Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

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

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

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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.... [2]

(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.

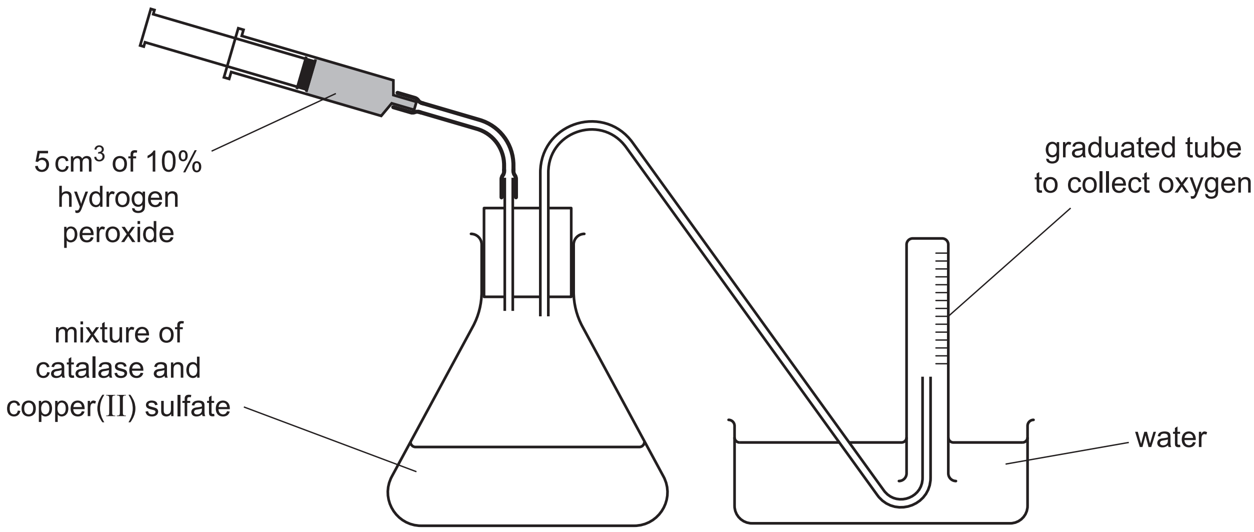

Fig. 1.2

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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[6]

(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.

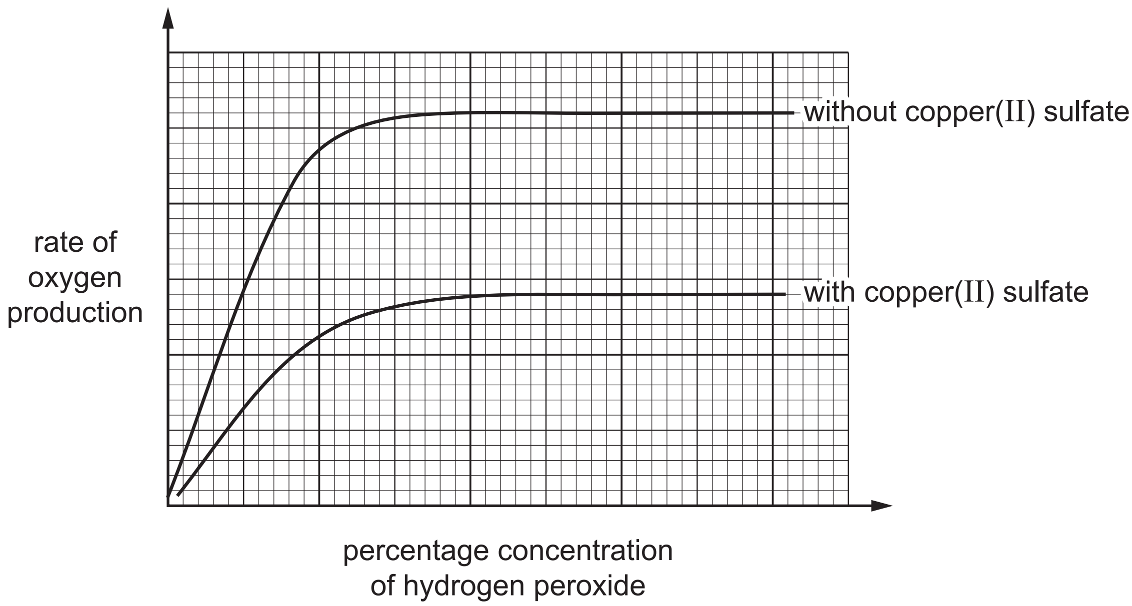

Fig. 1.4

(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.

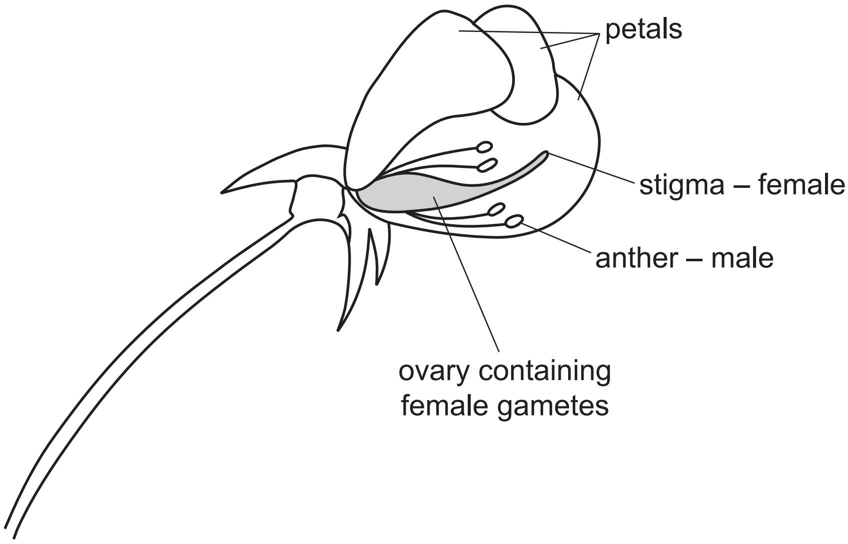

Fig. 2.1

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]

(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 ....

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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.

(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.

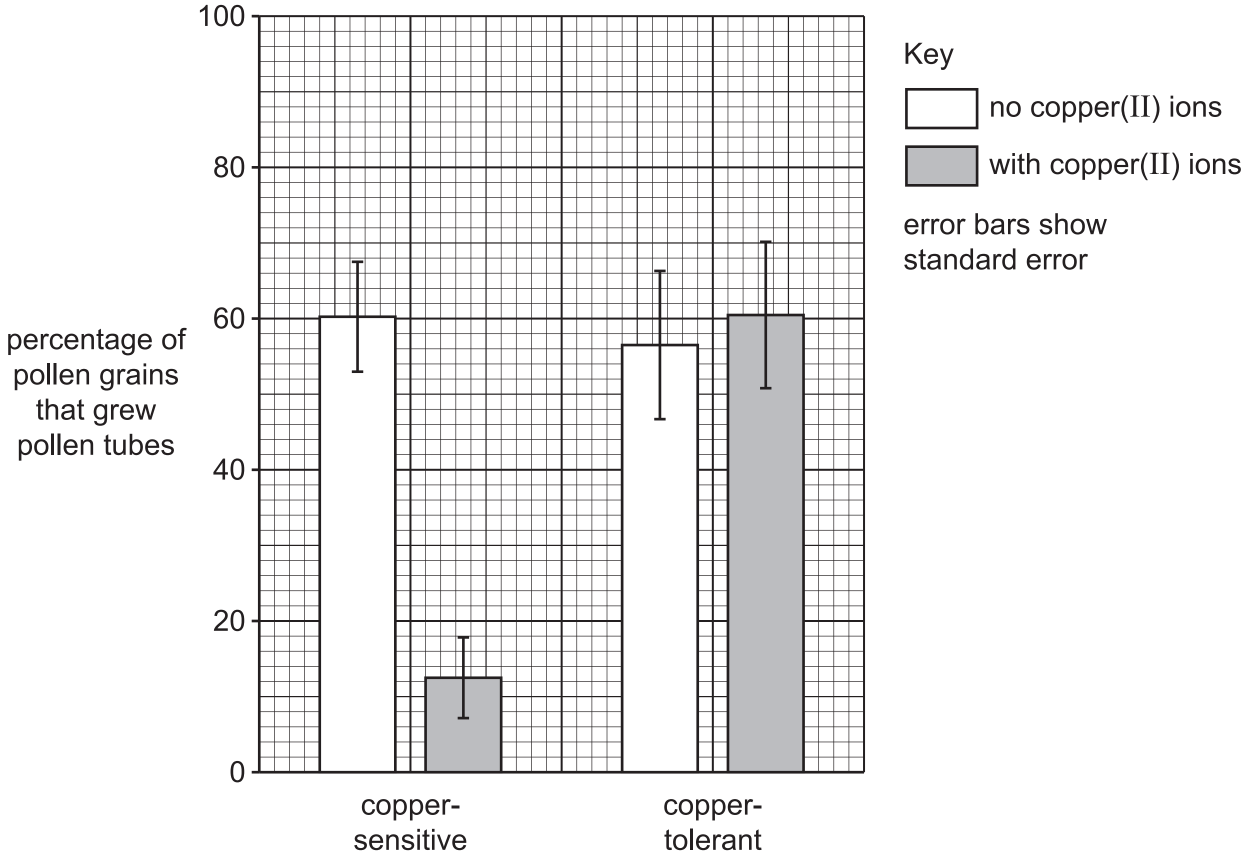

Fig. 2.2

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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