Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Wednesday 19 June 2024

Morning (Time: 2 hours 30 minutes)

Paper reference **9BI0/03**

Biology B

Advanced

PAPER 3: General and Practical Principles in Biology

You must have:
Scientific calculator, HB pencil, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 120.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In question(s) marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

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Answer ALL questions.

1 A student made a root tip squash to observe the stages of mitosis.

(a) Name the region of the root tip where cells are actively dividing.

(1)

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(b) Give **one** reason for each of the following:

(i) Treating the root tip with strong acid

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(ii) Adding a stain to the root tip

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(iii) Pressing lightly on the coverslip

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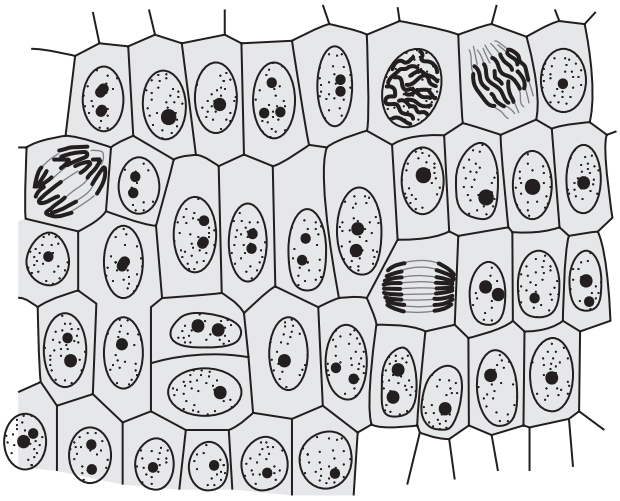
(c) The diagram shows cells from a root tip squash.

The total number of cells is 39.



Calculate the mitotic index for this root tip squash.

Use the formula

$$\text{Mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}} \times 100$$

Give your answer to **one decimal place**.

(2)

Answer .....

(Total for Question 1 = 6 marks)

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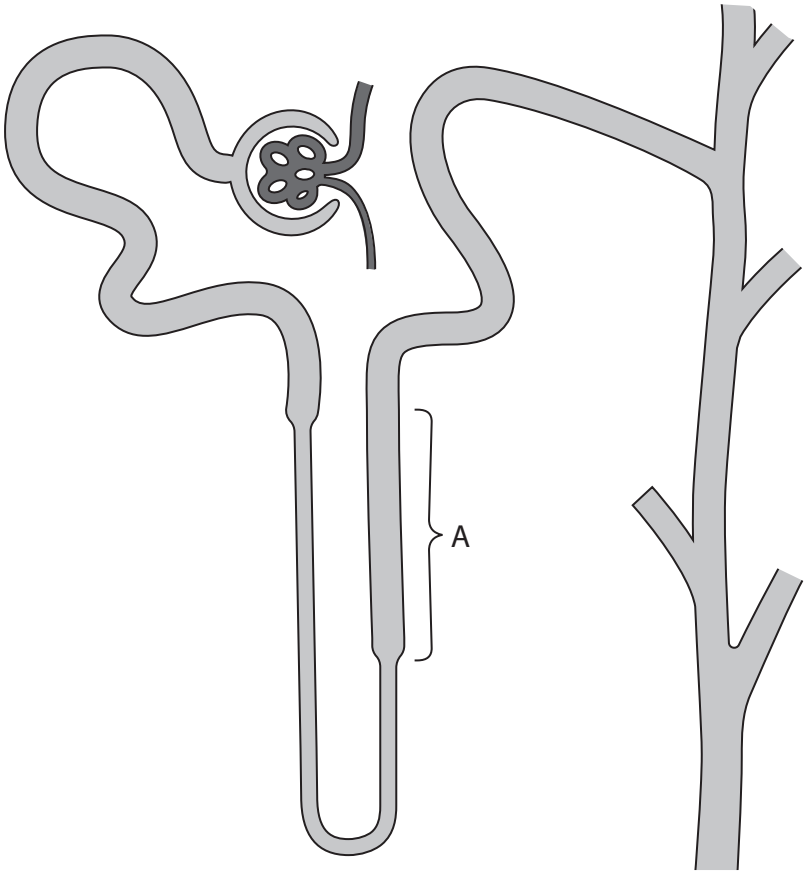
2 The mammalian kidney contains over one million nephrons.

One of their functions is to produce urine with a high concentration of urea.

(a) The diagram shows one nephron, collecting duct and some of the associated blood vessels.



(i) Explain how urea enters the nephron.

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(ii) In the region labelled A, sodium ions are actively pumped out of the nephron into the surrounding fluid.

Explain how this movement of ions results in the formation of concentrated urine.

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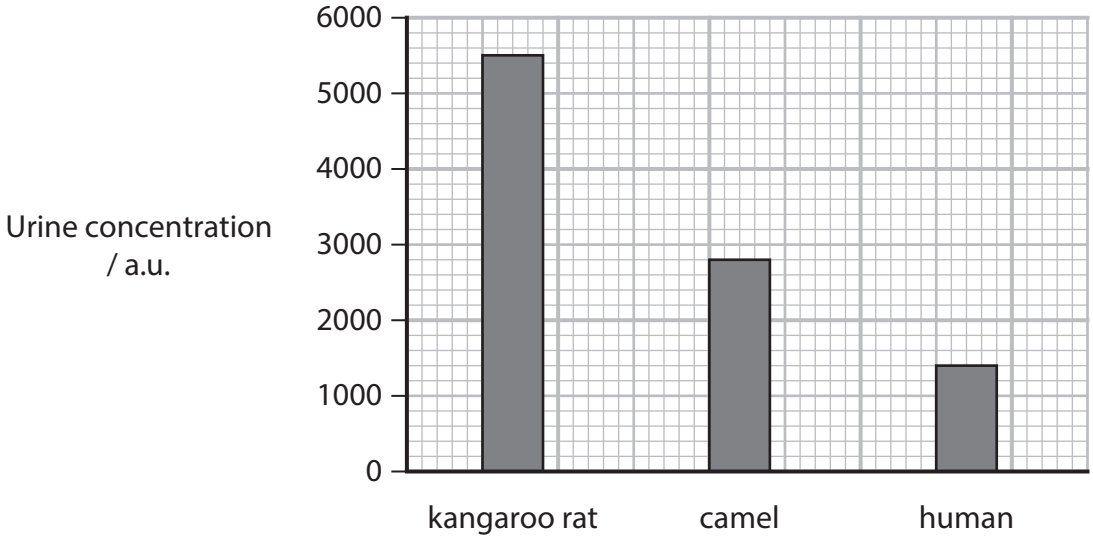
(b) The concentration of urine varies between species of mammals.

The graph shows the concentration of urine in kangaroo rats, camels and humans.



(i) Determine the ratio of urine concentration for these three mammals.

(1)

Answer .....

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(ii) Kangaroo rats live in a desert habitat.

Explain **one** adaptation in the structure of a kangaroo rat kidney that enables it to produce very concentrated urine.

(2)

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(iii) Kangaroo rats are endotherms.

Give **one** behavioural adaptation that you would expect to see in kangaroo rats that helps them to conserve water in a hot desert.

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(Total for Question 2 = 9 marks)

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3 Beetroot (*Beta vulgaris*) is an edible plant. The photograph shows some beetroot plants.

(Source: © VOISIN / PHANIE / SCIENCE PHOTO LIBRARY)

The root cells contain a red pigment, betalain, in the vacuole.

(a) (i) Draw a typical cell from a root, as seen using a light microscope. Label **three** named membranes.

(2)

(ii) Describe the structure of a membrane in a plant cell.

(2)

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(b) A group of students investigated the effect of temperature on membrane permeability using tissue from a beetroot. They used the following method.

1. Tubes containing 20 cm^3 of water were placed in water baths for 15 minutes at 20°C, 30°C, 40°C, 50°C and 60°C.
2. Cylinders were cut from the same beetroot using a standard cork borer, and these were cut into 1 cm lengths.
3. Each piece was rinsed in water and then blotted dry, before being added to a tube in the water bath.
4. After 20 minutes, a sample of the liquid was removed.
5. The absorbance (amount of light absorbed by the red pigment) of each sample was measured using a colorimeter.

The table shows the results.

Temperature / °C	Absorbance					
	Group 1*	Group 2	Group 3	Group 4	Group 5	Mean of groups 2 – 5
20	0.33	0.14	0.07	0.08	0.11	0.10
30	0.57	0.24	0.32	0.33	0.31	0.30
40	0.87	0.53	0.63	0.56	0.51	0.56
50	1.87	1.58	1.63	1.53	1.56	1.58
60	1.93	1.59	1.62	1.49	1.56	1.57

*Group 1 results were excluded from the calculations of the means.

(i) Describe the relationship between temperature and absorbance, as shown by these results.

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(ii) Explain the results of this investigation.

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(c) Group 1 results were excluded from the calculations of the means as they were so different from the other groups.

Identify **four** errors this group may have made which would account for the difference in results.

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(Total for Question 3 = 12 marks)

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4 Woodlice are crustaceans found in many gardens and woodland habitats.

There are several species that are native to the UK and Ireland.

They obtain oxygen through gills, which are on their legs.

The photograph shows one species of woodlouse, *Armadillidium vulgare*.

Magnification × 2

(Source: © TED KINSMAN / SCIENCE PHOTO LIBRARY)

(a) (i) Describe how you could measure the respiration rate of woodlice collected from a garden.

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(ii) Identify **one** safety issue and **one** ethical issue involved in your method in part (a)(i) and state how you would minimise the effect of these.

(2)

Safety issue

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Ethical issue

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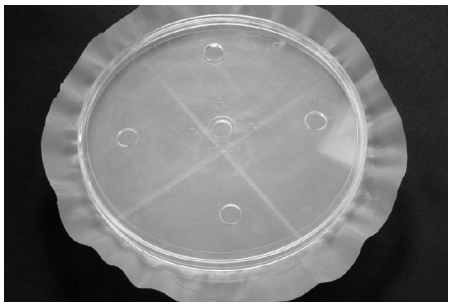
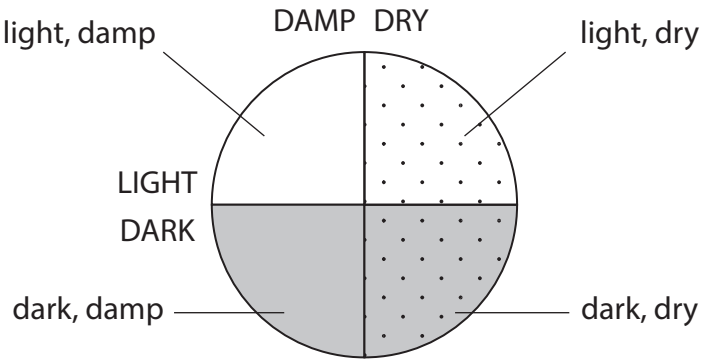
(b) A student used a choice chamber to investigate the habitat preferences of woodlice.

The photograph shows a choice chamber.



(Source: © TREVOR CLIFFORD PHOTOGRAPHY / SCIENCE PHOTO LIBRARY)

The diagram shows the conditions in each of the four sections.



Woodlice were able to move freely to all areas of the chamber.

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The student suggested the hypothesis that woodlice show no habitat preference.

- Five woodlice were placed in each of the four sections and left to move.
- The position of the woodlice was recorded after five minutes.
- This was repeated three more times.

The table shows the results obtained.

Section	Number of woodlice in each section of the chamber after 5 minutes			
	Trial 1	Trial 2	Trial 3	Trial 4
Light and dry	2	1	0	2
Light and damp	4	4	1	5
Dark and dry	4	3	3	3
Dark and damp	10	12	16	10

(i) Explain which statistical test could be used to analyse these results.

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(ii) The results suggest woodlice prefer some conditions to others.

Explain why it is an advantage for them to live in these conditions.

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(iii) Describe **three** improvements that could be made to this investigation to ensure the conclusion is valid.

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(Total for Question 4 = 14 marks)

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5 Differences in water potential affect the direction of movement of water in and out of cells.

(a) The water potential of plant cells can be determined using plasmolysis.

A plant cell is plasmolysed when it loses water and the plasma membrane moves away from the cell wall. This can be observed when the cells are viewed with a light microscope.

A group of students used the following method to find the osmotic potential of cell sap in onion epidermal cells. The osmotic potential is equivalent to the concentration of the sucrose solution when 50% of cells are plasmolysed.

Step 1: A stock sucrose solution of 0.8 mol dm^{-3} was diluted to make a range of concentrations.

Step 2: A thin layer of onion epidermis was placed in 10 cm^3 of sucrose solution in each tube, and left for 20 minutes.

Step 3: Each piece of onion epidermis was placed on a microscope slide covered with a drop of the sucrose solution in which it had been soaking, and a coverslip placed on top.

Step 4: Using a microscope, the total number of cells in the field of view, and the total number that were plasmolysed, were counted.

Step 5: The percentage of plasmolysed cells in each sucrose concentration was calculated.

(i) Describe how you would prepare 10 cm^3 of a solution of sucrose with a concentration of 0.6 mol dm^{-3} from the stock solution.

(2)

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(ii) The table shows the mean results.

Concentration of sucrose solution / mol dm^{-3}	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Mean percentage of plasmolysed cells (%)	0.0	1.3	4.0	31.9	59.6	76.3	92.5	99.4	99.8

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Plot a suitable graph to display these results.

Join the points with straight lines.

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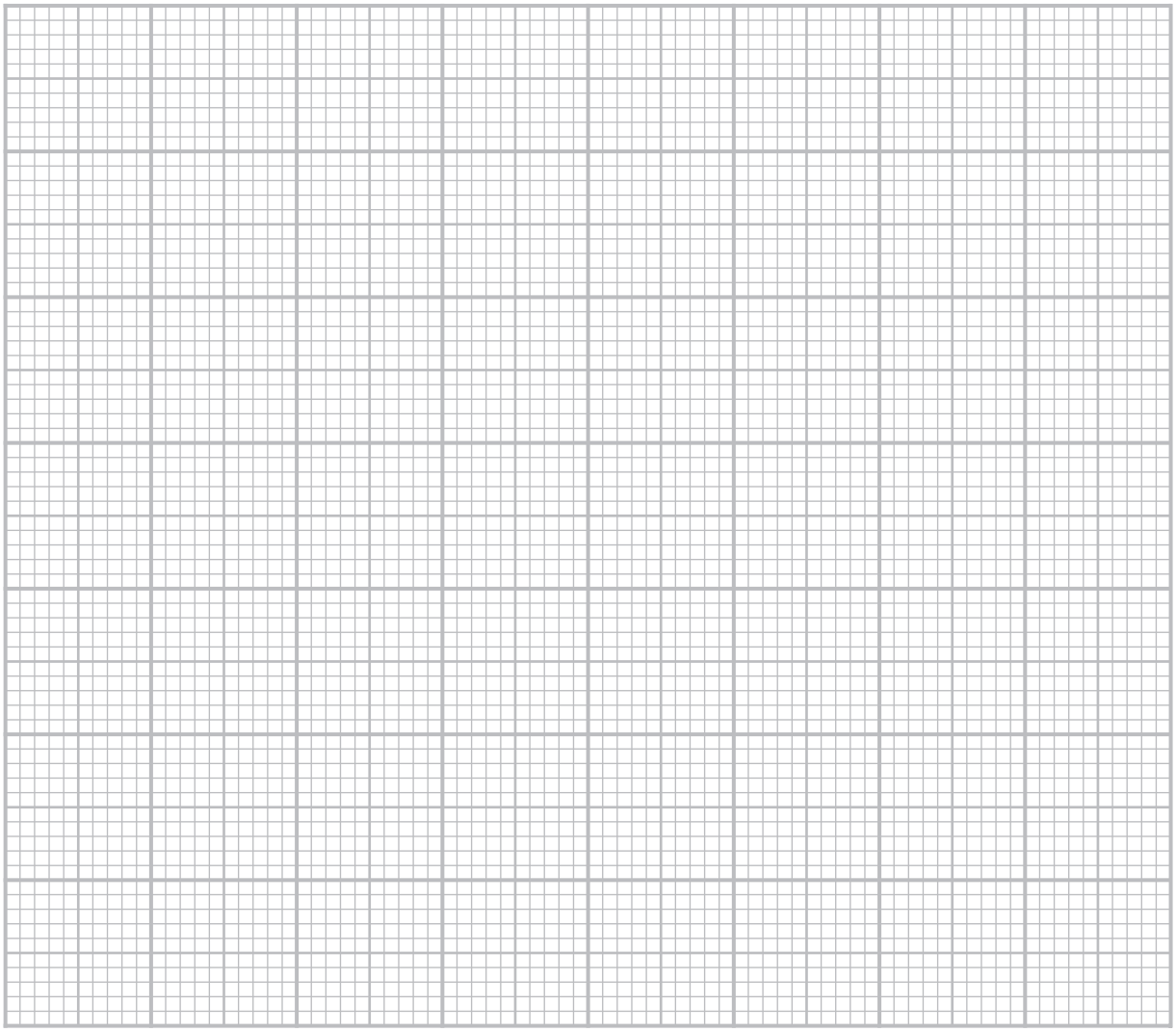

(iii) Determine the concentration of the cell sap of the onion epidermal cells, using your graph.

(1)

Answer ..... mol dm^{-3}

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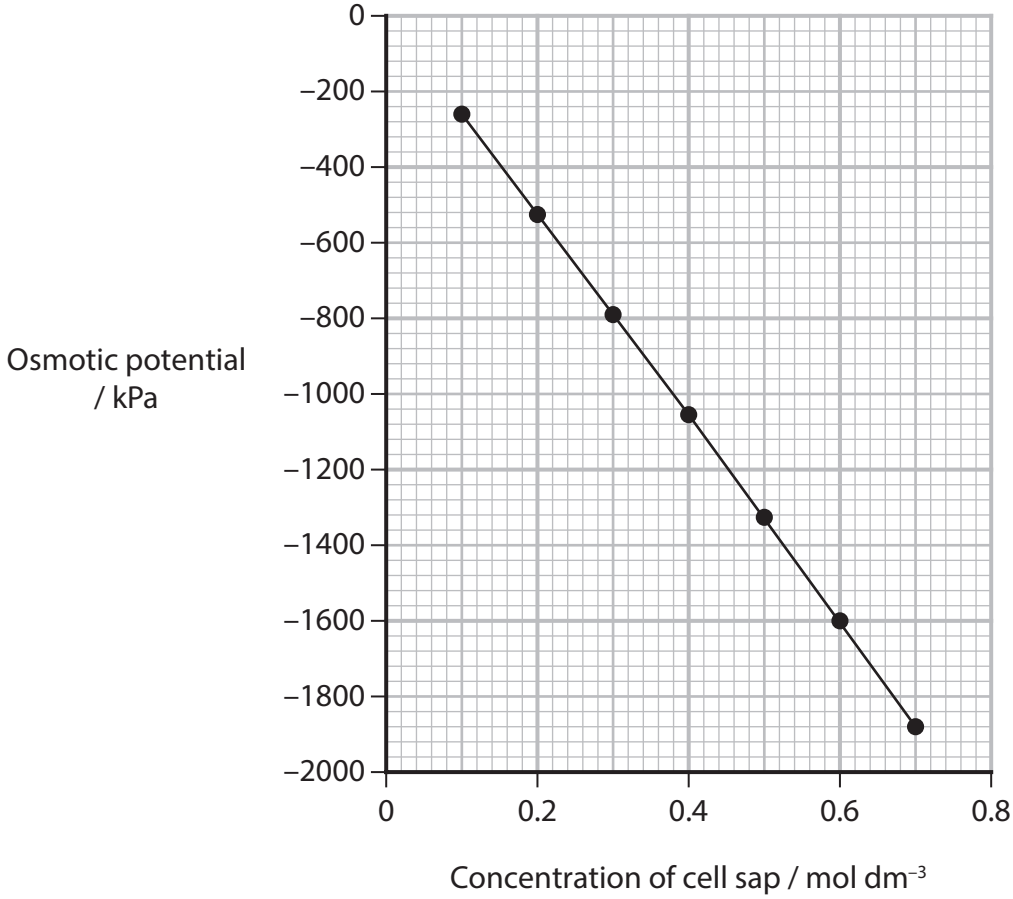
(iv) This conversion graph can be used to convert the concentration of cell sap into osmotic potential.



Determine the osmotic potential of the cell sap of the onion epidermal cells. Use your answer to (b)(iii) and the conversion graph.

(1)

Answer ..... kPa

(v) Write the equation that is used to calculate the water potential of a plant cell.

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(vi) State the water potential of the cell sap of the onion epidermal cells when 50% of the cells are plasmolysed.

(1)

Answer ..... kPa

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(b) The students modified the method and repeated the investigation. The changes are shown in italics.

Step 2: all pieces of onion epidermis were cut *from a single onion*.

Step 2: tubes containing sucrose solution and onion epidermis layers were left *in a thermostatically controlled water bath* for 20 minutes.

Step 4: the total number of cells in the field of view, and the number that were plasmolysed were counted. *This was repeated twice for each of the sucrose concentrations*.

Explain why each of these changes are likely to improve the validity of this investigation.

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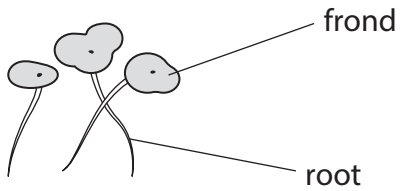
6 Duckweed, *Lemna minor*, is a small plant that floats on the surface of freshwater ponds.

Each plant consists of a frond, which contains photosynthetic pigments, and a root which absorbs inorganic ions from the water.

The diagram shows duckweed plants.

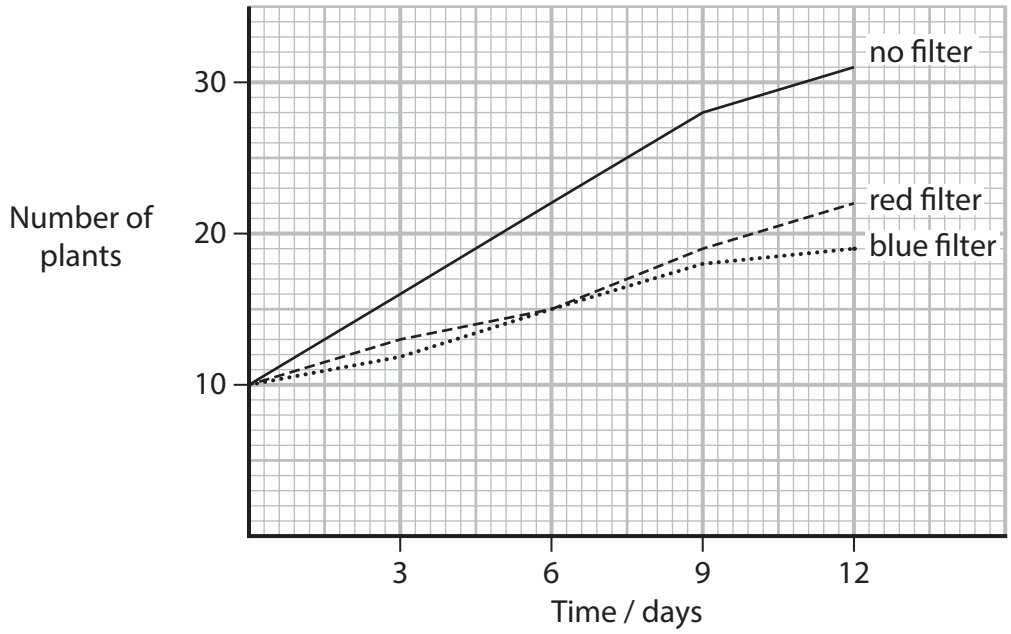


Duckweed typically reproduces asexually by budding, to produce daughter plants. In ideal conditions, the doubling time is around 3 days.

A student investigated the effect of changing the wavelength of light on the time taken for the number of duckweed plants to double.

- Ten duckweed plants were added to a tank containing 3 dm^3 of water with dissolved inorganic ions. The temperature was maintained at 10°C.
- A lamp with no filter was placed at a known distance from the tank.
- The total number of plants were counted at intervals of 3 days.
- The investigation was repeated with a red filter over the lamp and then again with a blue filter over the lamp.

The graph shows the results of this investigation.



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(a) (i) Explain the results of this investigation.

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(ii) The shortest time for the number of plants to double was more than 3 days.

Give **two** ways of reducing the time taken for the number of plants to double.

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(iii) Give **one** reason why the results may not be accurate.

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(iv) Describe a method that could be used to measure the growth of the plants more accurately.

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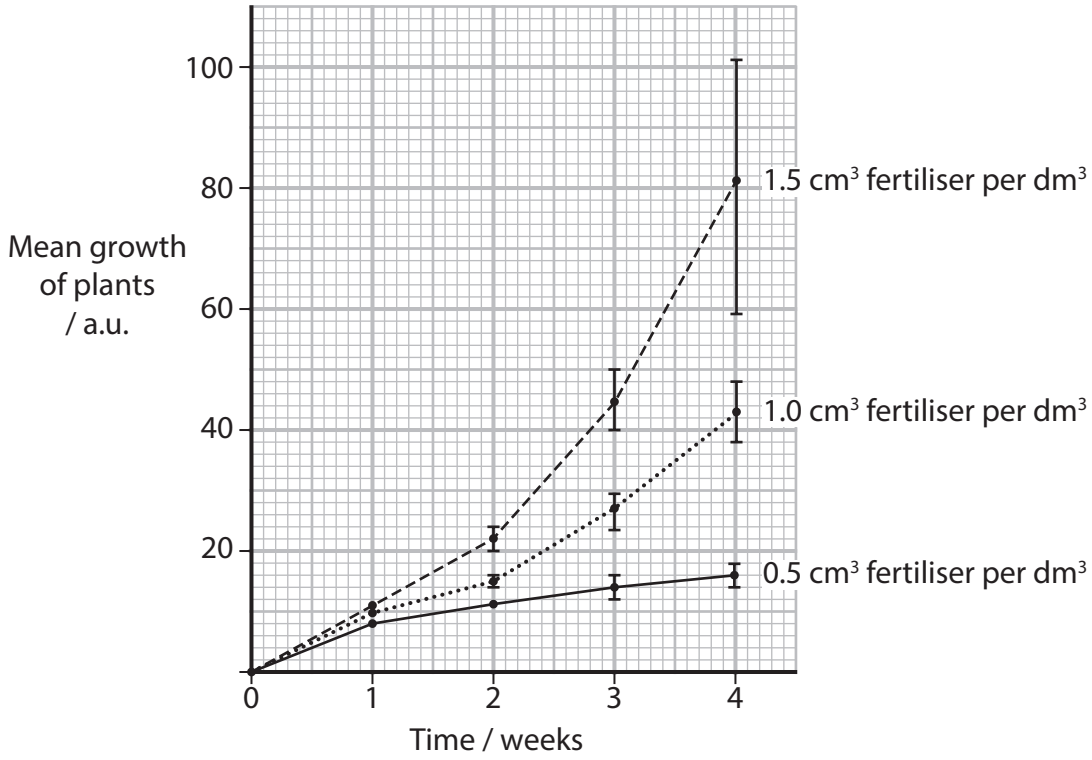
(b) In another investigation, the student grew duckweed plants in water containing a fertiliser.

The fertiliser contained nitrate, phosphate and magnesium ions.

Three concentrations of the fertiliser were used, with all other conditions kept constant.

The graph shows the results of this investigation.



Explain the effect of increasing fertiliser concentration on the growth of these plants.

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(c) It has been suggested that duckweed could be grown in water polluted with organic waste from cows.

These plants could be processed to make feed for poultry and cattle.

Analyse the information to comment on this suggestion.

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(Total for Question 6 = 14 marks)

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7 Turmeric is a spice made from the root of the plant *Curcuma longa*.

It has been used in traditional medicine for many years.

(a) A student investigated the antibacterial properties of turmeric.
The student suggested the hypothesis:

An extract made from turmeric root will reduce the growth of bacteria.

Devise a valid method to test this hypothesis.

(6)

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(b) Curcumin is an organic compound found in the spice turmeric and may be used to treat joint pain.

In 2019, a trial compared the treatment of joint pain with curcumin and Drug A. Joint pain is due to inflammation and can lead to immobility.

This trial involved 139 patients aged 38 to 65, who had been taking anti-inflammatory medication to combat pain for at least three months. These patients were randomly assigned into two groups.

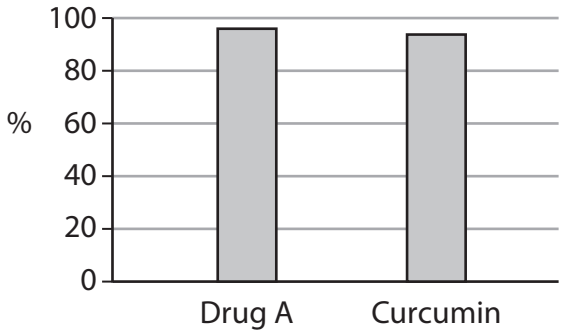
- One group was given 50 mg of Drug A (an anti-inflammatory drug which is an existing treatment for knee pain) twice a day for 28 days.
- The other group was given 500 mg of curcumin three times a day for 28 days.

At the end of the trial, patients were asked to rate their pain on a scale of 0 to 100. The scientists also collected data about side effects, weight loss and overall outcomes.

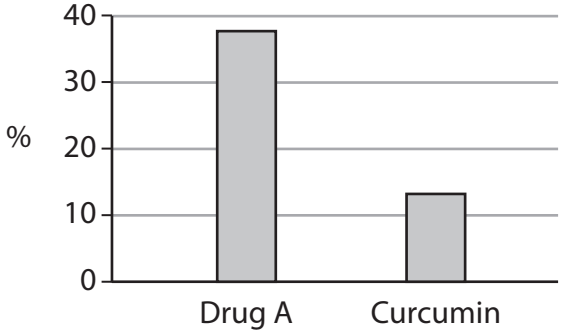
Patients who had liver or kidney disease, heart disease, bronchitis or stomach ulcers were excluded from the trial.

The graphs show the results of this trial.

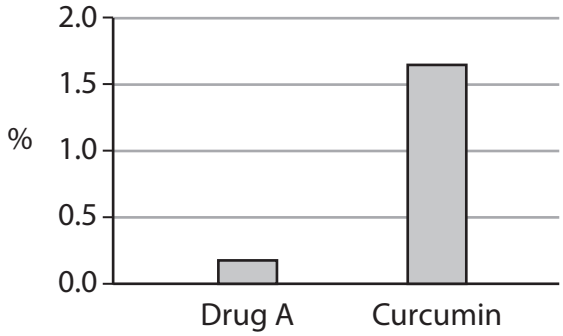
Percentage (%) of patients who reported at least 50% improvement in pain levels at day 28



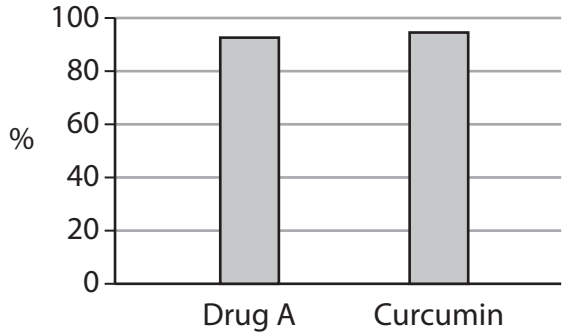
Percentage (%) of patients who reported side effects, including nausea and vomiting



Mean percentage (%) weight loss reported in each treatment group



Percentage (%) of patients rated as having excellent or good outcomes by doctors



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Analyse the data to discuss the suggestion that curcumin should be used to replace Drug A as a treatment for knee pain.

Use information about the design of this trial **and** the results to support your answer.

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8 The photograph shows a celandine plant, *Ficaria verna*, that is commonly found in woodlands in the UK.

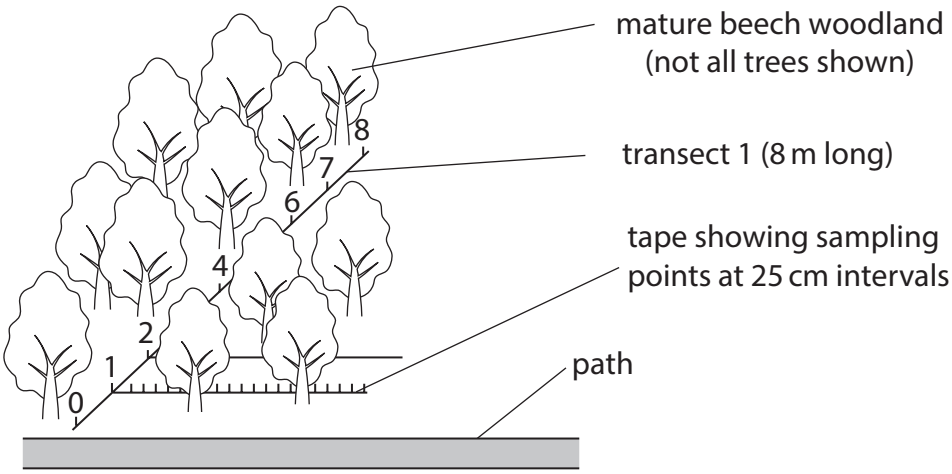
(Source: © TH FOTO-WERBUNG / SCIENCE PHOTO LIBRARY)

A student noticed that many of these plants grew in a mature beech woodland, but seemed to be less abundant as the distance from a path increased.

The student investigated the distribution of celandine using this method:

- set up a transect at 90° to the path (transect 1)
- at 1 metre intervals along the transect, place a tape parallel to the path
- record the presence or absence of celandine every 25 cm along the tape
- repeat for two more transects in the woodland (transects 2 and 3).

The diagram shows the arrangement of the transect and the tape.



(a) Give a null hypothesis for this investigation.

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(b) Table 1 shows the results collected.

Distance from path / m	Number of celandine plants recorded			
	Transect 1	Transect 2	Transect 3	Mean
0	18	19	20	19.0
1	19	16	17	17.3
2	17	15	12	14.7
3	15	8	13	12.0
4	9	9	6	8.0
5	3	16	6	8.3
6	5	4	4	4.3
7	2	3	2	2.3
8	1	6	2	3.0

Table 1

Table 2 shows how the student analysed this data to calculate the Spearman's Rank correlation coefficient.

Distance from path / m	Mean number of celandine plants	Rank distance from path	Rank number of celandine plants	d	d^2
0	19.0	1	9	–8	64
1	17.3	2	8	–6	36
2	14.7	3	7	–4	16
3	12.0	4	6	–2	4
4	8.0	5	4	1	1
5	8.3	6	5	1	1
6	4.3	7	3	4	16
7	2.3	8	1	7	49
8	3.0	9	2	7	49

Table 2

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(i) Calculate the correlation coefficient, r_s.

Use the formula:

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$$r_s = 1 - \frac{6\sum d^2}{n\left(n^2 - 1\right)}$$

Where:

$\sum$ = the sum of

d = the difference between each pair of ranks

n = the size of the sample (number of pairs of values)

Give your answer to **three significant figures**.

Answer .....

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(ii) The table shows some critical values for this correlation coefficient.

Number of pairs of values	Level of significance		
	0.10	0.05	0.01
4	1.000	–	–
5	0.900	1.000	–
6	0.829	0.886	1.000
7	0.714	0.786	0.929
8	0.643	0.738	0.881
9	0.600	0.700	0.833
10	0.564	0.648	0.794

Analyse the data to explain the conclusion that can be drawn from this investigation.

Use the table of critical values and your calculated correlation coefficient.

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(c) (i) Name **one** abiotic factor that might influence the distribution of celandine plants.

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(ii) Describe a method that could be used to measure how this abiotic factor changes along the transect.

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(iii) Explain why the factor you have chosen would change along the transect **and** how this affects the growth of celandine plants.

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(Total for Question 8 = 14 marks)

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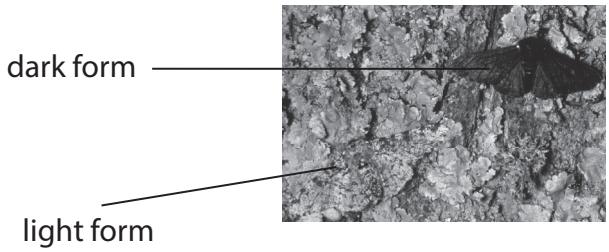
9 Peppered moths, *Biston betularia*, are found in many parts of the UK.
Two forms of this species are found, a light form and a dark form.

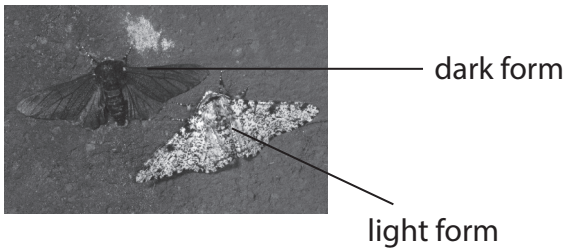
Peppered moths sometimes rest on tree trunks during the day. In rural areas with clean air, the tree trunks are often covered with lichen. In industrial areas the trees have less lichen on them due to air pollution.

The photographs show both forms resting on tree trunks.



Tree trunk in rural area

(Source: © MICHAEL W. TWEEDIE / SCIENCE PHOTO LIBRARY)



Tree trunk in industrial area

(Source: © STEPHEN DALTON / NATURE PICTURE LIBRARY / SCIENCE PHOTO LIBRARY)

Peppered moths are often preyed on by birds.

(a) Until 1848, light peppered moths were the only form recorded.

In 1848, a single darker form of the moth was observed in an industrial area in the north-west of England.
In 1895, 98% of peppered moths in this industrial area were the dark form.

Explain how natural selection could have led to these changes.

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*(b) Scientists have carried out several investigations to explain changes in the peppered moth populations.

Investigation 1: scientists placed both forms of the moths onto tree trunks in industrial and rural areas. They recorded the number of each type of moth eaten by birds.

The scientists found that on lichen-covered trunks, birds were twice as likely to eat dark moths as light moths.

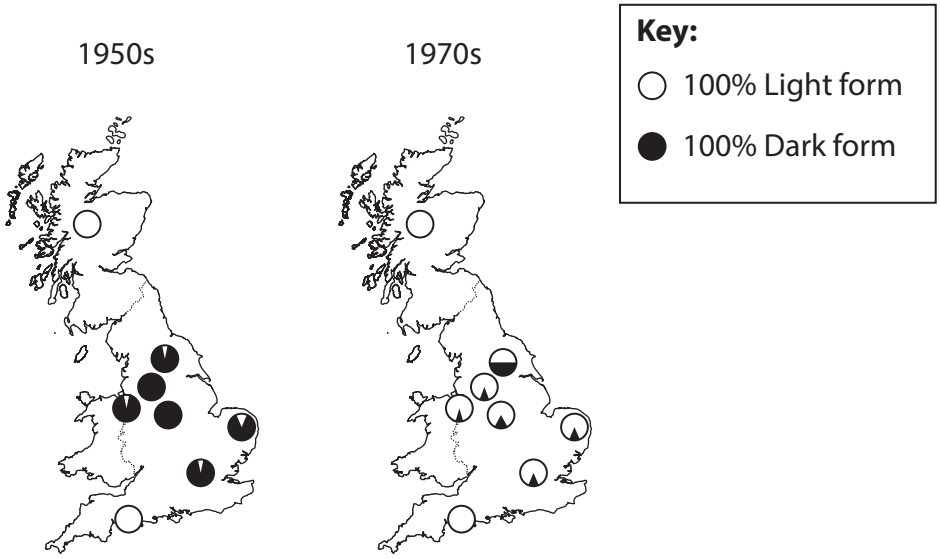
Investigation 2: scientists released marked peppered moths in an industrial area and in a rural area.

A few days later they trapped moths and calculated the percentage of trapped moths that were marked (recaptured moths). The table shows the results.

Type of peppered moth	Percentage of marked moths released which were recaptured (%)	
	Industrial area	Rural area
Light form	13.1	13.7
Dark form	27.5	4.7

Investigation 3: scientists collected data about the proportions of light and dark moths in different parts of England and Scotland in the 1950s and in the 1970s.

The maps show the results.



Investigation 3 found that in the 1970s there was a higher proportion of light moths than dark moths in areas that were once industrial, but the amount of lichen growing on tree trunks had not changed significantly.

Recent investigations have provided new evidence for the changes in the proportions of peppered moth:

- peppered moths do not typically rest on tree trunks during the day, but are more likely to rest on the underside of high branches
- the main predators of peppered moths are bats, not birds.

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It has been suggested that the change in proportions of peppered moth forms is an example of natural selection.

Discuss the validity of this suggestion.

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10 During respiration, yeast cells break down sugars to produce carbon dioxide and ethanol.

The respiration rate of yeast is affected by several factors. It can be estimated by measuring the rate of production of carbon dioxide gas.

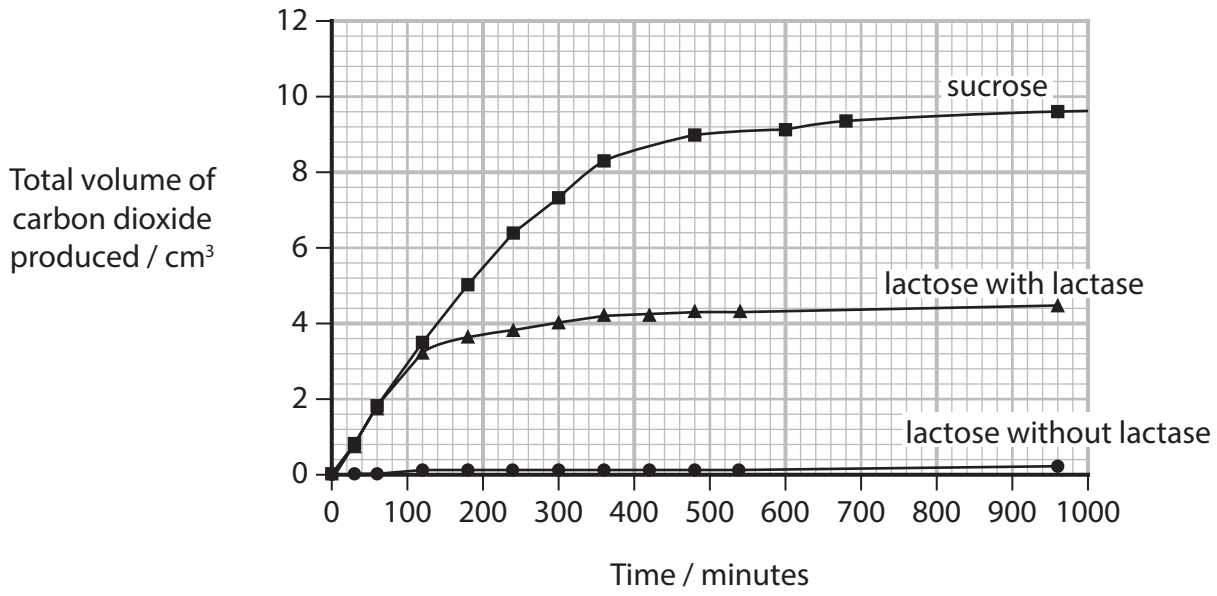
(a) Scientists measured the rate of respiration of yeast using the sugar sucrose as a substrate.

This was repeated using the sugar lactose with and without lactase.

Lactase is an enzyme that hydrolyses lactose.

The same concentrations of both sugars were used and the suspensions were incubated at 30°C.

The graph shows the results.



(i) Calculate the initial rate of respiration of yeast with sucrose.

(1)

Answer ..... $cm^3\ min^{-1}$

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(ii) Explain the results for sucrose compared with **lactose without lactase**.

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(iii) Explain the effect of **lactase** on the respiration rate of yeast during the first 400 minutes.

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(b) The experiment with sucrose was repeated at a temperature 10°C lower.

All other variables remained the same.

Explain the effect of this temperature change on the rate of respiration of yeast.

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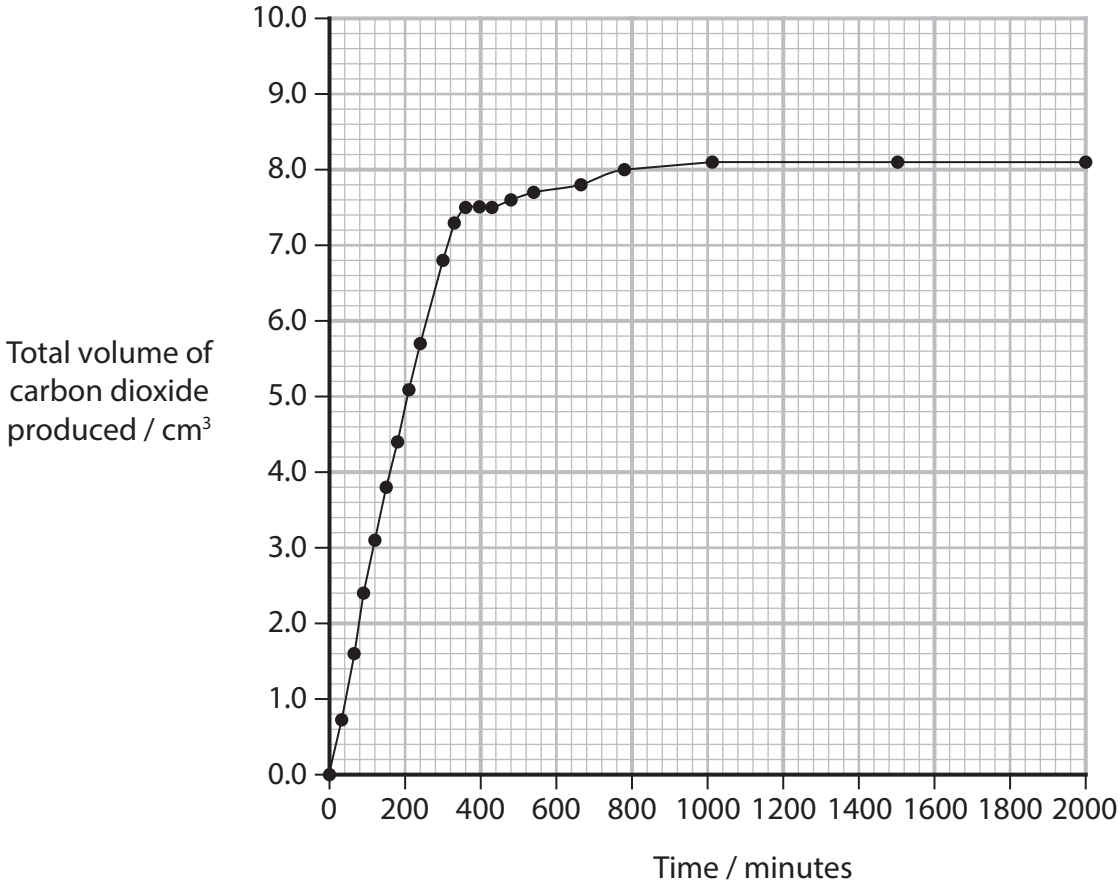
(c) The effect of changing the concentration of yeast on the rate of respiration was also investigated.

Two yeast suspensions were made by adding different masses of yeast to 100 cm^3 of water containing 20 g of sucrose.

The graph shows the results for a suspension containing 7.0 g of yeast.



(i) Sketch a line on this graph to show the expected results for a suspension containing 3.5 g of yeast.

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(ii) Explain the effect of the concentration of yeast on the volume of carbon dioxide produced in this investigation.

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(Total for Question 10 = 14 marks)

TOTAL FOR PAPER = 120 MARKS

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