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CAMBRIDGE
International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

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BIOLOGY **9700/54**

Paper 5 Planning, Analysis and Evaluation **May/June 2026**

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. 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 30.
- 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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1 The stinging nettle, *Urtica dioica*, is a plant species that is commonly found in many areas of the world. Stinging nettles grow in woodland, in gardens and in farmland.

Figure 1.1 shows a stinging nettle.



Figure 1.1

A student decided to investigate photosynthesis in stinging nettles.

(a) The student made a leaf extract containing chloroplast pigments by grinding some leaves from stinging nettles. The student used chromatography to identify the chloroplast pigments present in the leaves.

Figure 1.2 shows the chromatogram.

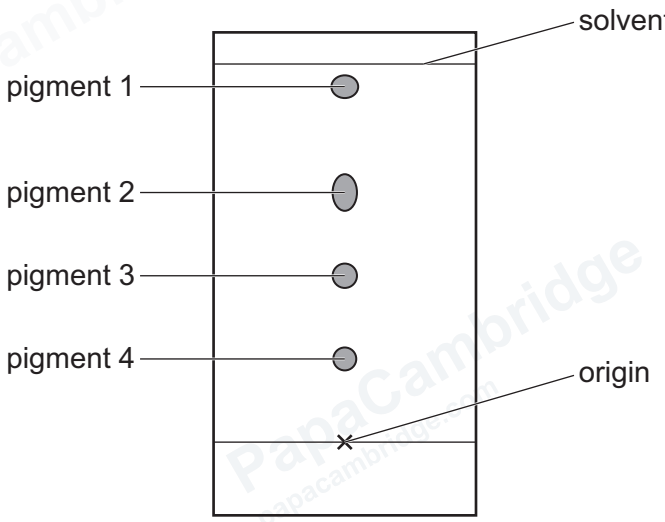


Figure 1.2

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Table 1.1 shows the reference R_f values of some chloroplast pigments from a published source.

Table 1.1

chloroplast pigment	R_f value
carotene	0.95
chlorophyll *a*	0.65
chlorophyll *b*	0.45
phaeophytin	0.83
xanthophyll	0.71

Use Figure 1.2 and Table 1.1 to identify pigment 1 **and** pigment 2.

pigment 1 .....

pigment 2 .....

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(b) (i) The student read that different light intensities result in different combinations of chloroplast pigments present in the leaves of stinging nettles.

The student decided to investigate the different combinations of chloroplast pigments present in the leaves of stinging nettles growing in:

- direct sunlight, with high light intensity
- the shade, with low light intensity.

Describe a method that the student could use to:

- collect leaves from stinging nettles growing in direct sunlight **and** in the shade
- use chromatography to separate the chloroplast pigments present in the leaves
- collect the data needed to identify each chloroplast pigment.

The student had access to standard laboratory equipment and a suitable solvent for chromatography. Your method should be set out in a logical order and be detailed enough to allow another person to follow it.

You should **not** include a risk assessment.

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(ii) Trichomes are small hair-like structures on the stems and leaves of the stinging nettle that release irritants when they are touched.

The student decided to wear gloves to protect their skin from irritation when touching stinging nettles.

State **one other** hazard, the risk associated with that hazard **and** the safety precaution that the student should take when carrying out their investigation.

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2 *Anabaena doliolum* is a species of photosynthetic prokaryote that is found in many freshwater ecosystems. The individual cells of *A. doliolum* form long chains.

Figure 2.1 shows a photomicrograph of several chains of *A. doliolum*.



×600

Figure 2.1

Some scientists investigated the effect of sodium chloride concentration on the rate of photosynthesis of *A. doliolum* by carrying out two different experiments.

In the first experiment, the scientists estimated the rate of photosynthesis of *A. doliolum* by determining the rate of oxygen production.

- A sample of *A. doliolum* cells was placed in a set volume of 0.25 mol dm^{-3} solution of sodium chloride.
- An oxygen electrode was used to determine the rate of oxygen production.
- The procedure was repeated with 0.20, 0.15, 0.10, 0.05 and 0.00 mol dm^{-3} solutions of sodium chloride.

In the second experiment, the scientists estimated the rate of photosynthesis of *A. doliolum* by determining the rate of DCPIP reduction. DCPIP changes colour from blue to colourless when it is reduced.

- An enzyme was added to a sample of *A. doliolum* cells. The enzyme partially hydrolysed the bacterial cell walls of *A. doliolum*.
- The sample of *A. doliolum* cells was placed in a test-tube with a set volume of 0.25 mol dm^{-3} solution of sodium chloride. This mixture was green in colour.
- A set volume of DCPIP was added to the test-tube to give a blue-green colour.
- The time taken for the mixture in the test-tube to change colour from blue-green to green was measured and the rate of DCPIP reduction was determined. The rate of reduction of DCPIP is a measure of the rate of NADP reduction during the light-dependent stage of photosynthesis.
- The procedure was repeated with 0.20, 0.15, 0.10, 0.05 and 0.00 mol dm^{-3} solutions of sodium chloride.

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(a) Identify the **two dependent** variables in this investigation.

first experiment .....

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second experiment .....

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[2]

(b) The scientists standardised the light intensity, temperature and volumes of solutions in the first and second experiments.

Identify **one other** variable that should be standardised in the **second** experiment.

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(c) Suggest a reason why an enzyme was added to partially hydrolyse the bacterial cell walls of *A. doliolum* cells before measuring the rate of DCPIP reduction.

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(d) The scientists were given a 0.50 mol dm^{-3} stock solution of sodium chloride. The scientists used the stock solution to make sodium chloride solutions with concentrations of 0.25, 0.20, 0.15, 0.10, 0.05 and 0.00 mol dm^{-3}.

The scientists made 20 cm^3 of each solution in separate beakers.

Complete Table 2.1 to show how **20 cm^3** of these solutions could be made by **proportional** dilution of the 0.50 mol dm^{-3} stock solution of sodium chloride.

Table 2.1

concentration of sodium chloride solution / mol dm^{-3}	**volume of 0.50 mol dm^{-3} stock solution of sodium chloride / cm^3**	**volume of ..... / cm^3**
0.25		
0.20		
0.15		
0.10		
0.05		
0.00		

[2]

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(e) Figure 2.2 shows the results of the investigation.

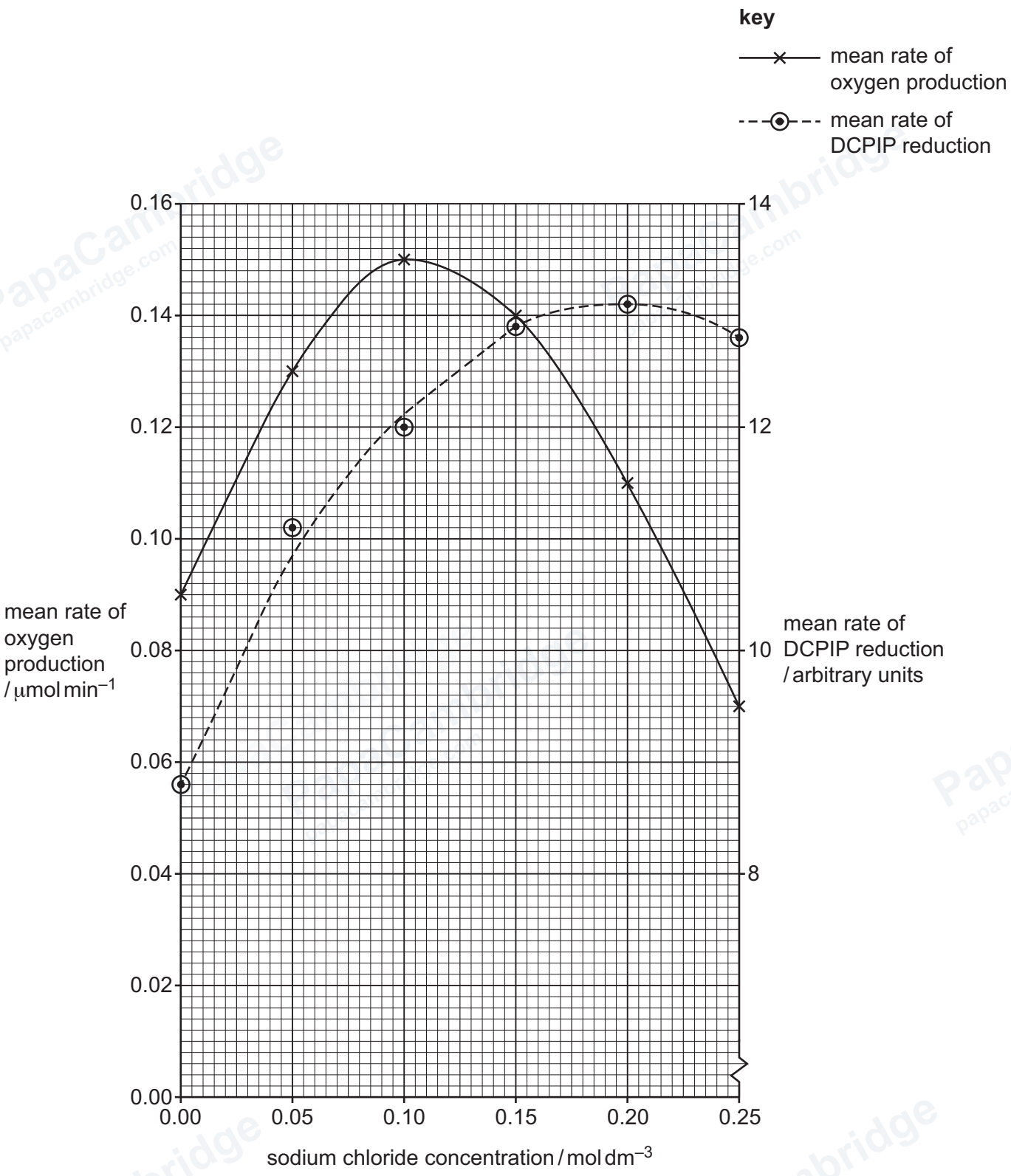


Figure 2.2

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Use Figure 2.2 to identify the key differences between the two sets of data from the investigation.

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3 Female *Anopheles* mosquitoes are the vectors that transmit malaria. Use of insecticides to control the transmission of malaria has resulted in many *Anopheles* mosquitoes becoming insecticide-resistant.

The fungus *Metarhizium pingshaense* infects and kills mosquitoes. Some biologists investigated how this fungus could be used to prevent the transmission of malaria by *Anopheles* mosquitoes. The biologists also genetically modified *M. pingshaense* to produce a toxin that is usually made by spiders.

(a) The biologists carried out a laboratory procedure to investigate the effect of *M. pingshaense* on the reproduction of *Anopheles coluzzii* mosquitoes. The percentage of female *A. coluzzii* mosquitoes that produced eggs was determined for:

- a control group of uninfected *A. coluzzii* mosquitoes
- *A. coluzzii* mosquitoes infected with *M. pingshaense* that had **not** been genetically modified (non-GM)
- *A. coluzzii* mosquitoes infected with *M. pingshaense* that had been genetically modified (GM).

Figure 3.1 shows the results of the investigation. Error bars show 95% confidence intervals (95% CI).

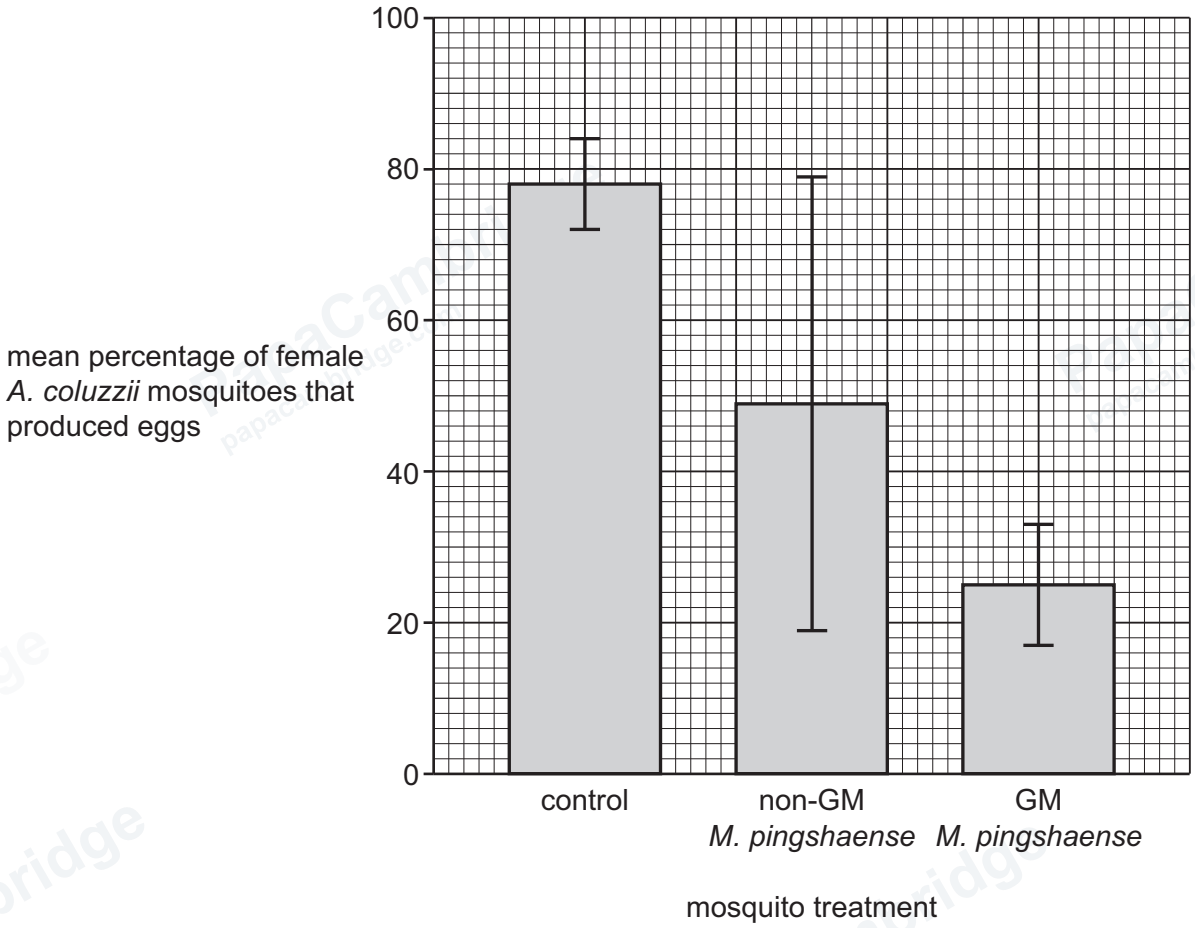


Figure 3.1

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Use Figure 3.1 to outline what can be concluded from the data.

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(b) Malaria is a common infectious disease in Burkina Faso, a country in west Africa.

The biologists investigated the effect of GM *M. pingshaense* on the reproduction of *A. coluzzii* mosquitoes in a natural environment in Burkina Faso.

The biologists set up two 9.55 m × 9.10 m experimental areas in Burkina Faso in 2017. With the help of people from Burkina Faso, the biologists:

- built a traditional hut inside each experimental area
- planted fruit trees as a source of sugar for the mosquitoes to feed on
- made small ponds as a source of water for the reproduction of mosquitoes.

Figure 3.2 shows some people building a traditional hut in Burkina Faso.



Figure 3.2

This procedure was used in one of the experimental areas.

- A piece of black cotton fabric was placed over one wall of the hut.
- GM *M. pingshaense* was added to the piece of black cotton fabric. The *A. coluzzii* mosquitoes were attracted to the black cotton fabric.
- 1000 male *A. coluzzii* mosquitoes and 500 female *A. coluzzii* mosquitoes were released into the hut.
- Some livestock were placed inside the hut every evening. Female *A. coluzzii* mosquitoes fed on blood from the livestock. This did not harm the livestock.
- The number of *A. coluzzii* mosquitoes was determined every day for 45 days. Two generations of *A. coluzzii* mosquitoes were produced in the 45 days.

The procedure was also carried out in the other experimental area, but *M. pingshaense* was **not** added to the piece of black cotton fabric.

The investigation was carried out in the summer, when rainfall is high in Burkina Faso (rainy season).

Three repeats of the whole investigation were carried out, each lasting for 45 days. The amount of rainfall decreased during repeat 2 and repeat 3.

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(i) Suggest a method the biologists could use to prevent *A. coluzzii* mosquitoes escaping from the experimental areas.

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(ii) The scientists used data from the investigation to calculate the total number of *A. coluzzii* mosquitoes in the second generation.

Table 3.1 shows the results of the investigation.

Table 3.1

repeat	total number of *A. coluzzii* mosquitoes in the second generation	
	experimental area with GM *M. pingshaense*	experimental area with no *M. pingshaense*
1	13	1396
2	61	731
3	12	429

A student used the chi-squared test (χ^2) to analyse the data from the investigation.

The student stated the null hypothesis as:

there is no difference between the number of *A. coluzzii* mosquitoes in the second generation from the experimental area with GM *M. pingshaense* and from the experimental area with **no** *M. pingshaense*.

The equation for the calculation of χ^2 is:

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

key

O = observed result
E = expected result
Σ = sum of

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Complete Table 3.2 to calculate the value of χ^2 for the data from the investigation.

Give the value of χ^2 to **three** significant figures.

Table 3.2

repeat	O	E	$O - E$	$(O - E)^2$	$\frac{(O-E)^2}{E}$
1	13	1396			
2	61	731			
3	12	429			
					χ^2 = ...

[3]

(iii) The student compared the calculated value of χ^2 to the critical values shown in Table 3.3.

Table 3.3

degrees of freedom	probability level (p)			
	0.50	**0.10**	**0.05**	**0.01**
1	0.455	2.706	3.841	6.635
2	1.386	4.605	5.991	9.210
3	2.366	6.251	7.815	11.345
4	3.357	7.779	9.488	13.277

The student rejected the null hypothesis.

Use Table 3.3 to identify the critical value for this investigation **and** explain whether the student was correct to reject the null hypothesis.

critical value .....

explanation .....

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(c) The student concluded that people in Burkina Faso could use pieces of black cotton fabric with GM *M. pingshaense* inside their houses to reduce the transmission of malaria.

Explain how the data in Table 3.1 and the calculated value of χ^2 support this conclusion.

Suggest what further information would be needed before this method could be used to reduce the transmission of malaria in Burkina Faso.

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