Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5328000591

BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2021**

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 **12** pages. Any blank pages are indicated.

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1 The enzyme β-galactosidase catalyses the breakdown of the compound ONPG (o-nitrophenyl 1-D-galactopyranoside) to the compound ONP (o-nitrophenyl), as shown in Fig. 1.1.

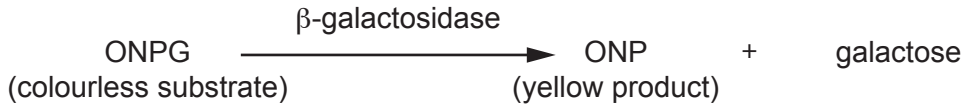


Fig. 1.1

As ONP is produced, the colour of the reaction mixture changes to yellow. The intensity of the yellow colour produced is proportional to the concentration of ONP.

A colorimeter is used to measure the absorbance of the reaction mixture. Absorbance is a measure of the light absorbed by a coloured solution. In the reaction shown in Fig. 1.1, the more intense the yellow colour, the higher the absorbance.

(a) A student was provided with a stock solution of the enzyme β-galactosidase. The student diluted this by a factor of 20 using a buffer solution of pH 8. The student made a final volume of 10 cm^3 of dilute β-galactosidase solution.

Describe how the student prepared the 10 cm^3 of diluted β-galactosidase solution.

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..... [2]

The student investigated the effect of substrate concentration on the enzyme-catalysed reaction shown in Fig. 1.1.

(b) The student was provided with:

- the diluted β-galactosidase solution prepared in step **(a)**, which was kept cold until needed
- a stock solution of 1.0% ONPG made up in a buffered solution of pH 8.0
- a buffer solution of pH 8.0.

The procedure used by the student is outlined in step 1 to step 3.

1. The diluted β-galactosidase solution was mixed with 1.0% ONPG solution.
2. After 2 minutes a colorimeter was used to measure the absorbance of this mixture.
3. Steps 1 and 2 were repeated using different concentrations of ONPG solution.

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(i) Suggest why the student used a colorimeter to measure the absorbance rather than judging the intensity of the colour by eye.

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..... [1]

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

independent variable .....

dependent variable ..... [2]

The student used the absorbance values at 2 minutes as the initial rates of reaction.

Fig. 1.2 shows the results.

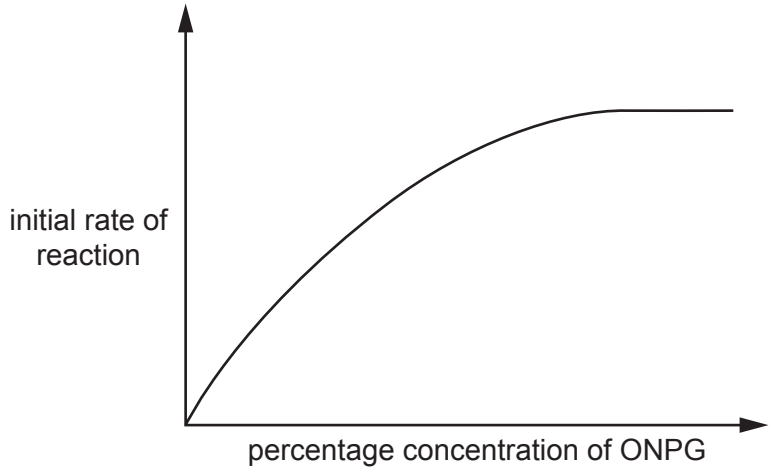


Fig. 1.2

(c) The student decided to investigate the effect of inhibitors on the reaction shown in Fig. 1.1. The student planned to add an inhibitor, inhibitor **X**, to reaction mixtures containing different concentrations of ONPG solution.

(i) Describe a method the student could use to collect the data needed to test the effect of inhibitor **X** in reaction mixtures containing different concentrations of ONPG solution.

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** repeat the details from **(a)** describing how to dilute the stock solution of β-galactosidase.

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Fig. 1.3 shows the results when **no** inhibitor **X** was added.

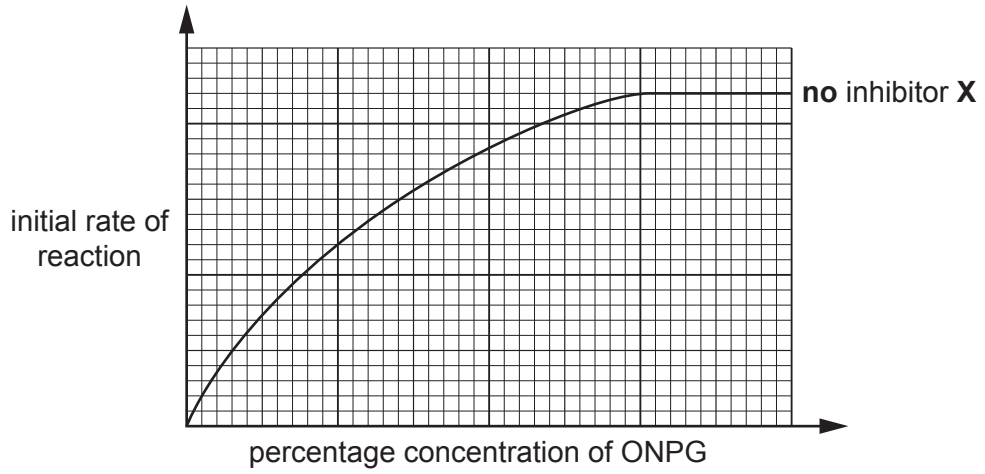


Fig. 1.3

The student suggested that inhibitor **X** was acting as a **competitive** inhibitor.

(ii) On Fig. 1.3, sketch the curve expected if inhibitor **X** was acting as a competitive inhibitor. [2]

V_{max} is the maximum initial rate of reaction of the enzyme.

The Michaelis-Menten constant, K_m, is the substrate concentration at which the initial rate of reaction is half its maximum value, V_{max}.

(iii) Draw on Fig. 1.3 the positions of V_{max} and K_m of the enzyme when **no** inhibitor **X** is present. [2]

(iv) Use your graph to describe the effect of the addition of inhibitor **X** on the K_m of this enzyme.

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..... [1]

(d) Acid reflux is a condition where some of the stomach contents are forced back up into the oesophagus (gullet). The main symptom is a burning pain in the oesophagus due to the acidic contents of the stomach. Acid reflux that happens more than twice a week is called gastroesophageal reflux disease (GERD).

Two main types of drug are used to treat GERD:

- proton pump inhibitors (PPIs)
- H_2 receptor antagonists (H_2RAs).

Scientists carried out trials to investigate the effect of these drugs on the relief of acid reflux symptoms in people suffering with GERD.

- 200 people were randomly divided into two groups, **A** and **B**.
- People in group **A** were given the PPI medication.
- People in group **B** were given the H_2RA medication.
- The trial lasted for 16 weeks.
- In weeks 4, 8, 12 and 16, the people were asked to score their symptoms, using the scale shown in Table 1.1.

Table 1.1

scale	symptom
1	none
2	minimal
3	mild
4	moderate
5	moderately severe
6	severe
7	very severe

- Mean values for each of the treatments **A** and **B** were calculated for weeks 4, 8, 12 and 16.
- People with a score of 1 were classified as showing **removal of symptoms**.
- People with a score of 2 or 3 were classed as showing **improvement of symptoms**.

The results of these trials are shown in Fig. 1.4 and Fig. 1.5.

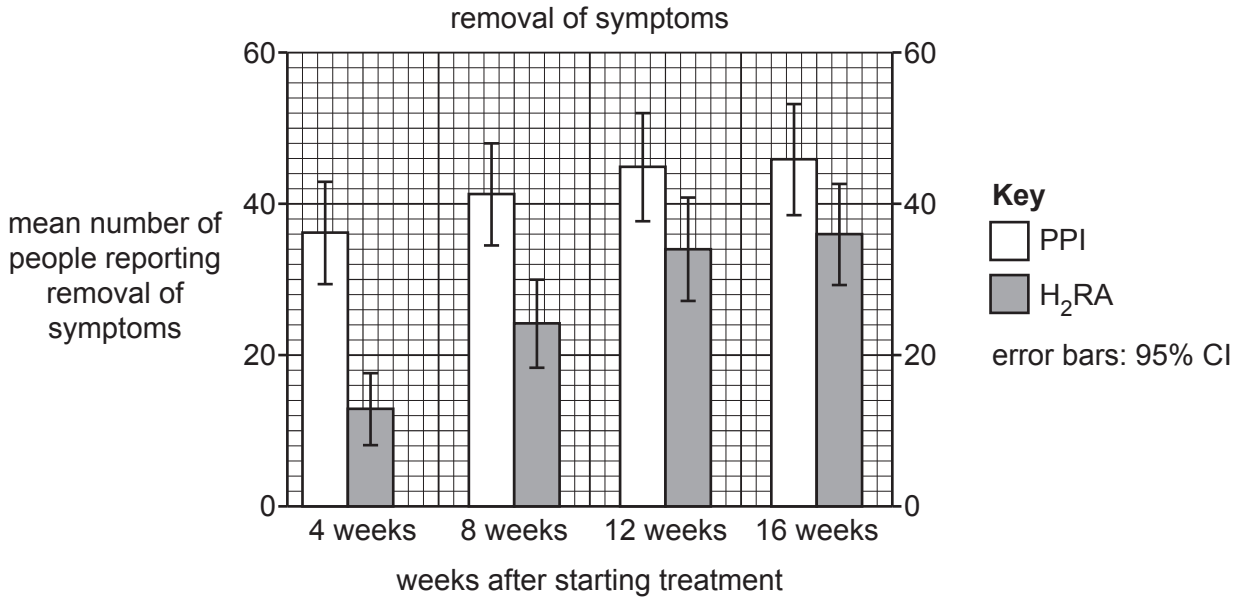


Fig. 1.4

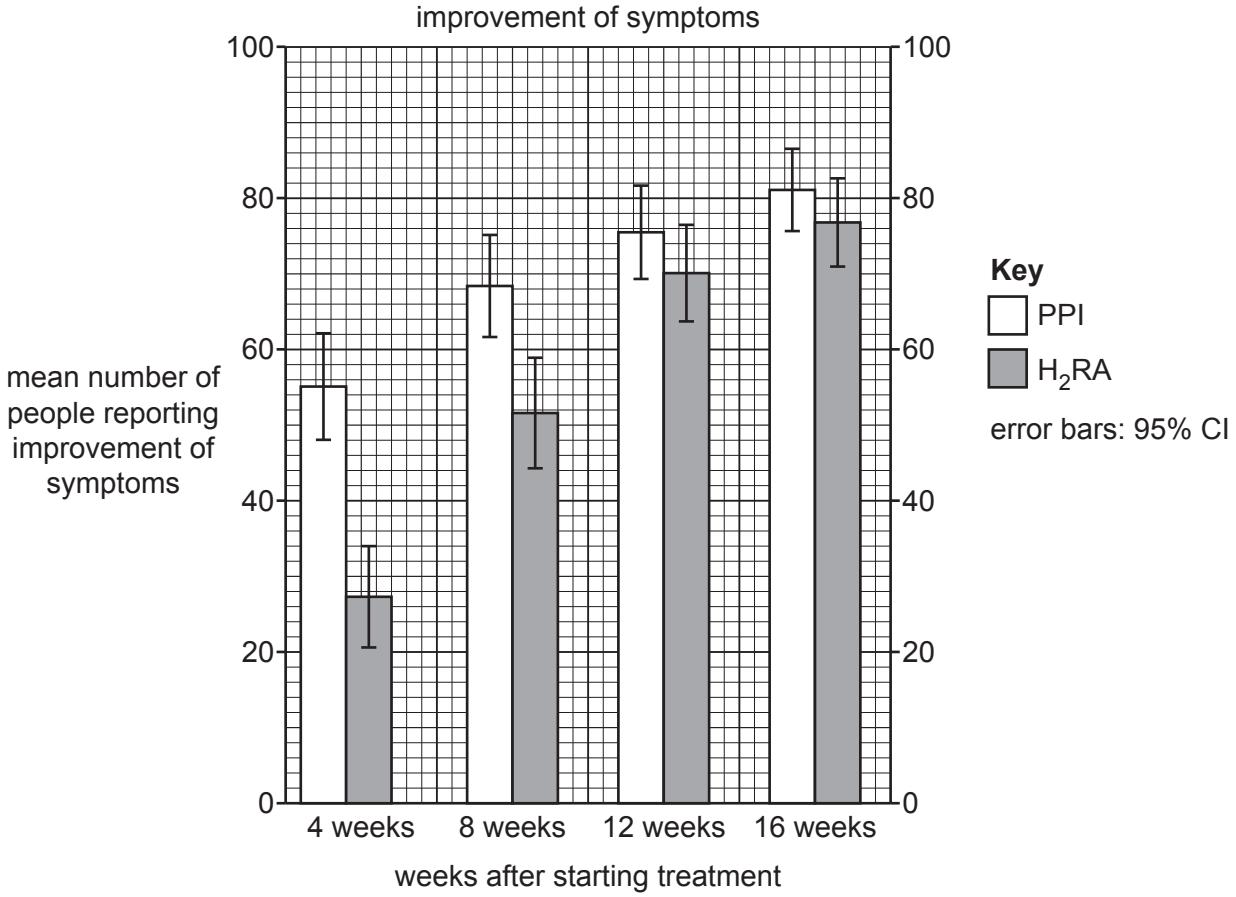


Fig. 1.5

The scientists analysed the data and concluded that PPIs should be used to treat acid reflux rather than H_2RAs.
With reference to the data in Fig. 1.4 and Fig. 1.5, discuss the conclusion that PPIs should be used to treat acid reflux.

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..... [3]

[Total: 21]

2 Inheritance of flower colour and flower position in pea plants are controlled by two genes.

- Gene **P**/**p** controls flower colour. Allele **P** for purple flowers is dominant to allele **p** for white flowers.
- Gene **A**/**a** controls flower position. Allele **A** for flowers growing from the side of the shoot (axial position) is dominant to allele **a** for flowers growing at the end of the shoot (terminal position), as shown in Fig. 2.1.

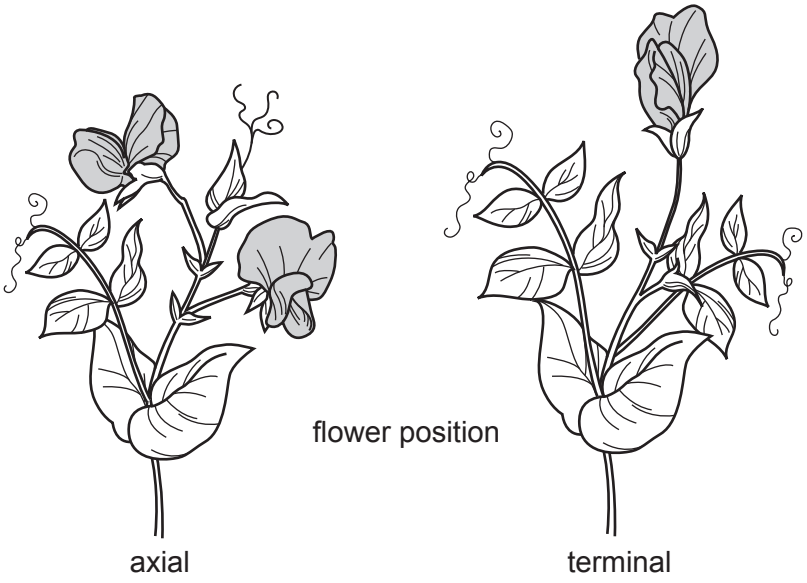


Fig. 2.1

A biologist predicted that, if the genes are on **different** chromosomes, the ratio of the phenotypes of the F2 generation would be 9:3:3:1.

The biologist carried out a breeding experiment.

- Plants homozygous for white flowers and axial position were crossed with plants homozygous for purple flowers and axial position.
- All the F1 plants had purple, axial flowers.
- The F1 plants were crossed with each other.

Table 2.1 shows the results for the F2 generation.

Table 2.1

F2 phenotype	frequency
purple, axial flowers	1756
purple, terminal flowers	653
white, axial flowers	702
white, terminal flowers	234
total	3345

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(a) The chi-squared test (χ^2 test) was used to analyse the data in Table 2.1.

(i) State **one** reason why the chi-squared test (χ^2 test) was used.

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..... [1]

(ii) State the null hypothesis that the biologist would use for this test.

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..... [1]

(iii) Complete Table 2.2 **and** calculate the value of χ^2 for the results of the F2 generation.

The equation for the calculation of χ^2 is:

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

O = observed result

E = expected result

$\sum$ = sum of

Table 2.2

offspring phenotype	***O***	***E***	$\frac{(O-E)^2}{E}$
purple, axial flowers	1756		
purple, terminal flowers	653		
white, axial flowers	702		
white, terminal flowers	234		
		χ^2 =	

[3]

Table 2.3 shows some critical values of χ^2 at different probability levels.

Table 2.3

degrees of freedom	probability (p)			
	0.10	**0.05**	**0.01**	**0.001**
1	2.71	3.84	6.64	10.83
2	4.61	5.99	9.21	13.82
3	6.25	7.82	11.34	16.27
4	7.78	9.49	13.28	18.46

(iv) State the critical value at $p < 0.05$ for this χ^2 test. ..... [1]

(v) Use your calculated value of chi-squared (χ^2) to:

- explain whether the null hypothesis should be accepted or rejected

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- suggest a conclusion the biologist could make about the inheritance of the genes controlling flower colour and flower position in pea plants.

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..... [3]

[Total: 9]

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