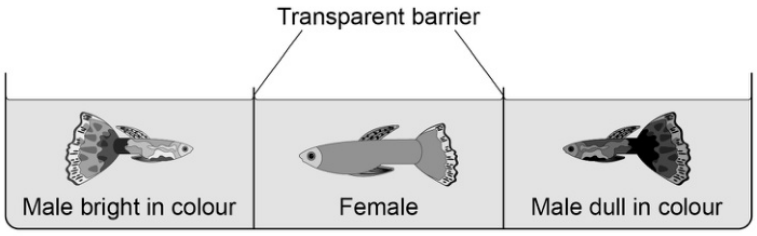
## Question 1

**0 1** Guppies are small fish. Female guppies are dull in colour. Male guppies can be
Guppies are small fish. Female guppies are dull in colour. Male guppies can be
bright or dull in colour.

Scientists investigated the effect of female brain size on choosing a mate. They used laboratory-bred female guppies with large brains and with small brains.

They set up a fish tank as shown in **Figure 1**.

**Figure 1**




They observed each female for 10 minutes and recorded which male they were attracted towards. They repeated this with 45 large-brained females and 45 small-brained females.

**0 1 . 1** Suggest **three** possible limitations of this investigation.

**[3 marks]**

1

2

3

Guppies with large brains are better at identifying predators.

The scientists found that **only** female guppies with large brains were attracted to male guppies bright in colour.

**0 1 . 2** Suggest and explain the advantage of this behaviour to the population of guppies.

**[3 marks]**

0 1 . 3 Describe how the behaviour of female guppies could result in sympatric speciation.

**[3 marks]**

## Question 2

**0 3** In Europe, viruses have infected a large number of frogs of different species. The viruses are closely related and all belong to the Ranavirus group.

Previously, the viruses infected only one species of frog.

**0 3 . 1** Suggest and explain how the viruses became able to infect other species of frog.

**[2 marks]**

**0 3 . 2** Name **two** techniques the scientists may have used when analysing viral DNA to determine that the viruses were closely related.

**[1 mark]**

1 _____

2 _____

**0 3 . 3** Determining the genome of the viruses could allow scientists to develop a vaccine.

Explain how.

**[2 marks]**

**0 3 . 4** Describe how the B lymphocytes of a frog would respond to vaccination against Ranavirus.

You can assume that the B lymphocytes of a frog respond in the same way as B lymphocytes of a human.

Do **not** include details of the cellular response in your answer.

**[3 marks]**

## Question 3

**0 3** A student prepared a stained squash of cells from the root tips of garlic to calculate a mitotic index. He:

**1.** cut the end 5 mm from 10 garlic roots
**2.** placed the root tips into a Petri dish containing 5 $cm^3$ of hydrochloric acid for 12 minutes
**3.** rinsed the root tips in distilled water
**4.** placed one of the root tips on a microscope slide and added toluidine blue stain
**5.** placed a coverslip onto the microscope slide, and gently pressed the coverslip downwards on the root tip
**6.** observed the root tip using an optical microscope.

**0 3 . 1** Suggest why the student soaked the root tips in hydrochloric acid in step **2**.

**[2 marks]**

**0 3 . 2** Pressing the coverslip downwards enabled the student to observe the stages of mitosis clearly.

Explain why.

**[2 marks]**

**Question 3 continues on the next page**

**Figure 6** shows the student's drawing of one field of view.

**Figure 6**


**0 3 . 3** Name the stage of mitosis shown in cell **G**. Explain the appearance of this cell.

**[2 marks]**

Stage of mitosis _____

Explanation _____

_____

_____

_____

_____

**0 3 . 4** Use **Figure 6** to calculate a mitotic index for the cells in this field of view.

**[1 mark]**

Mitotic index _____

**0 3 . 5** Other students in the class followed the same method, but calculated different mitotic indices.

Apart from student errors, suggest **two** explanations why.

**[2 marks]**

1 _____

_____

_____

2 _____

_____

_____

box

9

## Question 4

**Section A**

Answer **all** questions in this section.

You are advised to spend no more than 1 hour and 15 minutes on this section.

**0 1** In one species of squirrel, *Sciurus carolinensis*, fur colour is controlled by one gene, with two codominant alleles. $C^G$ represents the allele for grey fur colour, and $C^B$ represents the allele for black fur colour.

**Table 1** shows the three possible phenotypes.

**Table 1**

| Genotype | Phenotype |
|---|---|
| $C^GC^G$ | Grey fur |
| $C^GC^B$ | Brown-black fur |
| $C^BC^B$ | Black fur |

**0 1 . 1** In a population of 34 *S. carolinensis*, 2 had black fur.

Use the Hardy–Weinberg equation to estimate how many squirrels in this population had brown-black fur. Show your working.

**[2 marks]**

Answer _____

**0 1 . 2** The actual number of squirrels in this population that had brown-black fur was 16.

Use all of the information to calculate the **actual** frequency of the $C^G$ allele.

Do **not** use the Hardy–Weinberg equation in your calculation.

Give your answer to 2 decimal places.

**[1 mark]**

Answer _____

**0 1 . 3** *S. carolinensis* were first introduced to the UK from North America in the 1870s. They are now widely distributed across the UK.

*S. carolinensis* from both North America and the UK show exactly the same genotypic and phenotypic variation. An identical mutation causing black fur has also been found in several other species closely related to *S. carolinensis*.

Use this information to deduce which **one** of the following conclusions is most likely true.

Tick (✓) **one** box.

**[1 mark]**

**A** The mutation that caused black fur happened after *S. carolinensis* was introduced to the UK from North America. ☐

**B** The mutation that caused black fur happened in a common ancestor of *S. carolinensis* and other closely related species. ☐

**C** The mutation that caused black fur happened independently in *S. carolinensis* and all other closely related species. ☐

**D** The phenotypic variation shown in *S. carolinensis* and other closely related species is caused by genetic drift. ☐

**Question 1 continues on the next page**

Outside the box

The mutation that caused the $\mathbf{C^B}$ allele was due to a 24 base-pair deletion from the $\mathbf{C^G}$ allele.

**0 1 . 4** The protein coded for by the $\mathbf{C^B}$ allele is 306 amino acids long.

Calculate the percentage reduction in size of the protein coded for by the $\mathbf{C^B}$ allele compared with the protein coded for by the $\mathbf{C^G}$ allele.

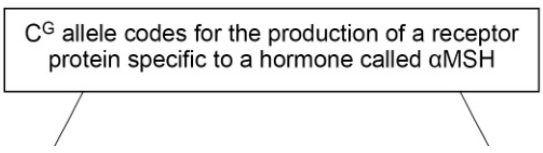
Give your answer to 3 significant figures and show your working.

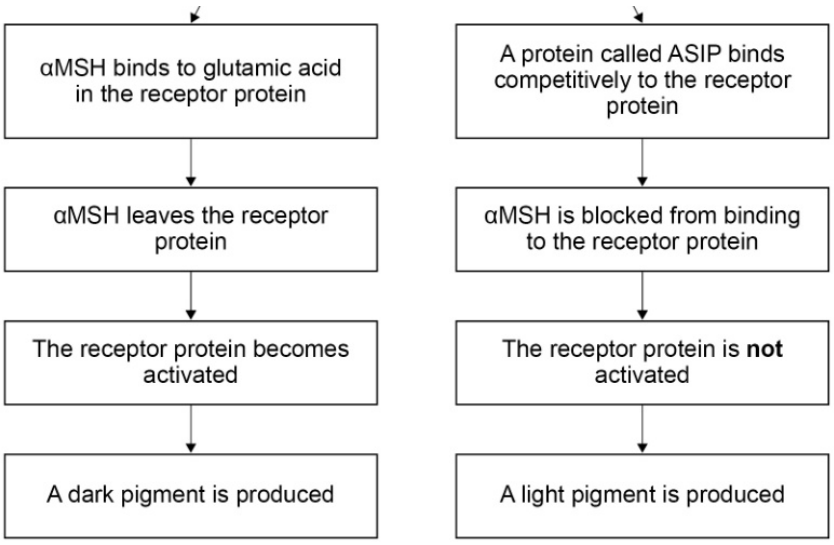
**[2 marks]**

Answer _____

In *S. carolinensis*, fur colour depends on the distribution and relative amounts of light pigments and dark pigments in the hairs of the fur. **Figure 1** shows how the protein produced from the $\mathbf{C^G}$ allele can result in the production of a light pigment or a dark pigment.

**Figure 1**






The deletion mutation in the $C^B$ allele results in the production of a receptor protein that does not have glutamic acid. The lack of glutamic acid in the receptor protein has the same effect as αMSH leaving the receptor protein.

box

**0 1 . 5** Use **Figure 1** and this information to suggest why *S. carolinensis* with the genotype $C^BC^B$ have black fur rather than grey fur.

**[3 marks]**

9

**Turn over for the next question**

## Question 5

**0 3** Farmers use artificial fertilisers to maintain or increase yield from grain-producing crop plants such as wheat.

**0 3 . 1** Artificial fertiliser is used to replace mineral ions removed from the land when crops are harvested. One of the mineral ions is nitrate.

Give **two** examples of biological molecules containing nitrogen that would be removed when a crop is harvested.

**[2 marks]**

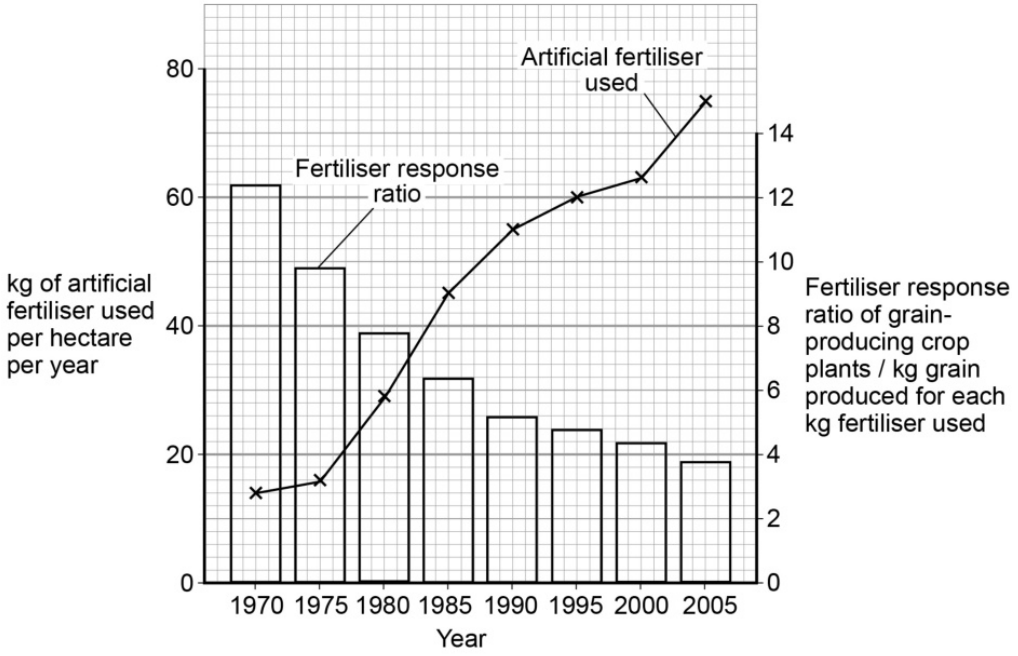
1 _____

2 _____

**0 3 . 2** Scientists investigated changes in the use of artificial fertiliser in India between 1970 and 2005. They also investigated changes in the **fertiliser response ratio**. This ratio shows how many kg of grain are produced for each kg of fertiliser used.

**Figure 4** shows their results in the form the scientists presented them.
(A hectare is a unit of area commonly used in agriculture)

**Figure 4**




Use these data to calculate the difference in the mass of grain produced per hectare in 1970 compared with 2005.

Show your working.

**[2 marks]**

Difference _____ kg hectare$^{-1}$

**0 3 . 3** Use the data in **Figure 4** to evaluate the use of artificial fertilisers on grain-producing crops in India.

**[2 marks]**

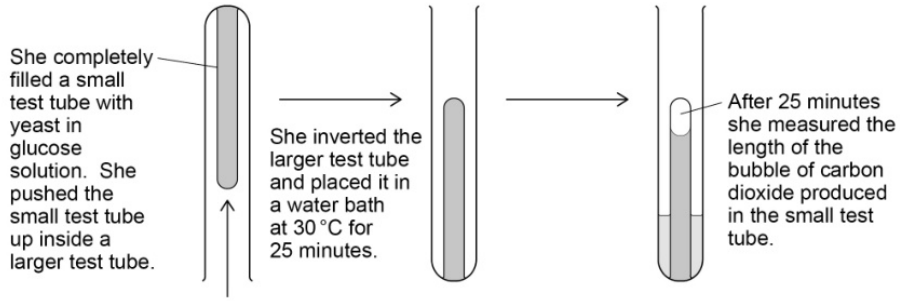
**Turn over for the next question**

## Question 6

**0 2** A student investigated the effect of different sugars on the rate of respiration in yeast. Yeast normally respires glucose.

**Figure 2** shows the method she used for her first experiment.

**Figure 2**

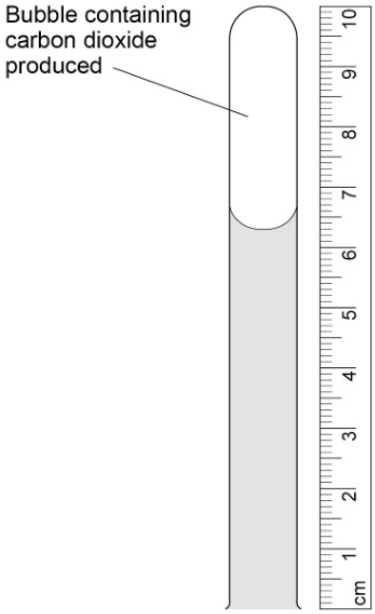



**0 2 . 1** Other than those stated, suggest **two** variables the student needed to keep constant in her investigation.

**[1 mark]**

**Figure 3** shows the result she obtained for yeast in glucose solution.

**Figure 3**




**0 2 . 2** Use **Figure 2** and **Figure 3** to calculate the rate of carbon dioxide production in mm $s^{-1}$ for yeast in glucose solution.

Give your answer in standard form **and** to **2** significant figures.

Show your working.

**[2 marks]**

Answer _____ mm $s^{-1}$

**0 2 . 3** The student repeated the experiment using yeast in maltose solution. She found the rate of carbon dioxide production was slower than with yeast in glucose solution. Suggest why. box

**[2 marks]**

**0 2 . 4** A second student used a different method to investigate the effect of different sugars on the rate of respiration in yeast.

He set up a tube with yeast in glucose solution and added bromothymol blue. Bromothymol blue changes from blue to yellow when carbon dioxide is produced.

To determine the rate of respiration, he timed how long it took for the solution to change from blue to yellow.

Suggest:

- why the method the second student used would be less accurate than the method the first student used
- how the accuracy of the method the second student used could be improved.

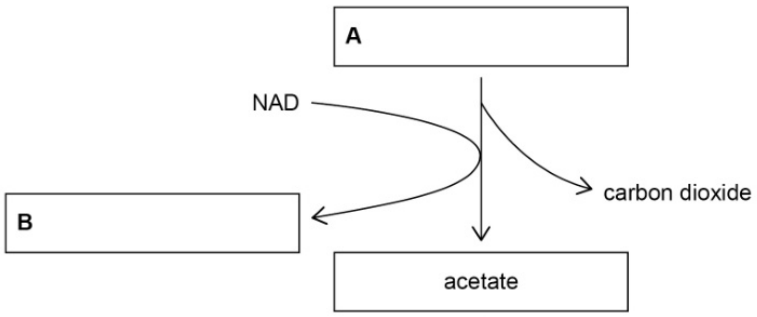
**[2 marks]**

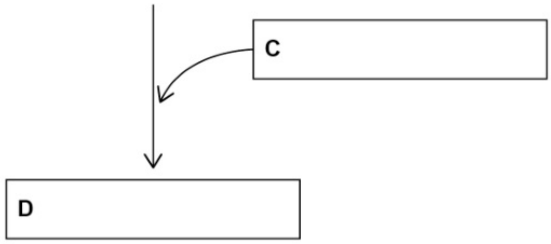
This method would be less accurate because

The accuracy of this method could be improved by

**0 2 . 5** Complete the boxes **A** to **D** in **Figure 4** to show the link reaction. box

**Figure 4**






[2 marks]

9

## Question 7

**Section B**

Answer **one** question.

You are advised to spend no more than 45 minutes on this section.

Do not write outside the box

**0 7** Write an essay on **one** of the topics below.

**Either**

**0 7 . 1** The importance of complementary shapes of molecules in organisms

**[25 marks]**

**Or**

**0 7 . 2** The importance of ions in metabolic processes

**[25 marks]**

Do not write outside the box

Do not write outside the box

*Do not write outside the box*

*Do not write outside the box*

*Do not write outside the box*

*Do not write outside the box*

*Do not write outside the box*

*Do not write outside the box*

**END OF QUESTIONS**