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 13 June 2025 | 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	

Do not write outside the box

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

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

Glycolysis is the first stage of respiration. It occurs in the ____(1)____ of cells and is an anaerobic process. Glycolysis involves the ____(2)____ of glucose to glucose phosphate, using ATP. The oxidation of triose phosphate to ____(3)____ results in the net gain of ATP and reduced ____(4)____ .

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

[2 marks]

1 _____

2 _____

3 _____

4 _____

0 1 . 2 The equation for the aerobic respiration of glucose is:

$$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O$$

Six carbon dioxide molecules are produced from each glucose molecule.

Use your knowledge of the link reaction **and** Krebs cycle to explain why.

[2 marks]

_____

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Do not write outside the box

0 1 . 3 An inhibitor of the electron transfer chain was added to aerobically respiring yeast cells.

As aerobic respiration was inhibited, the following changes occurred:

- oxygen uptake decreased
- ATP production decreased
- ethanol was produced.

Explain the changes in the yeast cells following the addition of the inhibitor.

[3 marks]

Oxygen uptake decreased _____

_____

_____

ATP production decreased _____

_____

_____

Ethanol was produced _____

_____

_____

7

Turn over for the next question

Do not write outside the box

0 2 . 1 What term is used to describe the maintenance of a stable internal environment?

[1 mark]

_____

0 2 . 2 A high blood glucose concentration can cause dehydration of body cells.

Explain why.

Do **not** refer to ADH or the role of the kidneys in your answer.

[2 marks]

_____

_____

_____

_____

_____

_____

0 2 . 3 The hormone glucagon is involved in maintaining a stable blood glucose concentration.

Which is **not** a result of the action of glucagon?

Tick (✓) **one** box.

[1 mark]

Activation of a protein kinase enzyme ☐

Activation of cyclic AMP hydrolysis ☐

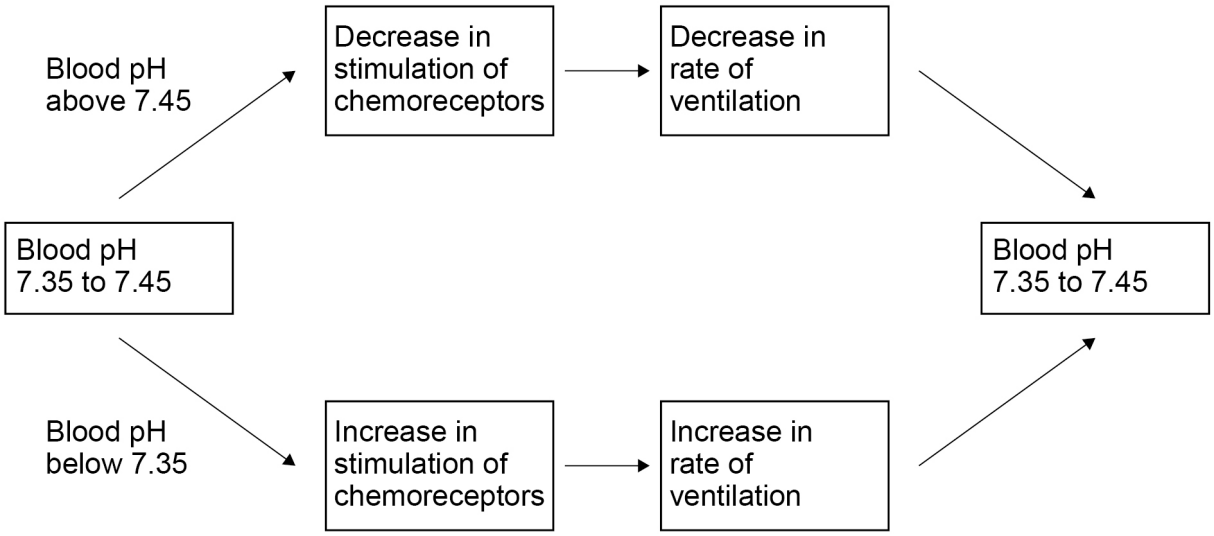
Gluconeogenesis ☐

Glycogenolysis ☐

Do not write outside the box

0 2 . 4 **Figure 1** shows one of the physiological systems involved in controlling blood pH.

Figure 1



Use the information in **Figure 1** to outline the principles of negative feedback.

[2 marks]

0 2 . 5 Vigorous exercise causes a change in blood pH and in the rate of ventilation.

Use **Figure 1** to describe and explain these changes.

[2 marks]

8

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0 3 . 1 A student determined the dry mass of lettuce leaves. The equipment used was an oven and a weighing balance.

Describe how the student could use this equipment to determine the dry mass of lettuce leaves.

[2 marks]

_____

_____

_____

_____

_____

_____

0 3 . 2 The student then used a calorimeter to determine the chemical energy stored in a sample of lettuce leaves with a dry mass of 1.50 g

The 1.50 g sample was fully combusted in a calorimeter.

The volume of water in the calorimeter was 150 cm^3

The increase in temperature of the water was 18.2 °C

4.18 J of heat energy are required to increase the temperature of 1 cm^3 of water by 1 °C

Use this information to calculate the heat energy released, in kJ g^{-1}, of dry mass of lettuce leaves.

Show your working.

[2 marks]

Answer _____ kJ g^{-1}

Do not write outside the box

0 3 . 3 Biomass can be measured as the dry mass of tissue per given area. Some crop plants are grown in large greenhouses (glasshouses) where optimum growing conditions can be maintained.

Growing crop plants at higher temperatures than their optimum temperature can decrease their biomass.

Use your knowledge of net primary production to explain why.

[2 marks]

_____

_____

_____

_____

_____

_____

6

Turn over for the next question

Do not write outside the box

0 4 . 1 People with the inherited blood disorder haemophilia A (HA) have a reduced ability to clot blood. One variant of HA is due to an inversion mutation in the *F8* gene. This mutation causes the production of a non-functional form of the protein, factor VIII. Factor VIII is **not** an enzyme.

Explain how an inversion mutation can cause the production of non-functional factor VIII.

[4 marks]

0 4 . 2 Currently, the most effective treatment for HA is weekly or monthly injections of factor VIII. Scientists investigated the effectiveness of a gene therapy product, Roctavian, as a treatment for HA. Roctavian contains a viral vector that has the DNA coding for factor VIII.

The scientists:

- selected 112 male volunteers with severe HA, who were at least 18 years of age
- treated each volunteer with a single injection of Roctavian into their blood
- recorded the number of bleeding episodes (internal bleeding) in these volunteers over a two-year period (set **A** results)
- compared these data with the number of bleeding episodes per year in the volunteers **before** receiving Roctavian (set **B** results).

Do not write outside the box

Table 1 shows the scientists' results.

A value of ±2 × SD from the mean includes over 95% of the data.

Table 1

Volunteer set	Mean number of bleeding episodes per year (±2 × SD)
A (Received Roctavian)	0.8 ± (1.2)
B (Received factor VIII)	4.8 ± (0.6)

Use all the information provided to evaluate the use of Roctavian as a treatment for HA.

[5 marks]

Question 4 continues on the next page

Do not write outside the box

0 4 . 3 Haemophilia C is an **autosomal** recessive condition.

Two parents are both heterozygous for the haemophilia C allele.

Calculate the probability of these parents producing a son who has haemophilia C.

[1 mark]

Probability = _____

10

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 5 . 1 Explain what is meant by the term **phenotype**.

[2 marks]

0 5 . 2 In genetic crosses, the observed phenotypic ratios obtained in the offspring are often **not** the same as the expected ratios.

Suggest **two** reasons why.

Do **not** refer to sex-linkage or autosomal linkage in your answer.

[2 marks]

1

2

Do not write outside the box

0 5 . 3 In sweet pea plants, the **F** allele for purple flowers is dominant to the **f** allele for red flowers. The **L** allele for long pollen is dominant to the **l** allele for round pollen.

A scientist carried out a genetic cross between a plant with purple flowers and long pollen (heterozygous for both genes) and a plant with red flowers and round pollen.

Table 2 shows the results of this cross.

Table 2

Phenotype of offspring	**Percentage of total offspring**
Purple flowers and long pollen	48.6
Red flowers and round pollen	47.5
Purple flowers and round pollen	2.1
Red flowers and long pollen	1.8

Use your knowledge of autosomal linkage to explain the results in **Table 2**.

Your answer should include:

- an explanation of what is meant by autosomal linkage
- a comment about the relative proportions of the different genotypes of gametes produced in this cross.

[3 marks]

7

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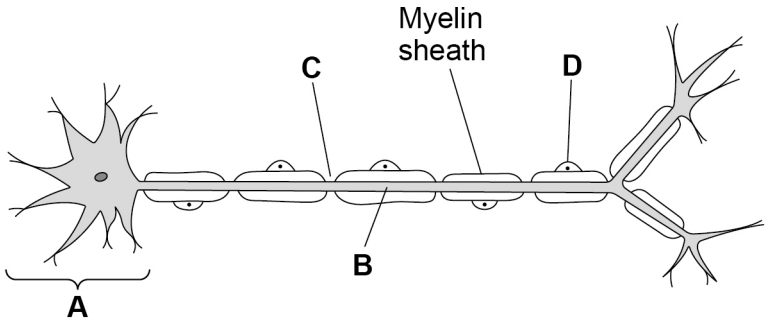
0 6 . 1 **Figure 2** shows a drawing of a myelinated motor neurone.

Figure 2



Name the parts labelled **A** to **D**.

[2 marks]

A _____

B _____

C _____

D _____

0 6 . 2 Osmotic demyelination syndrome (ODS) results in destruction of the myelin sheath of neurones in the brain.

ODS can **increase** reflex response times.

Explain why.

[3 marks]

_____

_____

_____

_____

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Do not write outside the box

0 6 . 3 The parasympathetic nervous system (PNS) uses acetylcholine as its neurotransmitter. Atropine is an anticholinergic drug that attaches to postsynaptic receptors.

Atropine can be used to increase the heart rate in patients with bradycardia (a slower than normal heart rate).

Use the information provided to explain how atropine causes an increase in the heart rate.

[3 marks]

Question 6 continues on the next page

Do not write outside the box

0 6 . 4 One study has suggested that the atropine dosage for severely obese male patients should be 0.01 mg kg^{-1} of lean body weight (LBW).

LBW is determined by using this equation.

$$\text{LBW} = \frac{9.27 \times 10^3 \times \text{TBW}}{(6.68 \times 10^3) + (216 \times \text{BMI})}$$

where TBW = total body weight
BMI = body mass index

Calculate the suggested dosage of atropine, in mg, for a severely obese male patient whose:

- TBW = 115.2 kg
- BMI = 41

Give your answer to 3 significant figures.

Show your working.

[2 marks]

Answer _____ mg

10

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 7 . 1 **Figure 3** shows *Gammarus pulex*, commonly known as a freshwater shrimp.

Figure 3

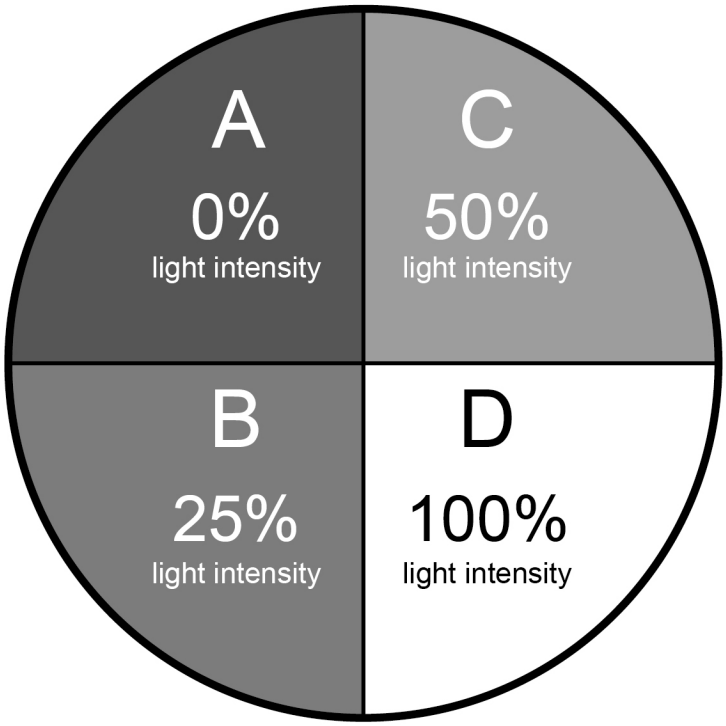
A student used a choice chamber to investigate the effect of light intensity on the movement of *G. pulex*.

The student:

- collected 30 shrimps from a freshwater stream
- added freshwater and gravel substrate from the same stream to each segment
- used layers of black paper on the lid of the choice chamber to reduce the percentage light intensity in 3 segments of the choice chamber as shown in **Figure 4**
- placed 30 shrimps at the centre of the choice chamber
- waited 10 minutes before counting the number of shrimps in each segment.

Do not write outside the box

Figure 4



The student stated that 'the procedure used in this investigation helps to ensure the validity of any conclusions made'.

Suggest and explain **three** features of this investigation that justify this statement.

[3 marks]

1 _____

_____

_____

2 _____

_____

_____

3 _____

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_____

Question 7 continues on the next page

Do not write outside the box

0 7 . 2 **Table 3** shows the student's results.

Table 3

Segment of choice chamber	Percentage light intensity	Number of *G. pulex* counted after 10 minutes
A	0	15
B	25	8
C	50	4
D	100	3

The student observed directional movement by *G. pulex*.

Name the type of behaviour shown by *G. pulex* **and** suggest an advantage to *G. pulex* of this behaviour.

Use the information in **Table 3** in your answer.

[2 marks]

Type of behaviour _____

Advantage _____

_____

_____

Do not write outside the box

0 7 . 3 The student analysed the results in **Table 3** using the chi-squared test (χ^2) and calculated a χ^2 value of 11.87

Table 4 shows the critical values of χ^2 at different probability (**P**) values for different degrees of freedom.

Table 4

	Critical values of χ^2 at different **P** values				
Degrees of freedom	**P = 0.95**	**P = 0.5**	**P = 0.05**	**P = 0.01**	**P = 0.005**
1	0.00	0.46	3.84	6.64	7.88
2	0.10	1.39	5.99	9.21	10.60
3	0.35	2.37	7.82	11.35	12.84
4	0.71	3.36	9.49	13.28	14.86
5	1.15	4.35	11.07	15.09	16.75

State a null hypothesis for this investigation **and** explain why the χ^2 test was the appropriate statistical test to use.

[2 marks]

Null hypothesis _____

_____

_____

Explanation for using a χ^2 test _____

_____

_____

Question 7 continues on the next page

Do not write outside the box

0 7 . 4 Using the calculated χ^2 value of 11.87 and the information in **Table 4**, what can you conclude from this investigation?

You should include the terms **probability** and **chance** in your answer.

[4 marks]

11

Do not write outside the box

0 8 . 1 A study of cells from a human embryo found that 2.66×10^{-7} % of the genome of one cell had changed due to mutation.

You can assume that:

- the genome contains 3×10^{9} nucleotides
- the mean rate of mutation is 1.14 mutations per cell cycle
- the cell cycle lasts 24 hours.

Use this information to calculate the age of the embryo in days.

Show your working.

[2 marks]

Answer _____ days

The genome of the bacterium *Escherichia coli* is approximately 4.6 million base pairs in length and contains around 4000 genes.

0 8 . 2 The analysis of the genome of *E. coli* allows the proteome to be determined more easily than that of eukaryotes.

Explain why.

[2 marks]

_____

_____

_____

_____

_____

_____

Question 8 continues on the next page

Do not write outside the box

0 8 . 3 Determining the proteomes of bacteria has helped provide protection for individuals and populations against some infectious diseases.

Explain how.

[2 marks]

Scientists investigated the relationship between one type of variable number tandem repeat (VNTR) and the risk of breast cancer occurring in women.

The scientists determined the risk of breast cancer occurring in women:

- with 2, 3 or 4 repeats of the VNTR
- **without** the VNTR.

They calculated the odds ratio (OR) of breast cancer occurring with 2, 3 or 4 repeats of the VNTR.

An OR is a measure of how strongly an outcome is associated with a risk factor.

The OR formula is:

risk of breast cancer occurring **with** the VNTR : risk of breast cancer occurring **without** the VNTR

Table 5 shows the scientists' results.

Table 5

Number of VNTR repeats	Odds ratio
2	0.55 : 1
3	1.58 : 1
4	1.94 : 1

Do not write outside the box

0 8 . 4 A student concluded that the number of repeats of the VNTR is associated with the risk of breast cancer occurring in women.

Evaluate the student's conclusion.

[4 marks]

10

Turn over for the next question

Do not write outside the box

0 9 Cystic fibrosis (CF) is a recessive inherited disorder caused by a defective *CFTR* gene.

Table 6 shows the number of people with CF and the estimated population of the UK in 2020 and 2022.

Table 6

Year	Number of people with CF	Estimated population of the UK × 10^6
2020	10 837	67.06
2022	11 148	67.51

0 9 . 1 Calculate how many more people had CF than was expected in 2022.

You can assume the relative frequency of CF in a population remains constant.

Show your working.

[2 marks]

Additional number of people _____

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Question 9 continues on the next page

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ANSWER IN THE SPACES PROVIDED

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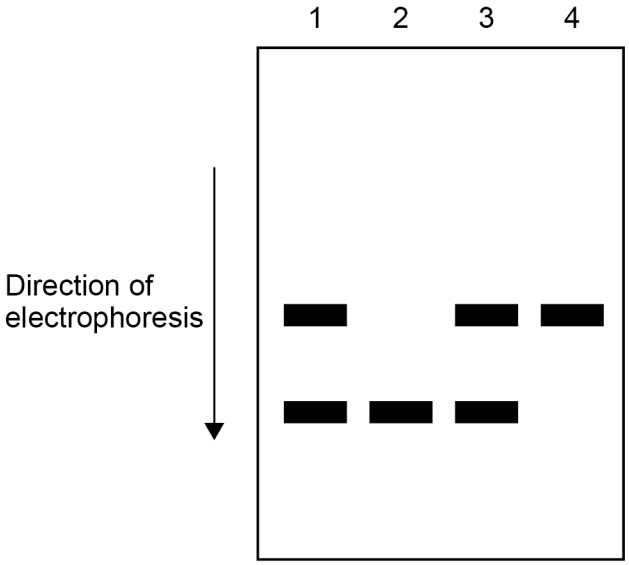
CF can be caused by a three-base deletion mutation in the *CFTR* gene. This deletion creates a recessive allele called F508del.

DNA probes and gel electrophoresis were used to screen two parents and their two children for the F508del allele. One of the children was diagnosed with CF.

Figure 5 shows the results.

Figure 5



0 9 . 2 What is a DNA probe?

[2 marks]

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0 9 . 3 The identity of each family member can be determined from the relative position of the bands shown in **Figure 5**.

Use information in **Figure 5** to:

- complete **Table 7**
- explain how you identified the child with CF.

You can use **F** to represent the dominant *CFTR* allele and **f** to represent the recessive F508del *CFTR* allele.

[3 marks]

Table 7

Lanes	Parent or child	Genotype
1		
2		
3		
4		

Explanation _____

_____

_____

_____

_____

7

Turn over for the next question

Do not write outside the box

1 0 Read the following passage.

Tropical rainforests are among the most biologically diverse ecosystems in the world. Their varied plant communities support a high biodiversity of animal species. Tropical rainforests form in parts of the world with high annual rainfall and high mean temperatures providing moist, warm conditions. Nutrient recycling occurs rapidly on the ground of these rainforests. The recycling of nitrogen-containing compounds from dead organic matter sustains the growth of plants.

Each year, large areas of rainforests are lost due to fires. Natural regeneration of rainforests occurs slowly by secondary succession. Secondary succession is similar to primary succession but occurs in areas previously inhabited. There is conflict between the needs of humans and conservation of rainforests. Deforestation by humans is removing large areas of rainforests. Farming practices have prevented the natural regeneration of rainforests by secondary succession.

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

1 0 . 1 In tropical rainforests, there is a high biodiversity of animal species (lines 1–3).

Explain why.

[3 marks]

Do not write outside the box

1 0 . 2 Nutrient recycling occurs rapidly on the ground of tropical rainforests (lines 4–5).

Explain how **two** abiotic factors in these rainforests enable the rapid rate of recycling.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

1 0 . 3 The recycling of nitrogen-containing compounds from dead organic matter sustains the growth of plants (lines 5–7).

Describe the roles of bacteria in this recycling.

[4 marks]

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Question 10 continues on the next page

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1 0 . 4 Natural regeneration of rainforests occurs by secondary succession (lines 8–10).

Describe the process of secondary succession.

[4 marks]

1 0 . 5 Farming practices have prevented the natural regeneration of rainforests by secondary succession (lines 12–14).

Suggest **two** farming practices that prevent the natural regeneration of rainforests by secondary succession.

[2 marks]

1

2

15

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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