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 21 June 2023

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* ▶

P71911A

©2023 Pearson Education Ltd.
N:1/1/1/1/

P 7 1 9 1 1 A 0 1 4 0

Pearson

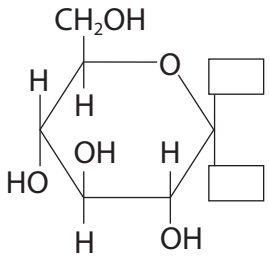
**Answer ALL questions.**

**Write your answers in the spaces provided.**

**1** Glucose is a monosaccharide.

(a) Complete the diagram to show the structure of beta-glucose.

**(1)**




(b) Glucose molecules can be joined to form the polysaccharides starch and cellulose.

Give **three** differences between the structures of starch and cellulose.

**(3)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(c) Explain how the properties of starch make it suitable as an energy store in cells.

**(2)**

.....

.....

.....

.....

.....

.....

**(Total for Question 1 = 6 marks)**

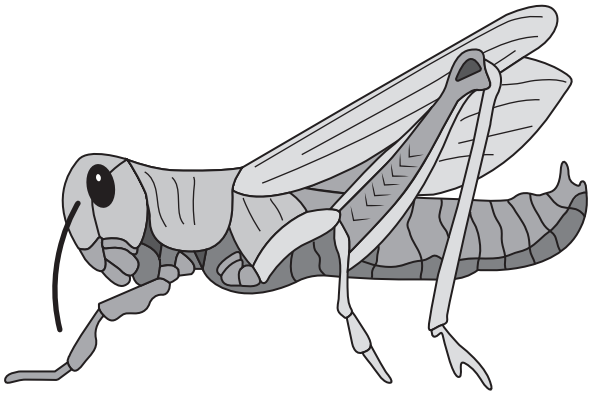
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**2** Insects, such as locusts, can be dissected to show their gas exchange system.

(a) (i) The diagram shows a dead locust.



Draw a line on this locust to show where you would cut through the exoskeleton to expose the gas exchange system.

**(1)**

(ii) State why you would cover the dissected locust with water.

**(1)**

.....

.....

.....

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) The photograph shows part of the dissected gas exchange system, as seen using a microscope.




(Source: © blickwinkel/Alamy Stock Photo)

(i) Name the structures labelled A and B.

**(2)**

A .....

B .....

(ii) Name the structure that supplies oxygen directly to the muscle tissue.

**(1)**

.....

(iii) At the point labelled A, the structure is 0.9 mm in diameter.

Calculate the diameter of the structure at the point labelled X.

Give your answer to **two** decimal places.

**(2)**

Answer ..... mm

**(Total for Question 2 = 7 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**3** In genetic modification, DNA from one species is joined to DNA from another species, to form recombinant DNA.

This recombinant DNA is inserted into the host organism using a vector.

The diagram shows a simplified sequence of events in the formation of herbicide-resistant, genetically modified (GM) soya beans.

Herbicides are chemicals that kill plants. They can be used to kill unwanted plants, such as weeds.

**Step A** Plasmids are extracted from *A. tumefaciens* bacteria

↓

**Step B** Plasmids are cut using an enzyme

↓

**Step C** The gene for herbicide-resistance is inserted into the plasmids.

↓

**Step D** Plasmids are returned to *A. tumefaciens* bacteria

↓

**Step E** A soya bean plant is infected with the modified *A. tumefaciens* bacteria

↓

**Step F** Herbicide-resistant soya bean plants are cloned from the infected plant.

(a) (i) Name the enzyme used in **Step C**.

**(1)**

.....

(ii) Name the vector in this process.

**(1)**

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) Explain why it is possible to clone many herbicide-resistant plants from one infected plant in **Step F**.

**(2)**

(c) Explain how herbicide resistance would improve the yield of GM soya bean plants compared to non-GM soya bean plants.

**(3)**

**(Total for Question 3 = 7 marks)**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**4** When cereal grains germinate, stored starch is broken down by amylase.

(a) A student investigated the effect of gibberellin concentration on the production of amylase in cereal grains.

This method was used:

**Step 1** Dilute a stock solution of gibberellin to give five different concentrations.

**Step 2** Cut the cereal grains in half and discard the half containing the embryo.

**Step 3** Soak the remaining halves of the grains in sodium hypochlorite solution for five minutes.

**Step 4** Soak one grain in each of the gibberellin solutions for 24 hours.

(i) The stock solution of gibberellin has a concentration of 1 g per $dm^3$.

Describe how you would dilute this stock solution to give a test solution of 300 µg per $dm^3$.

**(2)**

(ii) State **one** reason for each of the following steps in the method.

**(2)**

**Step 2**

**Step 3**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) The student completed the investigation using the following steps:

- the grains soaked in gibberellin solution were transferred to starch agar plates using forceps
- after 12 hours the surface of each plate was covered with iodine in potassium iodide solution, which was then poured away
- the diameter of the clear zone around each grain was measured.

(i) Describe how you would control **one** named abiotic variable and **one** named biotic variable.

**(2)**

Abiotic

Biotic

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(ii) Describe **three** further improvements to the method outlined in parts (a) and (b) that would improve the validity of the results.

**(3)**

**(Total for Question 4 = 9 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**5** (a) Bacteria are prokaryotes.

(i) Give **two** differences between the structures of a prokaryotic cell and a eukaryotic cell.

**(2)**

(ii) Gram staining is often used to help identify bacteria.

A sample of bacteria from an infected person was tested by using Gram staining.

The bacteria stained red.

Explain why the bacteria stained red **and** why this information is useful for treating the infected person.

**(3)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) (i) Describe the method used to isolate individual species from a mixed culture of bacteria in nutrient broth.

**(4)**

(ii) Explain **three** precautions that would be taken to reduce the growth of pathogenic bacteria.

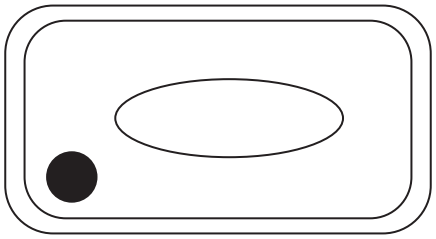
**(3)**

**(Total for Question 5 = 12 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**6** Water potential determines the direction of movement of water in and out of cells.

(a) The diagram shows a plant cell.



The turgor pressure (P) of the cell is 400 kPa and the osmotic potential ($\pi$) is –500 kPa.

(i) Calculate the water potential ($\psi$) of this cell.

**(1)**

Answer ..... kPa

(ii) Explain the direction of net movement of water for this plant cell when it is placed in a sucrose solution with a water potential ($\psi$) of –400 kPa.

**(2)**

.....

.....

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) A student carried out an investigation to determine the water potential of cells from a potato tuber, using a range of concentrations of sucrose solutions.

Cylinders of potato were cut using a cork borer, and the cylinders were then cut into discs.

The mass of each disc was recorded. One disc was placed in each sucrose solution and left for 12 hours. Each disc was then reweighed.

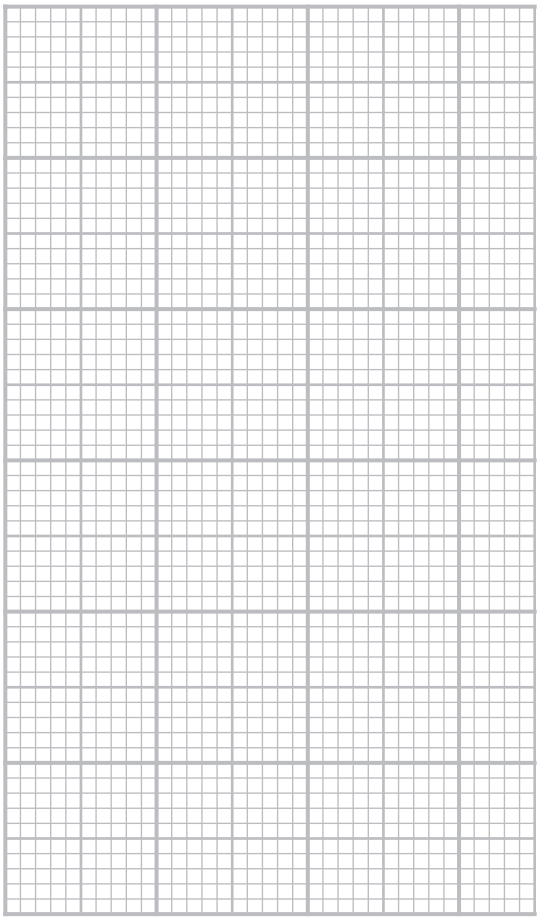
The table shows the data collected.

| **Concentration of sucrose solution / mol dm$^{-3}$** | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 |
|---|---|---|---|---|---|---|
| **Percentage change in mass of potato disc** | +14.2 | +1.9 | –9.8 | –22.7 | –31.9 | –37.1 |

(i) Plot a suitable graph of these results.

Join the points with straight lines.

**(3)**



DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) Determine the concentration of sucrose solution that causes no change in mass, using your graph.

**(1)**

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

(iii) Evaluate whether the method used in this investigation would provide valid results for the water potential of potato cells.

**(5)**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**(Total for Question 6 = 12 marks)**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**7** The photograph shows hedge woundwort (*Stachys sylvatica*).



(Source: © imageBROKER/Alamy Stock Photo)

This plant grows on the edge of woodlands and can be up to one metre in height.

A student investigated whether light intensity had an effect on the leaf area of hedge woundwort.

The student measured the area of 20 leaves from plants growing in full sun and 20 leaves from plants growing in shady conditions.

(a) (i) Give a suitable null hypothesis for this investigation.

**(1)**

.....

.....

.....

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) Devise a valid fieldwork method that the student could use to compare the leaf areas of the plants growing in full sunlight with the leaf areas of the plants growing in shady areas.

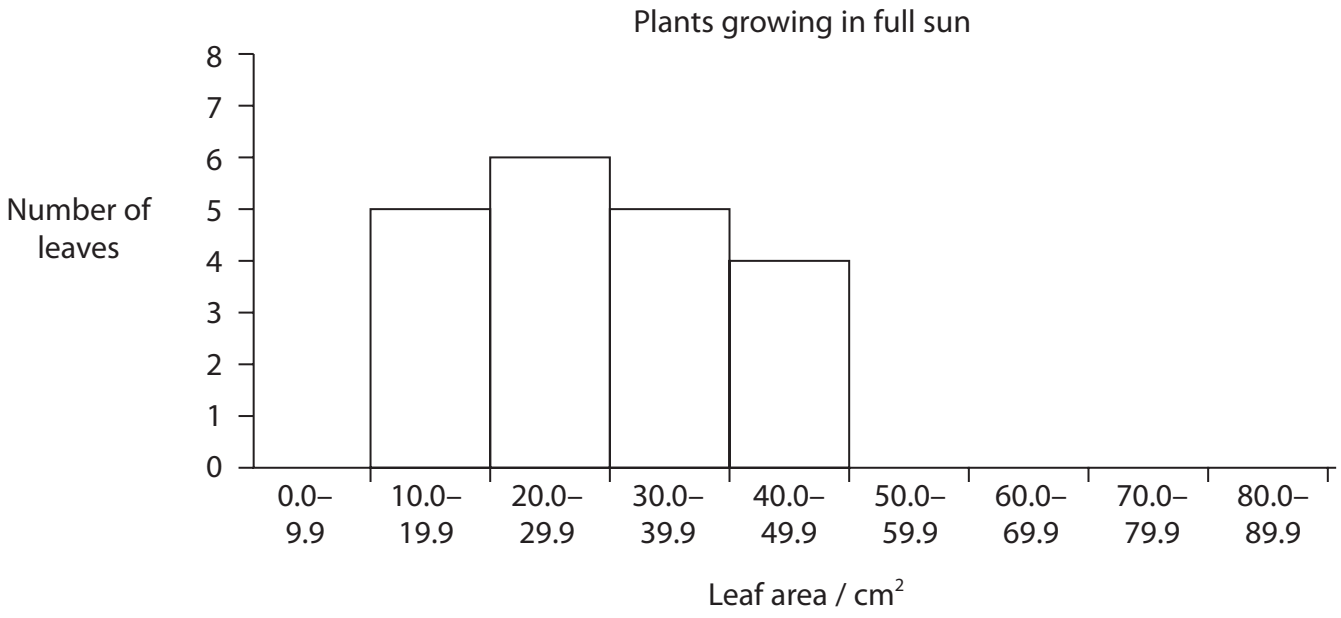
**(4)**

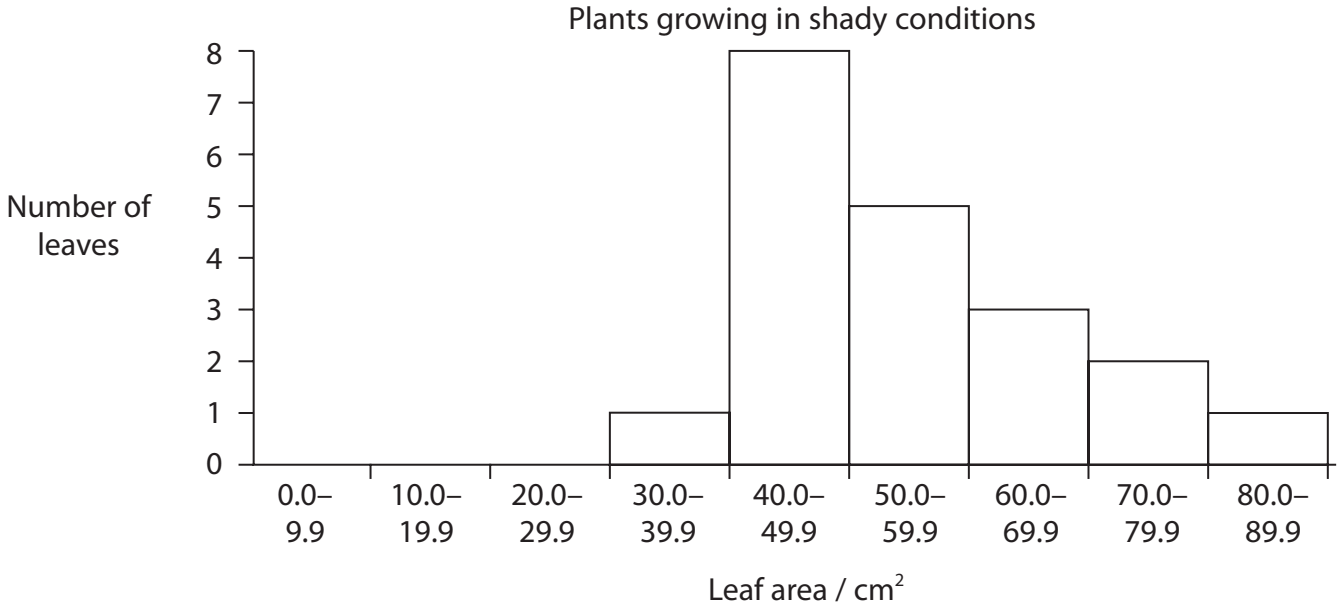
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) The student plotted histograms to display the data collected.




DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(i) The mean leaf area for leaves from plants in full sun is 27.55 $cm^2$ with a standard deviation of 9.62 $cm^2$.

The mean leaf area for leaves from plants in shady conditions is 55.50 $cm^2$ with a standard deviation of 13.40 $cm^2$.

Two standard deviations on either side of the mean will include 95% of the leaves.

Determine the size range that would include 95% of leaves from plants in full sun, using the standard deviation value.

**(2)**

Answer ..... $cm^2$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) The student analysed the data using a *t*-test.

Calculate the value of *t*.

Use the formula

$$t = \frac{(\bar{x}_A - \bar{x}_B)}{\sqrt{\frac{(S_A)^2}{n_A} + \frac{(S_B)^2}{n_B}}}$$

where:

$\bar{x}$ is the mean for each set of data

n is the number of samples in each set of data

S is the standard deviation for each set of data

**(3)**

Answer .....

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**BLANK PAGE**

(iii) The table shows the critical values of *t* for different degrees of freedom.

| Degrees of freedom | p = 0.10 | p = 0.05 | p = 0.01 |
|---|---|---|---|
| 20 | 1.73 | 2.09 | 2.85 |
| 21 | 1.72 | 2.08 | 2.83 |
| 22 | 1.72 | 2.07 | 2.82 |
| 23 | 1.71 | 2.07 | 2.81 |
| 24 | 1.71 | 2.06 | 2.80 |
| 25 | 1.71 | 2.06 | 2.79 |
| 26 | 1.71 | 2.06 | 2.78 |
| 27 | 1.70 | 2.05 | 2.77 |
| 28 | 1.70 | 2.05 | 2.76 |
| 29 | 1.70 | 2.05 | 2.76 |
| 30 | 1.70 | 2.04 | 2.75 |
| 31 | 1.70 | 2.04 | 2.74 |
| 32 | 1.69 | 2.04 | 2.74 |
| 33 | 1.69 | 2.03 | 2.73 |
| 34 | 1.69 | 2.03 | 2.73 |
| 35 | 1.69 | 2.03 | 2.72 |
| 36 | 1.69 | 2.03 | 2.72 |
| 37 | 1.69 | 2.03 | 2.72 |
| 38 | 1.69 | 2.02 | 2.71 |
| 39 | 1.69 | 2.02 | 2.71 |
| 40 | 1.68 | 2.02 | 2.70 |

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Comment on the results of this investigation.

Use the information in the table to support your answer.

**(3)**

**(Total for Question 7 = 13 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**8** Haemoglobin transports oxygen around the human body.

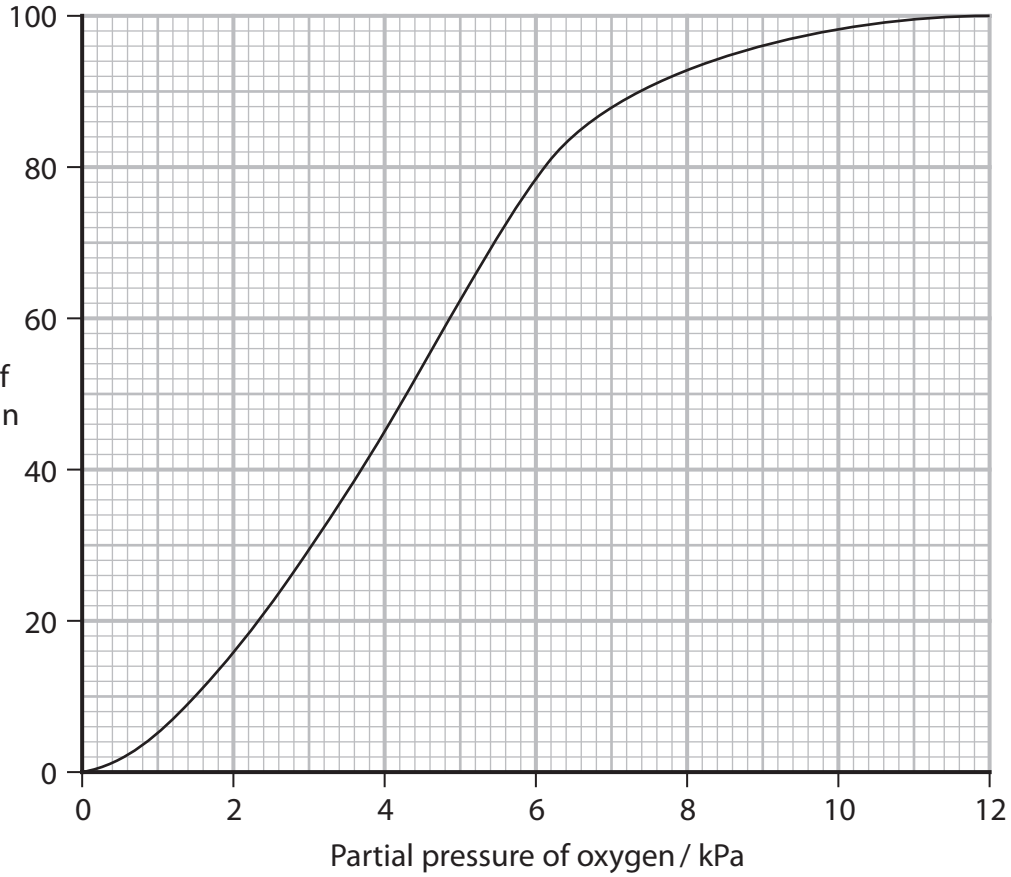
(a) (i) Explain how the structure of haemoglobin enables it to combine with oxygen in the blood vessels of the lungs.

**(3)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) The partial pressure of carbon dioxide affects how readily haemoglobin picks up and releases oxygen.

The graph shows an oxygen dissociation curve for haemoglobin in blood in the lungs.




The oxygen dissociation curve for haemoglobin in blood in the tissues of respiring muscle is different.

Sketch this curve onto the axes.

**(1)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(iii) Explain the advantage of this change in the position of the oxygen dissociation curve.

**(2)**

(b) Beta thalassaemia is an inherited condition affecting the gene for beta-globin (HBB gene).

People with beta thalassaemia have less or no beta-globin.

The most common form is a recessive condition caused by a mutation in the HBB gene.

(i) State the probability that two parents who are heterozygous for this condition would have a child who has beta thalassaemia.

**(1)**

(ii) Explain why a person who is heterozygous does not show the symptoms of beta thalassaemia.

**(2)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(c) Overall, the proportion of people with beta thalassaemia is 30 in 1000.

In some parts of the world it is much higher.

In one Mediterranean island, 280 in 1000 people have beta thalassaemia.

(i) Calculate the probability that a person on this island is heterozygous for beta thalassaemia.

Use the Hardy–Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

Give your answer to two significant figures.

**(3)**

Answer .....

(ii) Give **two** reasons why this value may not be accurate.

**(2)**

.....

.....

.....

.....

.....

.....

**(Total for Question 8 = 14 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**9** Coronary heart disease is a major cause of death in Europe.

(a) Explain how atherosclerosis can cause coronary heart disease and can lead to death.

**(4)**

DO NOT WRITE IN THIS AREA

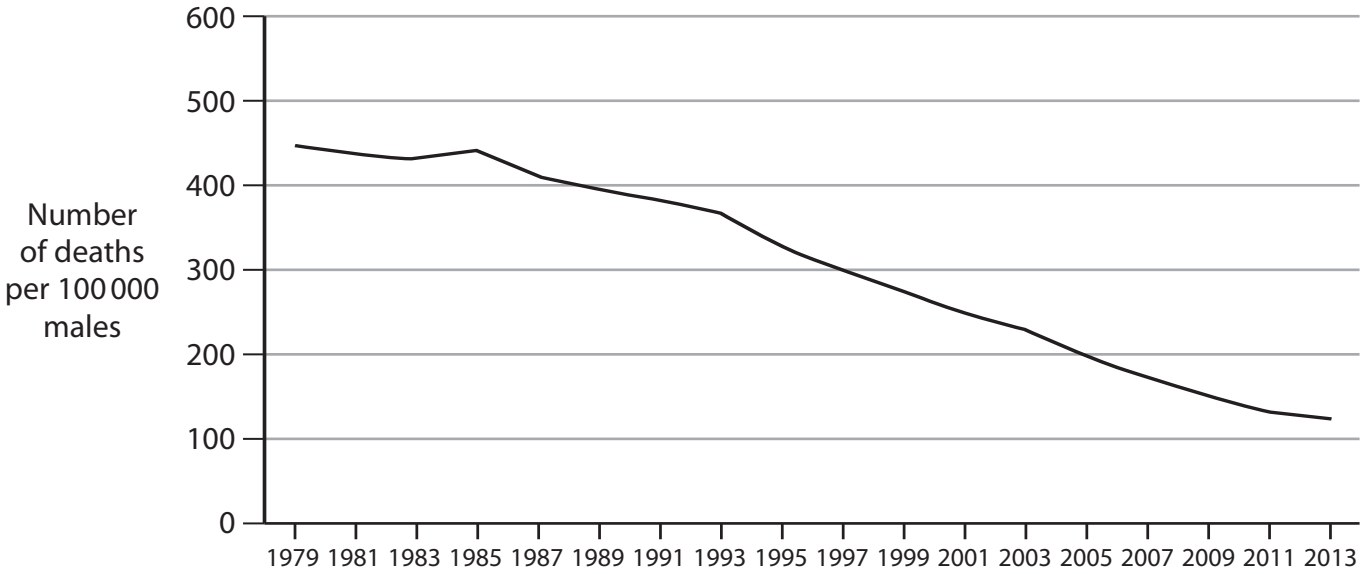
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

*(b) The table shows the change in the number of deaths from coronary heart disease in males and females in some European countries, and the whole of Europe, between 1990 and 2019.

| Country or region | Number of deaths per 100 000 of population | | Percentage change from 1990 to 2019 (%) |
|---|---|---|---|
| | 1990 | 2019 | |
| Albania | 389 | 314 | –19 |
| Bulgaria | 701 | 541 | –23 |
| France | 196 | 91 | –53 |
| Montenegro | 418 | 436 | +4 |
| Republic of Ireland | 357 | 133 | –63 |
| UK | 314 | 132 | –58 |
| Europe (all countries) | 393 | 242 | –38 |

The graph shows the number of deaths of males, per 100 000, from coronary heart disease in the UK from 1979 to 2013.




DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

It has been suggested that the change in deaths from coronary heart disease in the UK is due to improved lifestyle choices, and that coronary heart disease could be reduced to almost zero in the UK if people made better choices.

Discuss the validity of this suggestion.

Use the data and your own knowledge to support your answer.

**(9)**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

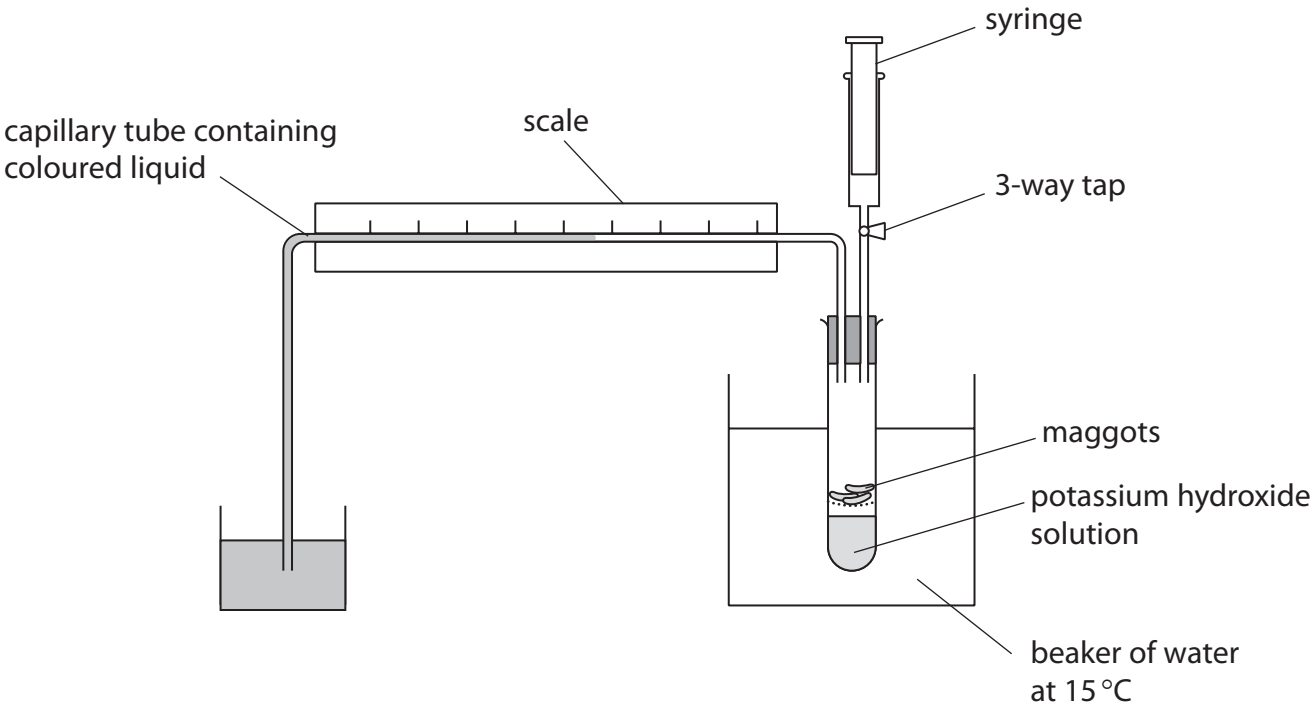
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**(Total for Question 9 = 13 marks)**

**10** Five groups of students used respirometers to investigate the rate of aerobic respiration by maggots.

The diagram shows the type of respirometer used.




Maggots were placed in the boiling tube and the 3-way tap was closed.

The distance the coloured liquid had moved was measured after 15 minutes.

The rate of oxygen uptake was calculated.

The table shows the results obtained.

| **Group number** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Rate of oxygen uptake / $mm^3\ min^{-1}\ g^{-1}$** | 0.14 | 0.16 | 0.13 | 0.12 | 0.14 |

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(a) The rate of aerobic respiration was determined as the oxygen uptake calculated in $mm^3$ per minute per gram.

State the **two** additional measurements that you would make to calculate the rate using these units.

**(2)**

(b) Justify **two** improvements that would ensure the validity of this investigation.

**(2)**

(c) (i) For enzyme-controlled reactions, a 10°C rise in temperature will double the rate of reaction.

Predict the mean rate of oxygen uptake if the water bath had been set at 5°C.

**(1)**

Answer ..... $mm^3 min^{-1} g^{-1}$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) Explain why decreasing the temperature affects the rate of respiration of maggots.

**(2)**

(d) Describe the role of oxygen in the formation of ATP during aerobic respiration.

**(3)**

**(Total for Question 10 = 10 marks)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**11** Citizen science involves members of the public collecting scientific data.

In 2019 and 2020, a citizen science project was carried out in the UK to investigate the numbers of flowers of wild plant species found in lawns.

Volunteers across the UK were asked to survey their own lawns to find out which wild flowering plants were growing there.

Participants were asked to mark out a one metre-squared area on their lawn, chosen at random, and count the number of flowers of each species within this area.

In 2020, the data were recorded from over 9 000 one metre-squared areas.

The table shows data for the five most commonly recorded wild plant species in 2020.

| Wild plant species | Total number of flowers recorded in 2020 | Percentage change from 2019 (%) |
|---|---|---|
| Daisy | 208 589 | –40 |
| White clover | 101 117 | +16 |
| Selfheal | 73 344 | –11 |
| Creeping buttercup | 56 719 | +48 |
| Bird's-foot trefoil | 30 646 | –32 |

(a) Scientists who analysed the data suggested that the unusually warm weather in Spring 2020 might be responsible for the change in the numbers of flowers recorded in 2020 compared to 2019.

(i) Name **one** factor, other than temperature, that could cause the change in the numbers of flowers of these five species.

**(1)**

.....

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) The scientists concluded that for all species recorded, the number of flowers of wild plants in lawns decreased 19% in 2020 compared to 2019.

Evaluate the method of data collection in this survey.

**(5)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) The table shows the total data collected in one quadrat placed on a lawn.

| Wild plant species | Total number of flowers recorded |
|---|---|
| Daisy | 11 |
| Dandelion | 8 |
| Cat's-ear | 14 |
| Selfheal | 2 |

(i) Calculate the biodiversity index (D) for the quadrat, using the data in the table.

Use the formula

$$D = \frac{N(N-1)}{\Sigma n(n-1)}$$

**(3)**

Answer .....

(ii) Describe **two** improvements which should be made to the method to give a more accurate measure of the biodiversity index for this quadrat.

**(2)**

.....

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) (i) Bees feed on nectar in flowers.

The mean mass of nectar sugar produced per square metre of lawn was calculated for 2019 and 2020.

Scientists then calculated the mean number of bees per square metre that could be supported by the nectar.

The table shows the data.

| 2019 | | 2020 | |
|---|---|---|---|
| **Mean mass of nectar sugar / mg $m^{-2}$** | **Mean number of bees supported per $m^2$** | **Mean mass of nectar sugar / mg $m^{-2}$** | **Mean number of bees supported per $m^2$** |
| 41 912 | 3.8 | 38 885 | |

Calculate the mean number of bees supported per square metre of lawn in 2020.

**(2)**

Answer .....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(ii) Bees are important pollinators of a variety of plants.

Explain the possible short-term **and** long-term consequences of the decline in flowers of wild plant species in lawns in 2020.

**(4)**

**(Total for Question 11 = 17 marks)**

**TOTAL FOR PAPER = 120 MARKS**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**BLANK PAGE**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA