Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____
I declare this is my own work.

A-level
BIOLOGY

Paper 2

Friday 16 June 2023 | Morning | Time allowed: 2 hours

Materials
For this paper you must have:
- a ruler with millimetre measurements
- a scientific calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for the questions are shown in brackets.
- The maximum mark for this paper is 91.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

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

0 1 . 1 A student used chromatography to separate the different photosynthetic pigments in a chlorophyll solution. She had the following materials.

Chromatography paper
A ruler and pencil
Suitable glassware
A solvent (solvent **A**)
2 cm^3 of the chlorophyll solution

Describe how she could use these materials to separate the photosynthetic pigments by chromatography.

[4 marks]

0 1 . 2 Using solvent **A**, the student separated five pigments. She then repeated her method using a different solvent, **B**. Using solvent **B**, she separated six pigments.

Explain the difference between these results.

[2 marks]

6

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0 2 . 1 Glutamate is a neurotransmitter involved in the transmission of nerve impulses from pain receptors to the brain. Ziconotide is a drug that can reduce severe, constant pain. Ziconotide blocks the calcium ion channels at some of the synapses which use glutamate.

The transmission of glutamate at synapses is similar to that of acetylcholine.

Explain how ziconotide reduces severe, constant pain.

[5 marks]

Ziconotide is a polypeptide and acts on synapses in the spinal cord. Scientists investigated the effectiveness of ziconotide in reducing severe, constant pain.

Ziconotide was injected into each patient's cerebrospinal fluid that bathes the brain and spinal cord. Patients recorded the intensity of their pain using a statistically valid scale.

0 2 . 2 Suggest **two** reasons why the patients had ziconotide injected into their cerebrospinal fluid rather than taking a pill containing the drug.

[2 marks]

1

2

Question 2 continues on the next page

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0 2 . 3 Ziconotide was injected at 3 ng kg^{-1} h^{-1} for 8 days into each patient.

1 ng = 1×10^{-9} g

Calculate the total mass in grams of ziconotide injected after 8 days into a patient with a body mass of 82 kg

Show your working.

[2 marks]

Answer _____ g

0 2 . 4 When the patients recorded the intensity of pain, suggest **two** reasons why it was important to use a statistically valid scale.

[2 marks]

1 _____

_____

2 _____

_____

11

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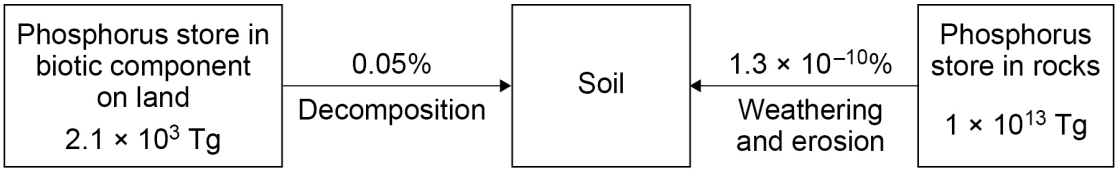
0 3 **Figure 1** shows part of a phosphorus cycle, including the mass of phosphorus in two stores.

Figure 1



One teragram (Tg) is 1×10^{12} grams.

The supply of phosphorus to the soil is shown as a percentage of the total phosphorus mass of each store.

0 3 . 1 Calculate in teragrams the difference in the supply of phosphorus to the soil from the two stores shown in **Figure 1**.

Show your working.

[2 marks]

Answer _____ Tg

Question 3 continues on the next page

Do not write outside the box

Water shortage can inhibit crop production. Scientists investigated the effect of the mycorrhizal species *Glomus intraradices* on the growth of tomato plants under conditions of water shortage and **no** water shortage.

- The scientists planted tomato seeds into a large number of pots containing sterilised soil.
- They added a culture of *G. intraradices* to 50% of the pots and 50% were left untreated.
- After the seeds had developed into seedlings (young plants), the seedlings from the untreated and treated pots were planted into four separate large greenhouses (glasshouses).
- A very limited supply of water (water shortage) was provided to two of the greenhouses. A sufficient supply of water (**no** water shortage) was provided to the other two greenhouses.
- After 60 days, the scientists determined the mean mass of tomatoes (kg m^{-2}) from each greenhouse.

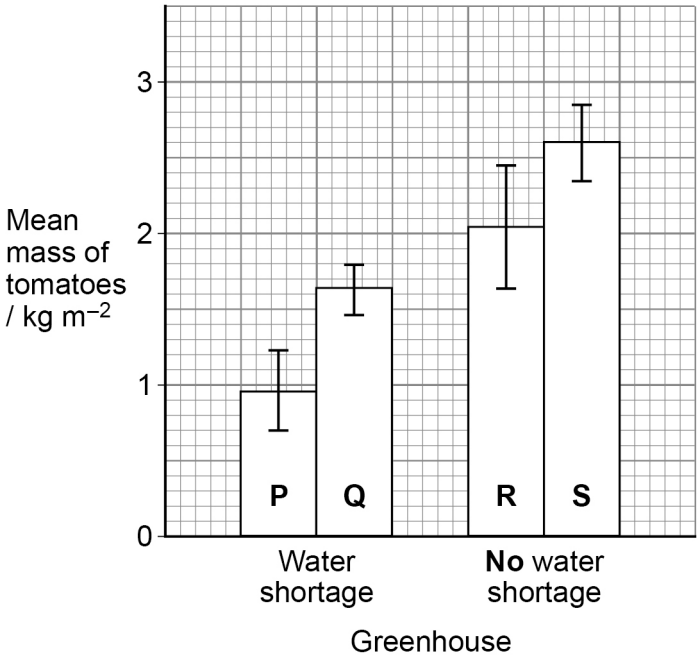
Greenhouse **P** – untreated seedlings with water shortage
Greenhouse **Q** – treated seedlings with water shortage
Greenhouse **R** – untreated seedlings with **no** water shortage
Greenhouse **S** – treated seedlings with **no** water shortage

Treated seedlings are plants grown with *G. intraradices*.

Figure 2 shows the scientists' results.

The error bars represent ± 2 standard deviations from the mean, which includes over 95% of the data.

Figure 2



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0 3 . 2 Using all the information, evaluate the effectiveness of using mycorrhizae to increase crop production under conditions of water shortage and **no** water shortage.

[5 marks]

Do not write outside the box

0 3 . 3 The tomato seeds were planted into sterilised soil.

Suggest **two** reasons why the soil was sterilised.

[2 marks]

1 _____

_____

2 _____

_____

0 3 . 4 The soil used in this investigation had the recommended concentration of fertiliser.

Suggest **two** reasons why the soil contained the recommended concentration of fertiliser.

[2 marks]

1 _____

_____

2 _____

_____

11

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Turn over for the next question

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0 4 In cats, males are XY and females are XX. A gene on the X chromosome controls fur colour in cats. The allele **G** codes for ginger fur and the allele **B** codes for black fur. These alleles are codominant. Heterozygous females have ginger and black patches of fur and their phenotype is described as tortoiseshell female.

The two alleles, **F** and **f** of a different gene, which is **not** sex-linked, interact with the gene controlling fur colour. The allele **F** is dominant and stops the formation of pigment in the fur, resulting in white fur. The allele **f** is recessive and has no effect on fur colour.

0 4 . 1 Name the type of interaction between the two genes affecting fur colour.

[1 mark]

_____

0 4 . 2 What phenotype would a cat with the following genotype have?

[1 mark]

$\mathbf{X^G X^B ff}$ _____

0 4 . 3 Complete the genetic diagram to show all the possible genotypes and the ratio of phenotypes expected in the offspring of this cross.

[3 marks]

Phenotypes of parents $\mathbf{X^G X^G Ff}$ x $\mathbf{X^B Yff}$

Genotypes of offspring _____

Phenotypes of offspring _____

Ratio of offspring phenotypes _____

Do not write outside the box

0 4 . 4 In a population, 36% of cats had the **F** allele and had white fur.

Use the Hardy–Weinberg equation to calculate the frequency of the **f** allele in this population.

Show your working.

[2 marks]

Answer _____

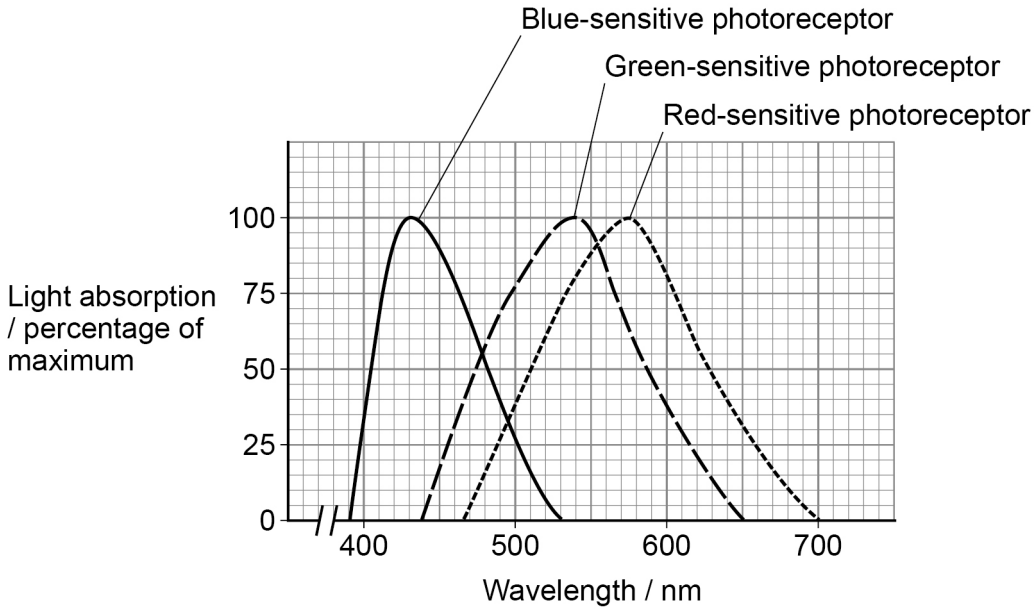
7

Turn over for the next question

Do not write outside the box

0 5 . 1 **Figure 3** shows the wavelengths of light absorbed by three types of photoreceptor found in the human retina.

Figure 3



Use **Figure 3** and your knowledge of colour vision to explain how an orange colour is seen at 600 nm

[3 marks]

Do not write outside the box

0 5 . 2 Which of the following statements is associated with high sensitivity to light in the retina?

Tick (✓) **one** box.

[1 mark]

A single photoreceptor connecting to one neurone and spatial summation ☐

A single photoreceptor connecting to one neurone and temporal summation ☐

Several photoreceptors connecting to one neurone and spatial summation ☐

Several photoreceptors connecting to one neurone and temporal summation ☐

Question 5 continues on the next page

Do not write outside the box

0 5 . 3 Variation in flower colour is considered one of the factors involved in the evolution of the following two species of monkeyflower.

- *Erythranthe lewisii* (Great Purple Monkeyflower), which has pink flowers, is mostly found at higher altitudes (1600 to 3000 metres) and attracts bumblebees.
- *Erythranthe cardinalis* (Scarlet Monkeyflower), which has red flowers, is mostly found at lower altitudes (up to 2000 metres) and attracts hummingbirds.

Bumblebees and hummingbirds are important in the pollination of flowers. Pollination involves the transfer of male gametes to female gametes.

Explain the different processes that may have been involved in the evolution of these two species of monkeyflower. Use the information provided to justify your answer.

[5 marks]

9

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ANSWER IN THE SPACES PROVIDED

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0 6 . 1 Describe and explain how **three** features of the cells in the proximal convoluted tubule allow the rapid reabsorption of glucose into the blood.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

0 6 . 2 Antidiuretic hormone (ADH) binds to **V** receptors found in cell-surface membranes in two parts of a nephron.

Name the **two** parts of a nephron where **V** receptors are found.

[1 mark]

_____

_____

0 6 . 3 **V** receptors only bind with ADH.

Suggest and explain why.

[2 marks]

_____

_____

_____

_____

Do not write outside the box

0 6 . 4 A decrease in blood pressure stimulates the release of ADH.

Give the location of the receptors that detect a decrease in blood pressure and explain how the release of ADH will affect blood pressure.

[3 marks]

Location _____

Explanation _____

_____

_____

_____

_____

9

Turn over for the next question

Do not write outside the box

0 7 . 1 In the following passage, the numbered spaces can be filled with biological terms.

An ecosystem supports a certain size of population of a species, called the ____(1)____ capacity. There are often numerous habitats within an ecosystem. Within a habitat, a species occupies a ____(2)____ governed by an adaption to both ____(3)____ and biotic conditions. Populations of different species form a ____(4)____ .

Write the correct biological term beside each number below that matches the space in the passage.

[2 marks]

1 _____

2 _____

3 _____

4 _____

0 7 . 2 Suggest **two** reasons for conserving rainforests.

[2 marks]

1 _____

_____

2 _____

_____

0 7 . 3 Give **three** reasons for the low efficiency of energy transfer from secondary consumers to tertiary consumers in an ecosystem.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

7

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 8 . 1 The *KRAS* gene codes for a protein called K-Ras. The protein relays signals from outside a cell to a cell's nucleus, stimulating cell division. An alteration in the *KRAS* gene produces an oncogene which can cause a tumour to develop.

Suggest and explain how an alteration in the *KRAS* gene can cause a tumour to develop.

[3 marks]

0 8 . 2 Alterations in the *KRAS* gene can cause colorectal cancer (CRC). Scientists investigated the survival time of the following three groups of CRC patients who had type II diabetes.

Group **A** – received no drug to treat type II diabetes
Group **B** – received the drug metformin to treat type II diabetes
Group **C** – received a combination of drugs (including metformin) to treat type II diabetes

The scientists used a statistical test to compare the survival time of these patients with CRC patients with no history of type II diabetes.

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Table 1 shows some of the results obtained by the scientists.

Table 1

Group	Mean survival time of CRC patients / months	Probability value (P)
No history of type II diabetes	32.2	–
A	21.3	0.007
B	49.7	0.022
C	38.3	0.636

Using the information provided, what can you conclude about the effects of type II diabetes and the different drug treatments on the survival time of CRC patients?

[5 marks]

8

Turn over for the next question

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0 9 Short tandem repeats (STRs) are short sequences of DNA, usually 2 to 7 base pairs. STRs are repeated a number of times, one after another. For example, the STR D5S818 is made up of AGAT repeated 7 to 16 times.

STRs are found throughout the whole genome.

The repeated sequences in STRs are common to all humans. Due to variation in the number of repeats, STRs can be used in genetic fingerprinting.

0 9 . 1 Describe how STRs could be removed from a sample of DNA.

[2 marks]

0 9 . 2 Genetic fingerprinting using STRs requires amplification of the STRs using the polymerase chain reaction (PCR). The short base sequences either side of a specific STR are known.

Explain the importance of knowing these base sequences in PCR.

[2 marks]

Do not write outside the box

0 9 . 3 A single STR molecule consisting of a 12 **base pair** sequence of AGAT was amplified 50 times using PCR.

Calculate the total number of base pairs in all the STR molecules after 50 cycles of PCR.

Show your working.

[2 marks]

Answer _____

0 9 . 4 During genetic fingerprinting, the different STRs are separated by gel electrophoresis.

Give **two** features of STRs which enable them to be separated by gel electrophoresis.

[2 marks]

1 _____

_____

2 _____

_____

8

Turn over for the next question

Do not write outside the box

1 0 Read the following passage.

ATP is essential for muscle contraction. The concentration of ATP in skeletal muscle is approximately 5×10^{-3} mmol g^{-1}. During maximum exercise, ATP in skeletal muscle is used at a rate of approximately 3.7 mmol kg^{-1} s^{-1}. If ATP was not resynthesised, maximum exercise would last a short time.

Some studies have suggested that taking creatine supplements can improve muscle performance during intense short-term exercise. Eating more carbohydrate, known as 'carbohydrate loading', for a few days before exercise can improve muscle performance when exercising for a long time. 5

During aerobic exercise, calcium ions in muscle cells have several roles. They activate the inclusion of glucose transport proteins, GLUT4, in the cell-surface membrane and the inclusion of fatty acid transport proteins, CD36, in mitochondrial membranes. An increase in muscle activity increases the concentration of carbon dioxide in the blood. This causes an increase in heart rate. 10

Use the information in the passage and your own knowledge to answer the following questions.

1 0 . 1 ATP is essential for muscle contraction (line 1).

Describe the roles of ATP in muscle contraction.

[2 marks]

_____

_____

_____

_____

_____

_____

1 0 . 2 Calculate how long maximum exercise would last if ATP was not resynthesised (lines 3–4).

[1 mark]

Answer _____ s

Do not write outside the box

1 0 . 3 Describe and explain how taking creatine supplements (lines 5–6) and 'carbohydrate loading' (lines 6–7) can improve performance of different types of muscle fibres during different types of exercise.

[5 marks]

Question 10 continues on the next page

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1 0 . 4 Suggest and explain how GLUT4 and CD36 transport proteins (lines 10–11) are beneficial during exercise.

[3 marks]

1 0 . 5 An increase in muscle activity causes an increase in heart rate (lines 12–14).

Describe and explain how.

[4 marks]

15

END OF QUESTIONS

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