Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

# A-level
# BIOLOGY

Paper 3

Specimen materials (set 2)

Time allowed: 2 hours

| For examiner's use | |
|---|---|
| Question | Mark |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| **TOTAL** | |

**Materials**

For this paper you must have:
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

**Instructions**
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of the page.
- Answer **all** questions in **section A**.
- Answer **one** question in **section B**.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 78.

**There are no questions printed on this page**

**DO NOT WRITE ON THIS PAGE**
**ANSWER IN THE SPACES PROVIDED**

## Section A

Answer **all** questions in the spaces provided.

**0 1** Scientists measured the rate of carbon dioxide release by three groups of insects of the same species at 10 °C, 20 °C and 30 °C. They also determined the mean mass of each group of insects.

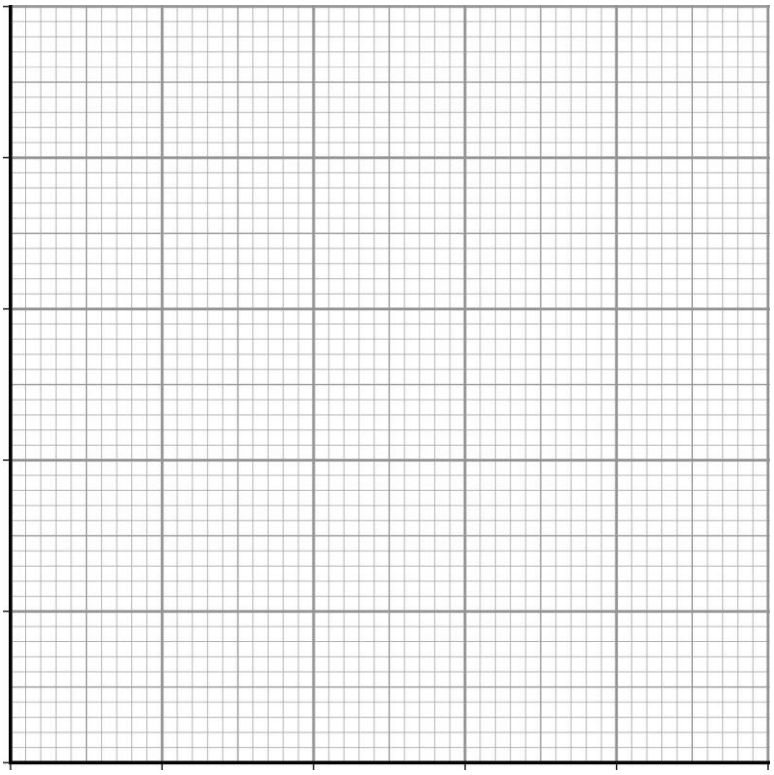
The scientists results are shown in **Table 1**.

**Table 1**

| Temperature / °C | Mean mass / g | Rate of carbon dioxide release / $\mu dm^3$ $minute^{-1}$ | Rate of carbon dioxide release per gram / $\mu dm^3$ $g^{-1}$ $minute^{-1}$ |
|---|---|---|---|
| 10 | 0.047 | 0.12 | |
| 20 | 0.046 | 0.33 | |
| 30 | 0.048 | 0.56 | |

**0 1 . 1** Complete **Table 1** and plot a graph of your calculated values against temperature on the graph paper. Express your calculated rates with the appropriate number of significant figures.

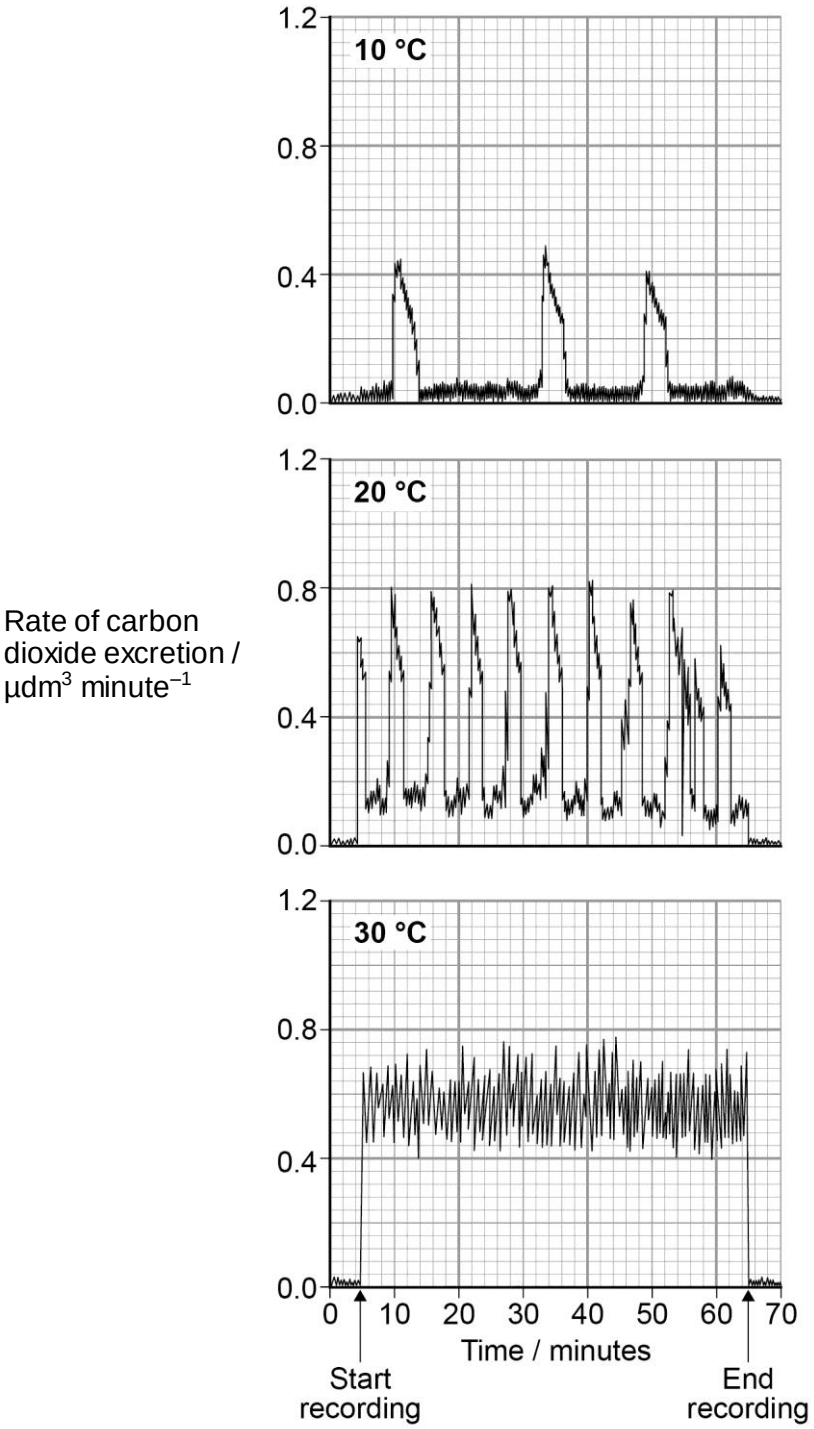
**[3 marks]**



**0 1 . 2** The body temperature of the insects was largely determined by the temperature they were kept at. At each temperature, the scientists recorded rate of carbon dioxide release by individual insects over time. This rate depends upon spiracles opening or closing.

**Figure 1** shows results for three insects.

**Figure 1**



Calculate the change in the rate per hour of opening of the spiracles between 10 °C and 20 °C.

**[1 mark]**

0 1 . 3 Explain how you could determine the total amount of carbon dioxide secreted at 30 °C during the period of recording.

**[1 mark]**

0 1 . 4 Suggest an explanation for the effect of temperature on the rate of carbon dioxide release.

**[3 marks]**

8

**Turn over for the next question**

**0 2** Some autism spectrum disorders (ASDs) are associated with a mutation affecting the neuroligin-3 gene. This gene codes for a protein called NL3, that is found in synapses.

Scientists investigated the effects of a mutation affecting NL3 in mice. They obtained brains from mice with the mutation and from mice without the mutation. For each type of mouse they:

- obtained a solution containing all of the proteins from synapses in one part of the brain
- separated these proteins using gel electrophoresis
- identified and measured the amount of three proteins from the solution using three different labelled antibodies.

The three proteins are parts of a postsynaptic membrane receptor.

**Figure 2** shows the scientists' results. Each band shows the presence of a protein. The size of a band shows the amount of the protein present.

**Figure 2**


**0 2 . 1** The mutation affecting NL3 in these mice was a substitution in the neuroligin-3 gene.

What is a substitution mutation?

**[1 mark]**

**0 2 . 2** Suggest how gel electrophoresis separated the proteins obtained from the synapses.

**[2 marks]**

**0 2 . 3** Each type of labelled antibody binds specifically to one of the proteins.

Explain why.

**[3 marks]**

**0 2 . 4** What do these data show about the effects of the mutation on the proteins?

**[2 marks]**

**Question 2 continues on the next page**

**0 2 . 5** These proteins are part of a receptor found in synapses in the part of the brain called the hippocampus. A high ratio of NR2B to NR2A protein in this receptor has been associated with good memory.

Using all of the information, suggest how the mutation affecting the NL3 protein may affect a mouse.

**[2 marks]**

10

**0 3** Ecologists developed a method for estimating the biomass of trees in a plantation. The plantation consisted of trees of the same species.

They collected samples of wood from trees. For each sample they:

- determined the density of the freshly cut wood
- dried the wood in an oven at 103 °C for 24 hours
- determined the volume of the dried wood sample
- determined the density of the dried wood.

**Table 2** shows data about one wood sample.

**Table 2**

| Volume of freshly cut wood sample / $dm^3$ | Density of freshly cut wood / g per $dm^3$ | Volume of dried wood sample / $dm^3$ | Density of dried wood sample / g per $dm^3$ |
|---|---|---|---|
| 1.345 | 993.0 | 1.125 | 769.0 |

**0 3 . 1** The loss of mass of the wood sample was due to loss of water. Water has a density of 1 g per $cm^3$.

Use the data in **Table 2** to calculate the percentage of water in the freshly cut wood sample. Show your working.

**[2 marks]**

Percentage of water = _____

**0 3 . 2** The ecologists dried the samples in an oven at 103 °C for 24 hours. Describe how the ecologists could have determined whether or not this drying removed all the water from a sample of wood.

**[2 marks]**

_____

_____

_____

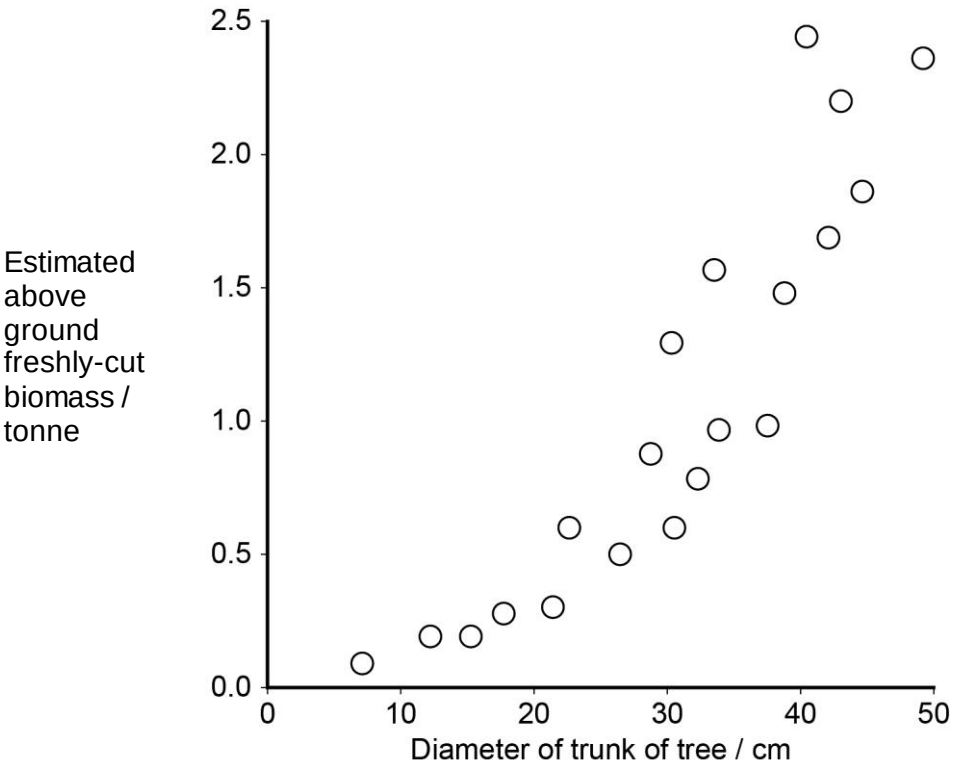
_____

_____

**0 3 . 3** Ecologists then investigated the relationship between the diameter of the trunk of the trees and their biomass.

**Figure 3** shows their results. Each point is the result for **one** tree.

**Figure 3**




What does **Figure 3** show about the relationship between the diameter of the trunk of the trees and their biomass?

**[2 marks]**

**0 3 . 4** Plantations of trees are often created to remove carbon dioxide from the atmosphere, to help to balance the carbon dioxide released by burning fossil fuels.

For different species of tree, information is available for:

- the relationship between diameter of trunk and freshly cut biomass
- the percentage of water in fresh-cut wood
- the mean dried density of wood.

Using only the information provided in question 3, suggest how the mass of carbon in the wood of a plantation of trees of a particular species could be estimated.

Start with measuring the diameter of a large number of trees.

Assume that the dry biomass of a tree consists of biological molecules that contain carbon.

**[4 marks]**

10

**Turn over for the next question**

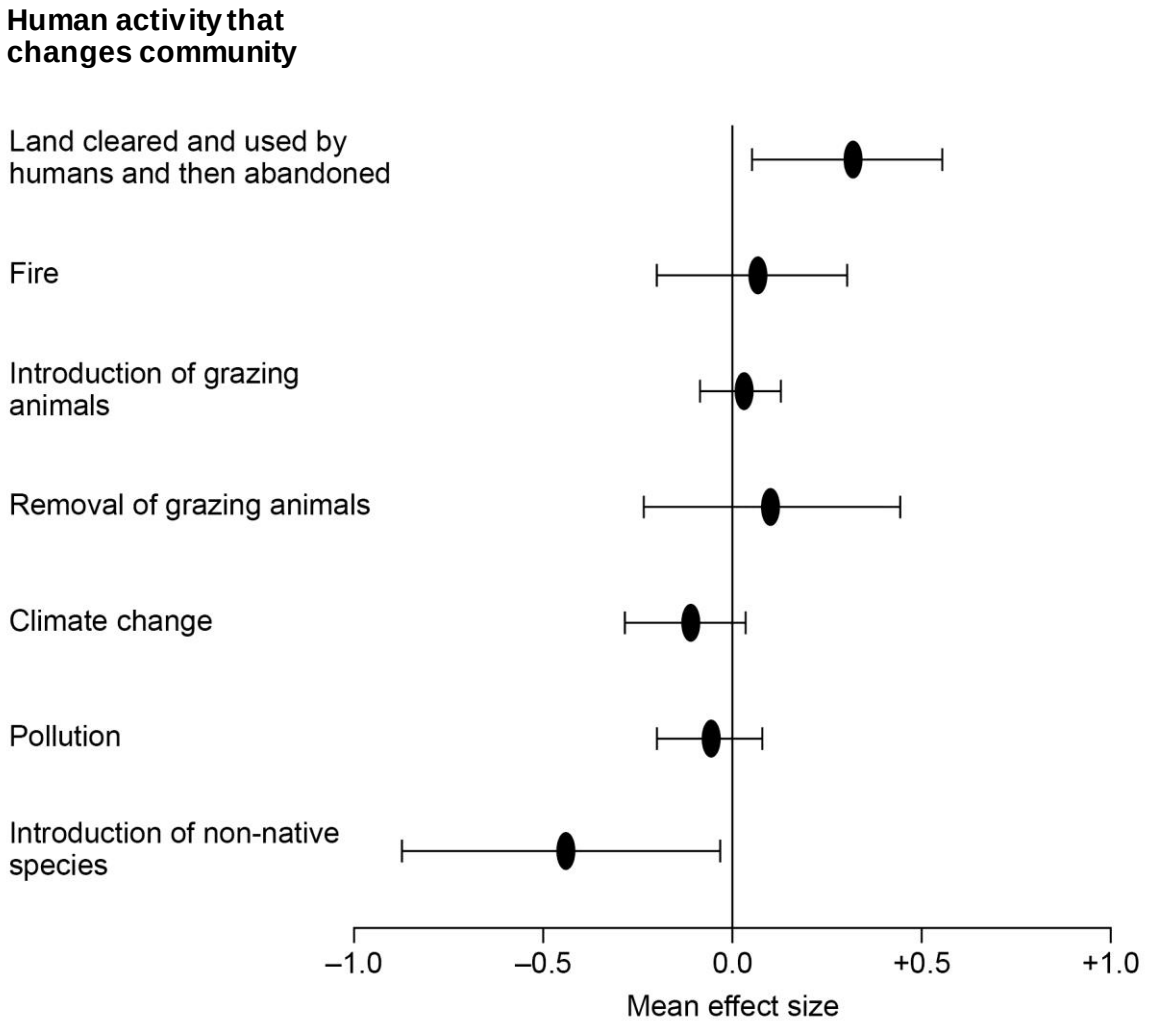
**0 4**

Scientists investigated changes in plant biodiversity in different communities after changes caused by humans. They collected data from many published investigations that recorded changes in species richness of plants over a large number of years.

The scientists used data from each investigation to calculate the effect size.
The effect size is a measure of change in species diversity with time. A positive value shows an increase in species richness with time.

**Figure 4** shows the scientists results in the form in which they were published. The horizontal bars represent ±2 standard deviations, which includes 95.4% of the data.

**Figure 4**



**0 4 . 1** What can you conclude from these data about the effects of human activities on biodiversity?

**[3 marks]**

**0 4 . 2** Suggest an explanation for the effect size when non-native species were introduced to communities.

**[2 marks]**

**Question 4 continues on the next page**

**0 4 . 3** Describe how you would investigate the effect of an invasion by a non-native species of plant (a biotic environmental factor) over many years on the abundance of a native species of plant in a community.

**[3 marks]**

**0 4 . 4** Effect size is calculated in the following way.

1. Divide the species richness in the last year of an investigation (SR2) by species richness in the first year of the investigation (SR1).
2. Find the natural log ($\log_e$) of the result.
3. Divide this by the time (T) between the first and last year in decades (1 decade = 10 years).

In one community:

- species richness in year 2 (SR2) was 15.3
- species richness in year 1 (SR1) was 18.2
- and the investigation lasted for 29 years.

Use $\log_e$, SR2, SR1 and T to write an equation for 'effect size' and calculate its value for this investigation. On a calculator, the key for $\log_e$ is shown as ln, or $\log_e$.

**[2 marks]**

Effect size = _____

10

**0 5** Scientists have investigated the use of different types of stem cell to treat damage to the heart after a myocardial infarction. During a myocardial infarction, a number of different cell types in the heart die. This includes cardiomyocytes which are heart-muscle cells.

Embryonic pluripotent stem cells (ESCs) can divide and differentiate into a wide range of different cell types.

**0 5 . 1** Using the information given, suggest **one** reason why ESCs might be suitable to treat damage to the heart.

**[1 mark]**

**0 5 . 2** ESCs have not yet been used to treat people who have had a myocardial infarction. This is because of concern that the use of ESCs might lead to more harm to the person. One way that ESCs might lead to more harm is by differentiating into the wrong types of cells.

Suggest **one** other way that putting ESCs into a person's heart might lead to more harm to the person.

**[2 marks]**

**Question 5 continues on the next page**

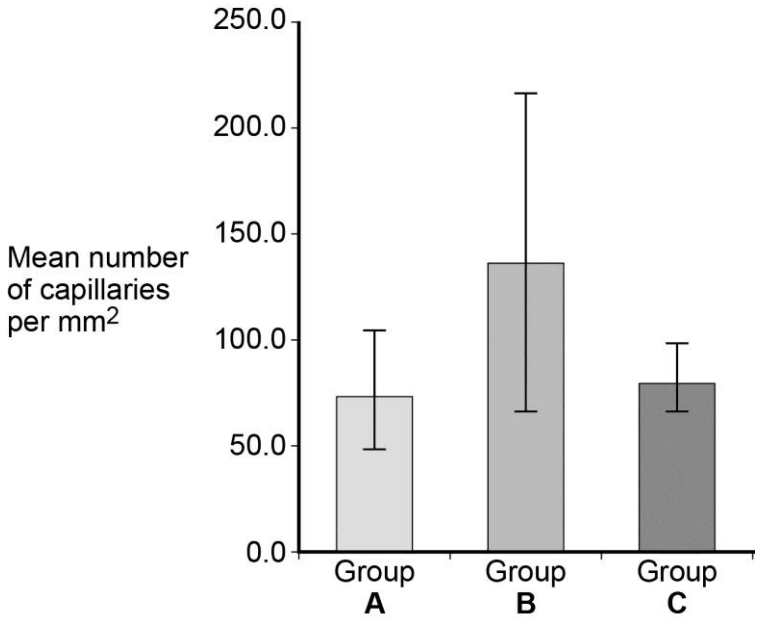
**0 5 . 3** Transplants of cardiomyocytes have been shown to increase the repair of heart tissue damaged by myocardial infarction.
One group of scientists investigated the hypothesis that these transplants work by stimulating growth of new blood vessels into damaged heart tissues. They obtained three groups of mice, **A**, **B** and **C** that had suffered myocardial infarctions.

- **Group A** were operated on but no transplant was given.
- **Group B** were operated on and given transplants containing cardiomyocytes and two other types of heart cell.
- **Group C** were operated on and given transplants containing the two other types of heart cells but no cardiomyocytes.

After a suitable time, the scientists measured the mean number of capillaries per $mm^2$ in sections taken from areas of the hearts of the mice affected by myocardial infarction.

Their results are shown in **Figure 5**. The bars show ±2 standard deviations, which includes 95.4% of the data.

**Figure 5**




Group **A** was a control group. Explain **two** ways in which Group **A** acts as a control.
**[2 marks]**

1 _____

_____

_____

2 _____

_____

_____

**0 5 . 4** What can you conclude from these data about the stimulation by cardiomyocytes on growth of new blood vessels into damaged heart tissues?

**[3 marks]**

**0 5 . 5** Suggest how the growth of new blood vessels into damaged heart tissues could increase the rate of repair of tissues.

**[3 marks]**

**Question 5 continues on the next page**

**0 5 . 6** The scientists used an optical microscope to measure the number of capillaries in thin sections cut from samples of heart muscle.

Describe the method they would have used to find the mean number of capillaries per $mm^2$.

**[4 marks]**

15

## Section B

Answer **one** question in the space provided.

**0 6** Write an essay on **one** of the topics below.

**0 6 . 1** How nucleotides, molecules derived from nucleotides and nucleic acids are important in keeping organisms alive.

**[25 marks]**

**OR**

**0 6 . 2** The ways in which water and the regulation of water content are important to organisms.

**[25 marks]**

**END OF QUESTIONS**