
- at 10 random sites along the edge of a path in the peat bog
- by sampling the invertebrates within a $1\,m^2$ quadrat placed at each site
- by using an identification key to identify the species
- by counting the number of individuals of each species.

Describe how this sampling method could be improved to make sure the results are more representative of all invertebrates in the whole of peat bog **A**.

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(ii) Table 2.2 shows the results of the invertebrate sampling in peat bog **A**.

The formula for Simpson's index of diversity (D) is:

$$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

n = number of individuals of each species present in the sample
N = total number of all individuals of all species present in the sample

Complete Table 2.2 **and** use the formula provided to calculate Simpson's index of diversity.

Table 2.2

species	n	n/N	$(n/N)^2$
Chartoscirta cocksii	11	0.071	0.005
Eristalis cryptarum	72	0.462	0.213
Glyphesis cottonae	8	0.051	0.003
Glyphesis servulus	6	0.038	0.001
Loxocera nigrifrons	29	0.186	0.035
Stenus argus	10	0.064	0.004
Trechus rivularis	7	0.045	0.002
Tipula limbata	13	.....	.....
		Σ =	.....

Simpson's index of diversity (D) = ... [3]

(iii) The ecologists calculated a D value of 0.710 for peat bog **B**.

Use your value of D from **(b)(ii)** to compare the **biodiversity** of peat bog **A** and peat bog **B**.

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