Cambridge Assessment International Education

Cambridge International AS & A Level

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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 [ ].

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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.

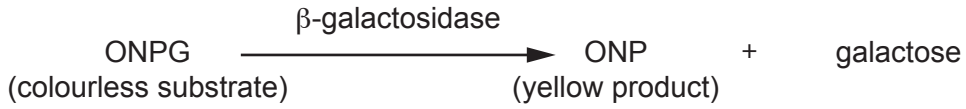


Fig. 1.1

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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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.

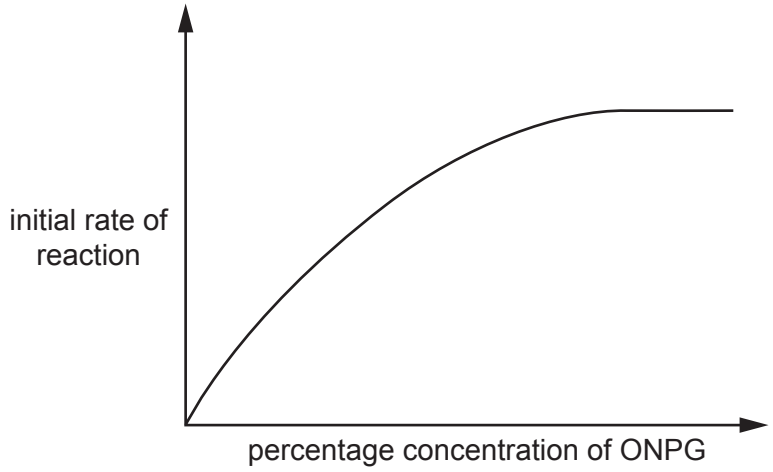


Fig. 1.2

(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.

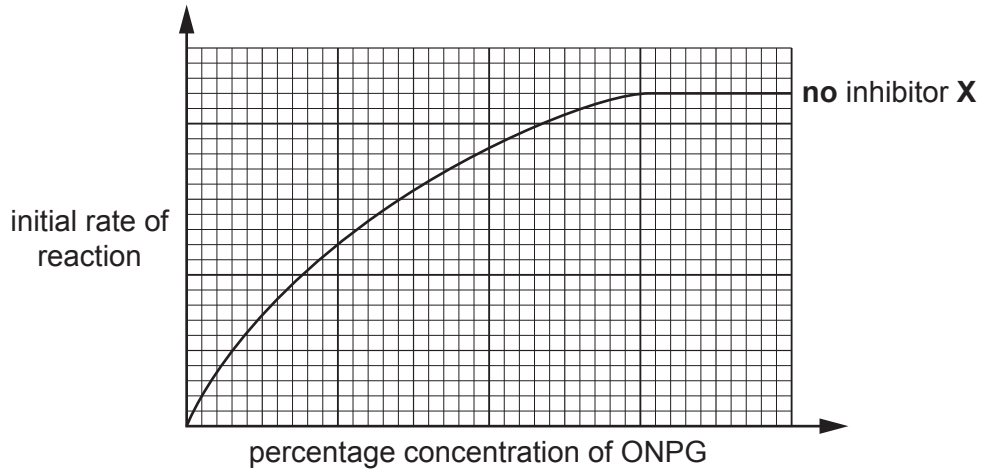


Fig. 1.3

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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(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.

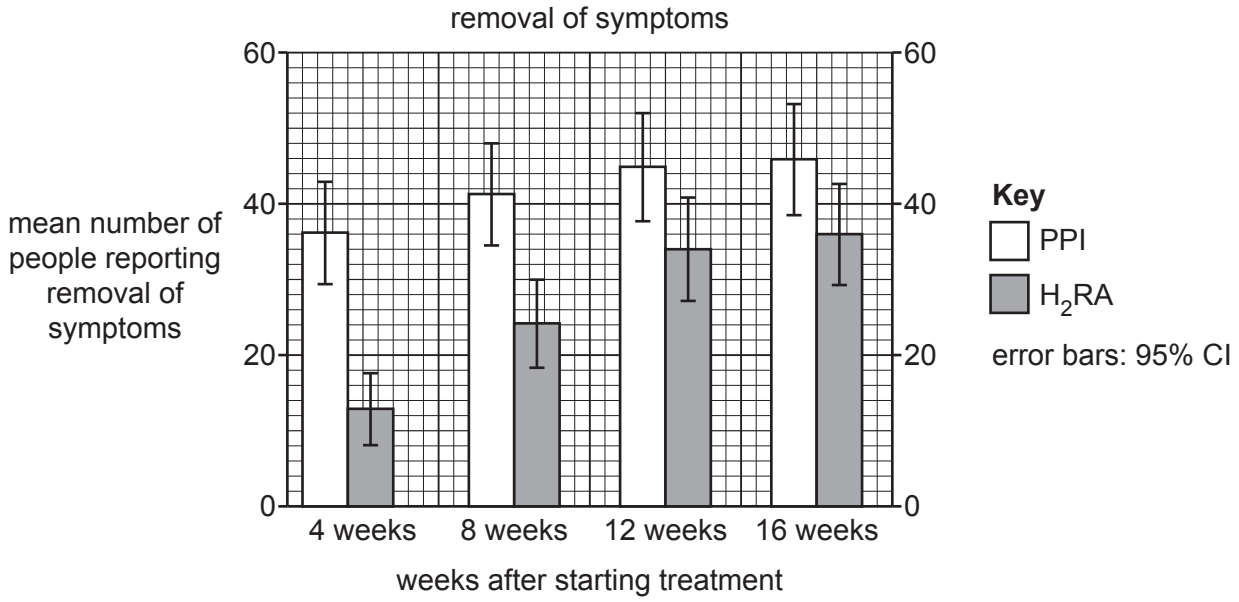


Fig. 1.4

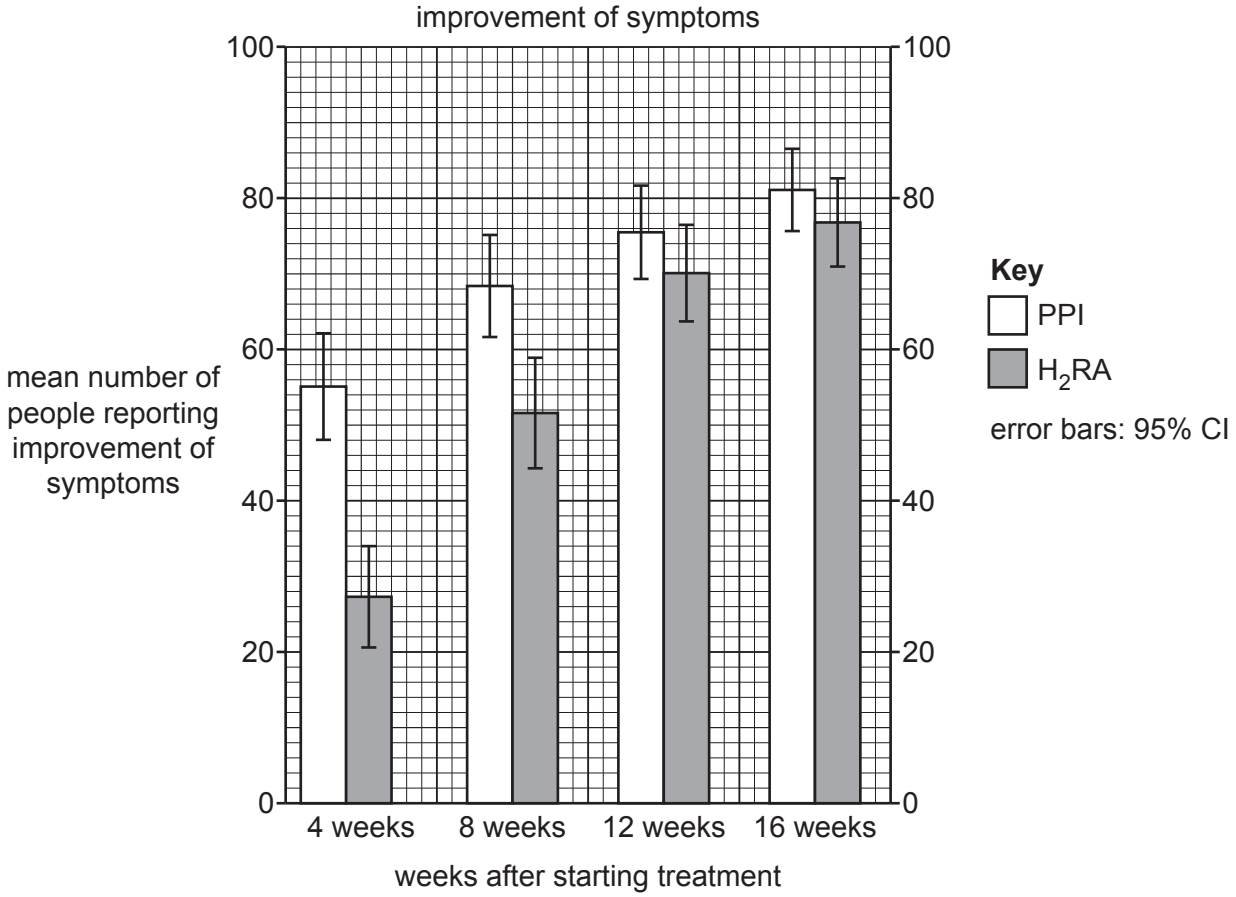


Fig. 1.5

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.

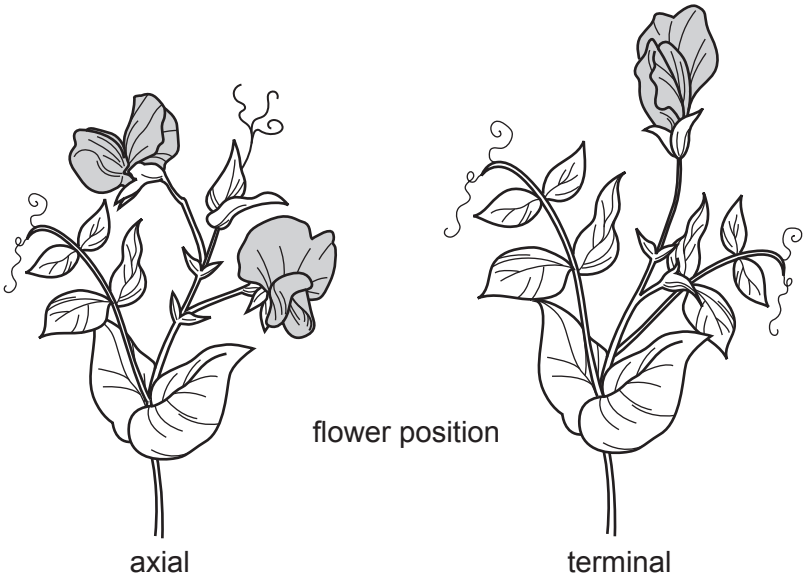


Fig. 2.1

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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[Total: 9]

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Cambridge International AS & A Level

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9655182319

BIOLOGY **9700/52**

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.
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INFORMATION

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1 The enzyme catalase catalyses the reaction shown in Fig. 1.1.

$$\text{hydrogen peroxide} \xrightarrow{\text{catalase}} \text{water} + \text{oxygen}$$

Fig. 1.1

A student had read that copper(II) sulfate can act as an inhibitor, reducing the activity of catalase.

The student wanted to investigate the effect of copper(II) sulfate as an inhibitor on the activity of catalase to test the hypothesis:

The higher the concentration of the inhibitor copper(II) sulfate, the lower the volume of oxygen produced in the presence of catalase.

(a) State the independent variable **and** dependent variable in this investigation.

independent variable .....

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dependent variable .....

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[2]

(b) (i) The student was provided with a 0.04 mol dm^{-3} solution of copper(II) sulfate.

Describe how the student could use serial dilution to make a suitable range of concentrations to test their hypothesis.

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(ii) The student used the apparatus shown in Fig. 1.2 to collect the data needed to test the effect of different concentrations of copper(II) sulfate on the production of oxygen in the presence of catalase.

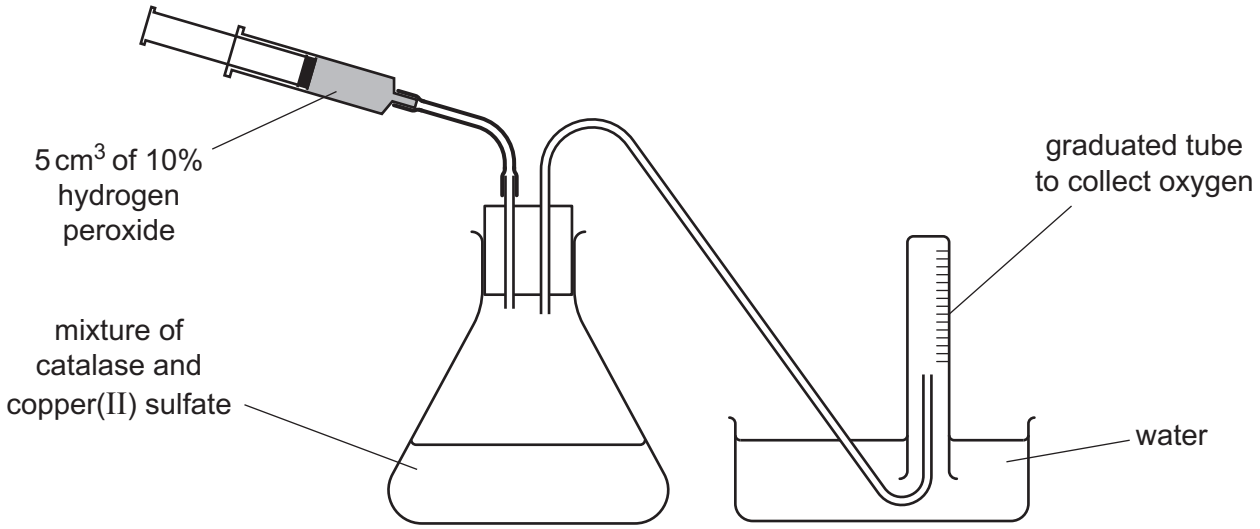


Fig. 1.2

Describe a method the student could use to collect the data needed to test the effect of different concentrations of copper(II) sulfate on the production of oxygen in the presence of catalase.

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 **(b)(i)** describing how to dilute the 0.04 mol dm^{-3} copper(II) sulfate solution or how to set up the apparatus shown in Fig. 1.2.

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(iii) The hypothesis the student tested was:

The higher the concentration of the inhibitor copper(II) sulfate, the lower the volume of oxygen produced in the presence of catalase.

Complete Fig. 1.3 by:

- adding axes labels and units
- sketching a graph of the results you would expect if the hypothesis is correct.



Fig. 1.3

[3]

(c) The student carried out a further investigation to find out if copper(II) sulfate was a competitive or non-competitive inhibitor.

- The student measured the oxygen produced in the presence and absence of copper(II) sulfate at different concentrations of hydrogen peroxide.
- The student processed the data to find the **rate** of oxygen production.

The student then plotted these rates on the graph shown in Fig. 1.4.

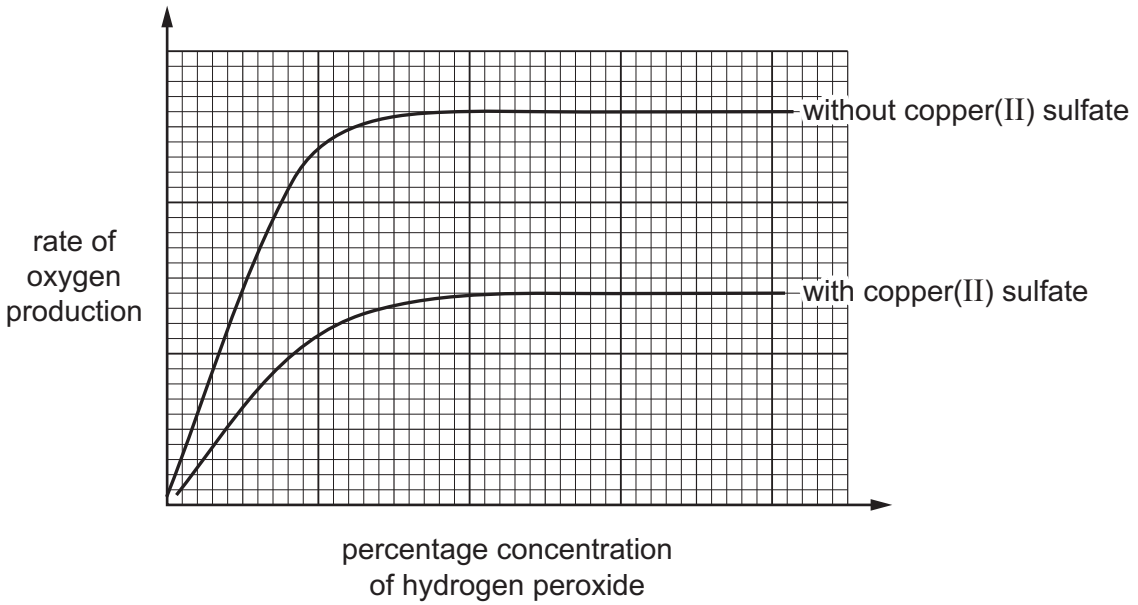


Fig. 1.4

(i) Draw on Fig. 1.4 to show how you could derive the K_m value of catalase **without** copper(II) sulfate. [3]

(ii) The student concluded that copper(II) sulfate was a non-competitive inhibitor of catalase.

State the evidence in Fig. 1.4 that supports this conclusion.

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..... [2]

[Total: 18]

2 **(a)** Inheritance of petal colour and pollen shape in sweet pea plants are controlled by two genes.

- Gene **P**/**p** controls petal colour. Allele **P** for purple petals is dominant to allele **p** for red petals.
- Gene **G**/**g** controls the shape of pollen grains. Allele **G** for long pollen grains is dominant to allele **g** for round pollen grains.

Fig. 2.1 shows the structures inside a flower from a sweet pea plant.

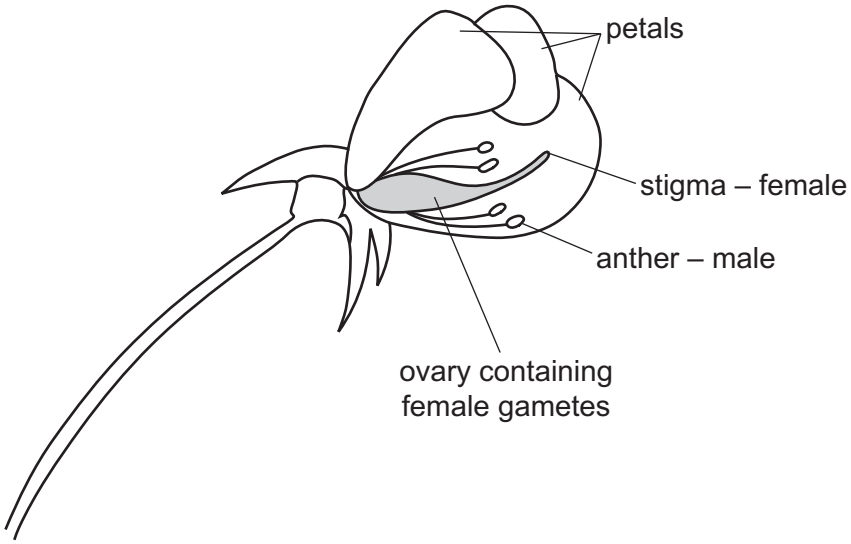


Fig. 2.1

Sweet pea plants are normally **self-fertilising**. Pollen grains containing the male gametes are produced in the anthers and released into the flower. The pollen grains fall on the stigma in the flower, leading to fertilisation of the female gametes.

A plant breeder **cross-fertilised** two sweet pea plants, **A** and **B**.

A homozygous dominant plant with purple petals and long pollen grains (plant **A**) was crossed with a homozygous recessive plant with red petals and round pollen grains (plant **B**).

The breeder transferred pollen grains from the flowers on plant **A** to the flowers on plant **B**.

(i) Suggest **one** way in which the breeder could prevent the self-fertilisation of plant **B**.

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..... [1]

(ii) Suggest **one** way in which the breeder could transfer pollen grains from an anther to a stigma.

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..... [1]

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(b) The plant breeder then:

- collected the seeds from plant **B**
- grew the seeds in a glasshouse.

The environmental conditions were standardised.

State **three** variables that should have been standardised in the glasshouse.

1 .....

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2 .....

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[3]

(c) All the F1 plants grown from the seeds collected from plant **B** had purple petals and long pollen grains.

The plant breeder then carried out a test cross by crossing the F1 plants with homozygous recessive plants with red petals and round pollen grains.

Table 2.1 shows the results of the test cross.

Table 2.1

offspring phenotypes	frequency
purple petals long pollen grains	102
red petals round pollen grains	112
purple petals round pollen grains	14
red petals long pollen grains	20
total	248

The plant breeder expected the test cross to result in a 1:1:1:1 phenotypic ratio.

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(i) Complete Table 2.2 **and** calculate the value of chi-squared (χ^2) for the results of the test cross.

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 petals long pollen grains	102	62	
red petals round pollen grains	112	62	
purple petals round pollen grains	14	62	
red petals long pollen grains	20	62	
		χ^2 =	

[2]

The null hypothesis of this chi-squared test (χ^2) is:

There is no difference between the observed and expected results.

The critical value at p = 0.05 is **7.82** at 3 degrees of freedom.

(ii) Use your calculated value of χ^2 to:

- explain whether the null hypothesis should be accepted or rejected

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- suggest a conclusion the plant breeder could make about the inheritance of the genes controlling petal colour and pollen grain shape in sweet pea plants.

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..... [3]

(d) Some individuals of the plant species *Mimulus guttatus* show copper tolerance as they are able to grow on land heavily polluted with copper.

Copper tolerance is controlled by an allele of a single gene. Plants that do not have this allele are sensitive to high concentrations of copper(II) ions in the soil and show poor growth.

Scientists wanted to investigate if pollen grains are sensitive to copper(II) ions.

Pollen viability is the ability of pollen to produce male gametes that can fertilise a female gamete.

The scientists investigated the viability of pollen grains by placing them into a culture medium. Normally, after several days pollen grains start to grow pollen tubes. Pollen tubes grow down into the ovary to carry the male gametes to the female gametes.

- Pollen grains were collected from copper-sensitive and copper-tolerant plants of *M. guttatus*.
- Pollen grains were placed in culture media as shown in Table 2.3.

Table 2.3

type of plant	**number of pollen grains added to culture medium**	
	culture medium containing **no** copper(II) ions	culture medium containing copper(II) ions
copper-tolerant	200	200
copper-sensitive	200	200

All other variables were standardised.

The results are shown in Fig. 2.2.

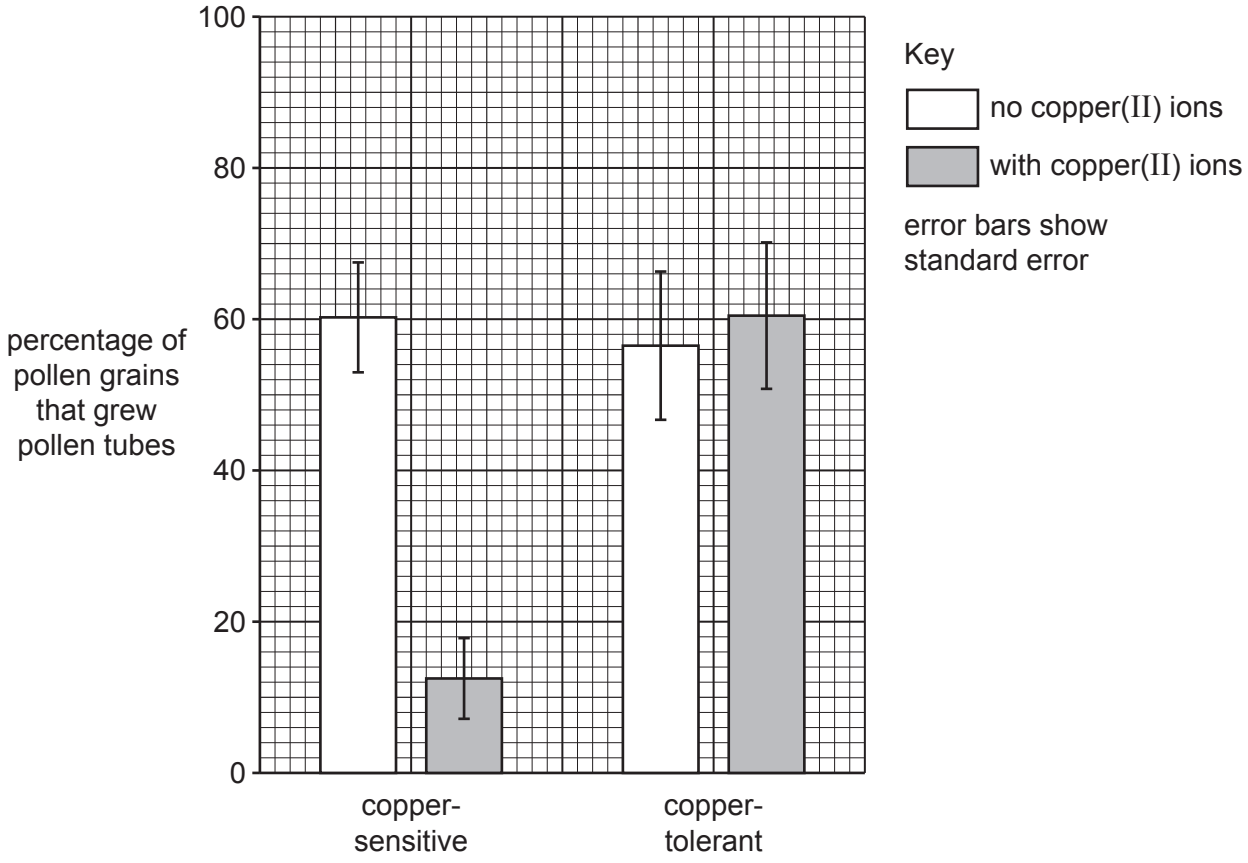


Fig. 2.2

The scientists concluded that the presence of copper(II) ions has a significant effect in reducing the viability of pollen grains.

Explain whether or not the scientists are justified in this conclusion.

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[Total: 12]

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BIOLOGY **9700/53**

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

1 hour 15 minutes

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[Turn over

1 When bananas ripen, they turn brown in colour. This is due to the formation of a brown product called melanin.

The enzyme catechol oxidase acts on its substrate, catechol, leading to the formation of a brown product, melanin, as shown in Fig. 1.1.

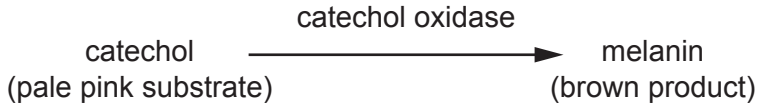


Fig. 1.1

As melanin is produced, the colour of the reaction mixture changes to brown. The intensity of the brown colour produced is proportional to the concentration of melanin. The more active the enzyme, the more intense the brown colour.

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

Catechol oxidase can be extracted from bananas.

(a) Some students were asked to extract catechol oxidase by grinding a slice of banana with sand and water, using a mortar and pestle. The resulting mixture was then filtered through a piece of cloth.

Suggest a reason for:

grinding with sand

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filtering through cloth.

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..... [2]

(b) The students investigated the effect of the substrate concentration on the enzyme-catalysed reaction shown in Fig. 1.1.

The students were provided with:

- the extracted catechol oxidase enzyme solution prepared in step **(a)**, which was kept cold until needed
- a stock solution of 1.0% catechol solution made up in a buffered solution of pH 7.0
- a buffer solution of pH 7.0.

The procedure used by the students is outlined in steps 1 to 3.

1. The extracted catechol oxidase enzyme solution was mixed with the 1.0% catechol solution.
2. After 2 minutes a colorimeter was used to measure the absorbance of this mixture.
3. Step 1 and step 2 were repeated using different concentrations of catechol solution.

(i) Suggest why the students 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 students used the absorbance values at 2 minutes as the initial rates of reaction.

Fig. 1.2 shows the results.

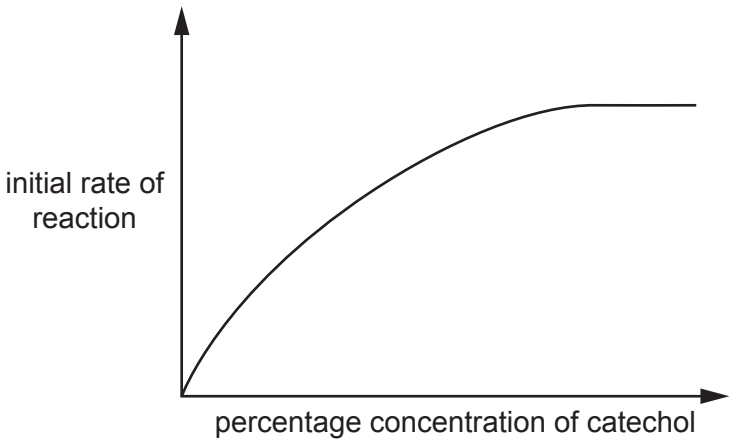


Fig. 1.2

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

(i) Describe a method the students could use to collect the data needed to test the effect of inhibitor **Y** in reaction mixtures containing different concentrations of catechol 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 the extract of catechol oxidase is prepared.

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

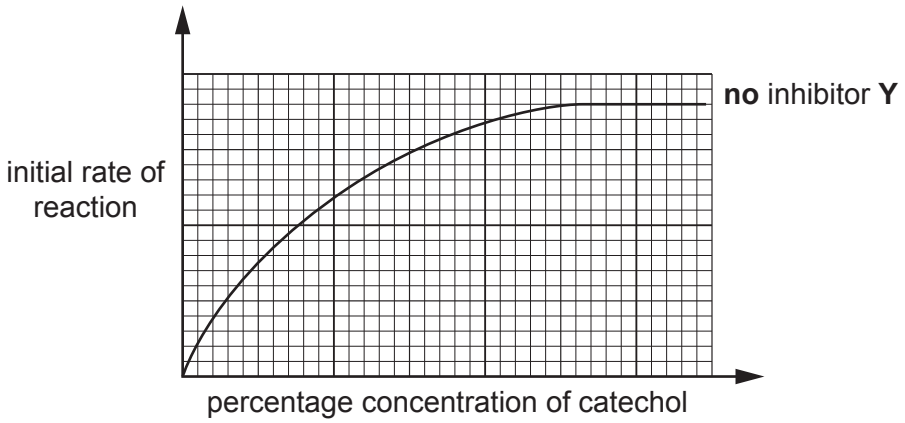


Fig. 1.3

The students suggested that inhibitor **Y** was acting as a **non-competitive** inhibitor.

(ii) On Fig. 1.3, sketch the curve expected if inhibitor **Y** was acting as a non-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.

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

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

.....

.....

..... [1]

(d) Hypertension is a condition where people have long-term high blood pressure.

Two main types of drug are used to lower blood pressure in people with hypertension:

- ACE inhibitors
- diuretics.

Scientists investigated the effectiveness of the drugs when used separately **and** in combination.

505 people with hypertension were split into four groups as shown in Table 1.1.

Table 1.1

group	treatment
1	placebo (no active drug given)
2	ACE inhibitor only
3	diuretic only
4	ACE inhibitor **and** diuretic

The results are shown in Fig. 1.4.

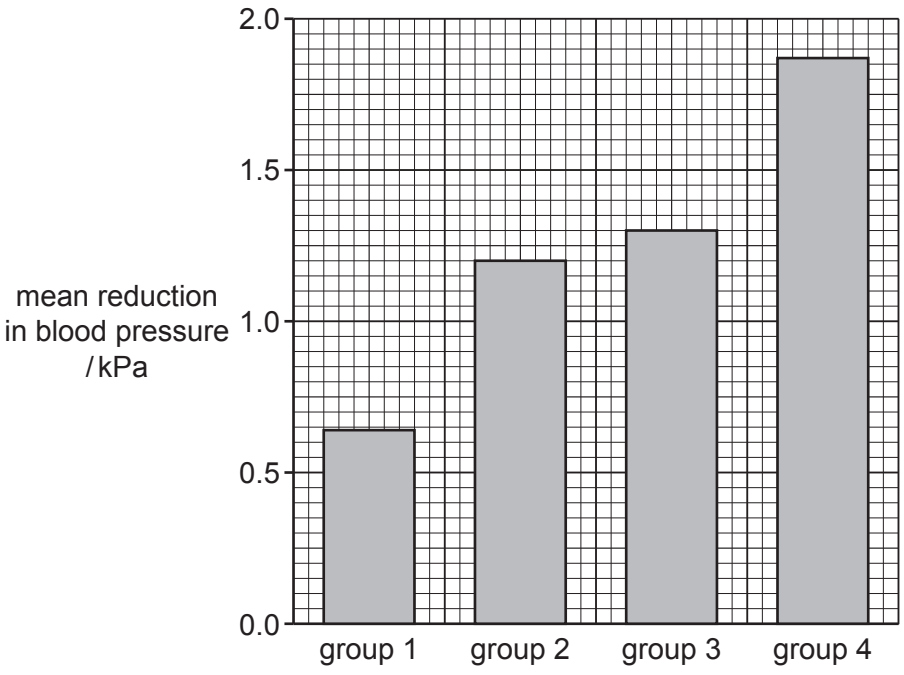


Fig. 1.4

The scientists analysed the data and concluded that a combination of an ACE inhibitor **and** a diuretic should be used to lower blood pressure in the treatment of hypertension.

With reference to the data in Table 1.1 and Fig. 1.4, discuss the conclusion that a combination of an ACE inhibitor and a diuretic should be used to lower blood pressure in the treatment of hypertension.

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.....

.....

..... [3]

[Total: 21]

2 Inheritance of wing shape and eye colour in the fruit fly, *Drosophila melanogaster*, is controlled by two genes.

- Gene **N**/**n** controls wing shape. Allele **N** for wrinkled wings is dominant to allele **n** for normal wings.
- Gene **E**/**e** controls eye colour. Allele **E** for rosy eyes is dominant to allele **e** for red eyes.

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.

- Homozygous dominant fruit flies with wrinkled wings and rosy eyes were crossed with homozygous recessive fruit flies with normal wings and red eyes.
- All the F1 fruit flies had wrinkled wings and rosy eyes.
- The F1 fruit flies were crossed with each other.

Table 2.1 shows the results for the F2 generation.

Table 2.1

F2 phenotype	frequency
wrinkled wings rosy eyes	44
wrinkled wings red eyes	2
normal wings rosy eyes	2
normal wings red eyes	16
total	64

(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.

.....

..... [1]

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

.....

.....

..... [1]

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(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***	$\frac{(O-E)^2}{E}$
wrinkled wings rosy eyes	44		
wrinkled wings red eyes	2		
normal wings rosy eyes	2		
normal wings red eyes	16		
		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 why the student used the critical value of **7.82** in this investigation.

.....

.....

..... [1]

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

- explain whether the null hypothesis should be accepted or rejected

.....

.....

.....

.....

- suggest a conclusion the biologist could make about the inheritance of the genes controlling wing shape and eye colour in fruit flies.

.....

.....

.....

..... [3]

[Total: 9]

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