

**Biology B**

**Advanced**

**PAPER 1: Advanced Biochemistry, Microbiology and Genetics**

**Wednesday 5 June 2024 – Afternoon**

**Time: 1 hour 45 minutes**

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|--------------------|
| <b>Total Marks</b> |
|--------------------|

In the boxes below, write your name, centre number and candidate number.

|                         |  |  |  |  |  |
|-------------------------|--|--|--|--|--|
| <b>Surname</b>          |  |  |  |  |  |
| <b>Other names</b>      |  |  |  |  |  |
| <b>Centre Number</b>    |  |  |  |  |  |
| <b>Candidate Number</b> |  |  |  |  |  |

## **YOU MUST HAVE**

**Scientific calculator, writing and drawing equipment, ruler**

## **YOU WILL BE GIVEN**

**Diagram Booklet**

## **INSTRUCTIONS**

**Answer ALL questions.**

**Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet – there may be more space than you need.**

## **INFORMATION**

**The total mark for this paper is 90.**

**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.**

**There may be spare copies of some diagrams.**

**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.**

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**Answer ALL questions.**

**Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.**

- 1 Blood is pumped around the body in blood vessels to supply cells with nutrients and oxygen.**
- (a) Look at the table for Question 1(a) in the Diagram Booklet. Which box in each row of the table shows where endothelial cells and valves are found?  
(2 marks)**
- (b) Nutrients and oxygen pass into cells from tissue fluid.**

**Explain how tissue fluid is formed.  
(2 marks)**

**Answer space continues on the next page.**

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**Turn over**

**1(b) continued.**

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**(Total for Question 1 = 4 marks)**

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**2 Glucose is a monosaccharide that is found in sucrose, amylose and amylopectin.**

**(a) Sucrose is made from glucose and one other molecule.**

**Which row of the table gives the name of this molecule and the type of reaction that joins the two molecules together?**

**(1 mark)**

|                                   | <b>Name of molecules</b> | <b>Type of reaction</b> |
|-----------------------------------|--------------------------|-------------------------|
| <input type="checkbox"/> <b>A</b> | fructose                 | condensation            |
| <input type="checkbox"/> <b>B</b> | fructose                 | hydrolysis              |
| <input type="checkbox"/> <b>C</b> | galactose                | condensation            |
| <input type="checkbox"/> <b>D</b> | galactose                | hydrolysis              |

**(continued on the next page)**

**(b) Compare and contrast the structure of amylose and amylopectin.**  
**(3 marks)**

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

**(Total for Question 2 = 4 marks)**

**3 Viruses can replicate using the lytic cycle.**

**Viruses can be grown in a laboratory by culturing them with appropriate cells.**

- (a) Explain why viruses have to be cultured with 'appropriate cells'.  
(2 marks)**

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**(continued on the next page)**

**3 continued.**

**(b) Look at the graph for Question 3(b) in the Diagram Booklet. It shows the changes in the number of viruses after they had been added to the cells.**

- (i) Explain why the number of viruses did not start to increase until after 20 minutes.  
(3 marks)**

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**Turn over**

**3(b)(i) continued.**

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**3(b) continued.**

- (ii) Calculate how many more viruses are present at 70 minutes than at 50 minutes.**

**Give your answer to THREE  
SIGNIFICANT FIGURES.  
(2 marks)**

**Answer \_\_\_\_\_**

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

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**Turn over**

**4**    **Photosynthesis results in the production of GALP. This molecule is used by plants to produce glucose and other organic molecules.**

**(a)    Glucose consists of the elements of carbon, hydrogen and oxygen.**

**Name the inorganic molecules that supply these elements for photosynthesis.**

**(2 marks)**

**Carbon**

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**Hydrogen**

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**Oxygen**

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**(continued on the next page)**

**Turn over**

4 continued.

- (b) Light is essential for photosynthesis. It is needed for photolysis and for the excitation of electrons in the photosystems.

Which row in the table shows where photolysis and the excitation of electrons occurs?

(1 mark)

|                            | <b>Photolysis</b>  | <b>Excitation of electrons</b> |
|----------------------------|--------------------|--------------------------------|
| <input type="checkbox"/> A | stroma             | stroma                         |
| <input type="checkbox"/> B | stroma             | thylakoid membrane             |
| <input type="checkbox"/> C | thylakoid membrane | stroma                         |
| <input type="checkbox"/> D | thylakoid membrane | thylakoid membrane             |

(continued on the next page)

**4 continued.**

- (c) Scientists have developed an experimental technique that uses artificial photosynthesis.**

**Electricity generated from solar panels was used to convert carbon dioxide and water into the organic compound acetate.**

**Plants were then able to grow in the dark using the acetate.**

- (i) Explain why these plants were able to grow in the dark.  
(3 marks)**

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**4(c)(i) continued.**

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**4(c) continued.**

- (ii) The scientists hope that this technique will be able to produce plant-based food.**

**State ONE advantage of using this method.**

**Give a reason for your answer.**

**(1 mark)**

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**(Total for Question 4 = 7 marks)**

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- 5 Septicaemia is a life-threatening condition that can arise from bacterial infection.**

**(a) In one year, 245 000 people were diagnosed with septicaemia and 49 735 of these people died as a result.**

**Which percentage of people SURVIVED septicaemia in this year?  
(1 mark)**

- ☐ **A    20·3%**
- ☐ **B    25·5%**
- ☐ **C    39·3%**
- ☐ **D    79·7%**

**(continued on the next page)**

5 continued.

- (b) Two types of bacteria that cause septicaemia are **Escherichia coli (E. coli)** and **Staphylococcus aureus (S. aureus)**.

**E. coli** is Gram negative and **S. aureus** is Gram positive.

- (i) Which of the following statements about the cell walls of these bacteria are correct?  
(1 mark)

1. Both bacteria have peptidoglycan (murein) in their cell walls.
2. **S. aureus** has an outer membrane (lipopolysaccharide layer).
3. The cell wall of **E. coli** is thinner than that of **S. aureus**.

- ☐ A 2 only
- ☐ B 3 only
- ☐ C 1 and 2 only
- ☐ D 1 and 3 only

(continued on the next page)

5(b) continued.

(ii) Both **E. coli** and **S. aureus** produce toxins.

**E. coli** produces the same type of toxin as **Salmonella** bacteria.

Which of the following statements about the toxins produced by these bacteria are correct?

(1 mark)

1. **E. coli** produces endotoxins.
2. The toxins produced by **S. aureus** are released only once the bacteria die.
3. The toxins produced by **S. aureus** are components of their cell wall.

- ☐ A 1 only
- ☐ B 2 only
- ☐ C 1 and 2 only
- ☐ D 1, 2 and 3

(continued on the next page)

**5 continued.**

- (c) Vaccines against bacteria are not always effective. The antigens they contain stimulate only a weak immune response.**

**Which of the following types of immune response is stimulated by a vaccine?**

**(1 mark)**

- ☐ **A artificial active**
- ☐ **B artificial passive**
- ☐ **C natural active**
- ☐ **D natural passive**

**(continued on the next page)**

**5 continued.**

- (d) There are currently no vaccines for either *E. coli* or *S. aureus*.**

**Scientists are developing vaccines against *E. coli* and *S. aureus* which can be implanted under the skin.**

**The bacterial antigens are held in a mesh that contains chemicals to attract tissue macrophages.**

**The effect of implantation of these vaccines on the immune response in mice was investigated.**

- (i) Look at the graph for Question 5(d)(i) in the Diagram Booklet. It shows the number of T helper cells in the lymph nodes that drain the part of the body where the vaccine was implanted.**

**Explain the results shown in the graph.  
(3 marks)**

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**5(d)(i) continued.**

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**5(d) continued.**

- (ii) In part of this investigation, mice had the vaccine implanted 35 days before being infected with *E. coli*.**

**A control group that had not received the vaccine was also infected with *E. coli*.**

**The levels of antibody in the blood of both groups of mice were determined.**

**Look at the graph for Question 5(d)(ii) in the Diagram Booklet. It shows these results.**

**Explain the results shown in the graph.  
(3 marks)**

**Answer space continues on the next page.**

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**5(d)(ii) continued.**

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**(Total for Question 5 = 10 marks)**

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6 In a cell, **DNA** is found in both the nucleus and the mitochondria.

(a) Where is **DNA** found in mitochondria?  
(1 mark)

- ☐ A cytoplasm
- ☐ B intermembrane space
- ☐ C matrix
- ☐ D nucleus

(b) Which row of the table describes **DNA** found in the mitochondria?  
(1 mark)

|                            | Shape    | Ratio of phosphodiester bonds : pentose sugars |
|----------------------------|----------|------------------------------------------------|
| <input type="checkbox"/> A | circular | higher than nuclear <b>DNA</b>                 |
| <input type="checkbox"/> B | circular | lower than nuclear <b>DNA</b>                  |
| <input type="checkbox"/> C | linear   | higher than nuclear <b>DNA</b>                 |
| <input type="checkbox"/> D | linear   | lower than nuclear <b>DNA</b>                  |

(continued on the next page)

**6 continued.**

- (c) Gel electrophoresis can be used to analyse the DNA of a person.**

**Look at the diagram for Question 6(c) in the Diagram Booklet. It shows some of the bands produced when the DNA of a family was analysed using gel electrophoresis.**

**Analyse the information to explain the bands found at positions 1 to 5 in this family.  
(4 marks)**

**Answer space continues on the next page.**

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**Turn over**

**6(c) continued.**

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6 continued.

- (d) A mutation in the **tRNA<sup>Lys</sup>** gene in the mitochondria replaces one uracil with a cytosine in the resulting **tRNA** molecule.

Look at the diagram for Question 6(d) in the Diagram Booklet. It shows the position of the uracil that is replaced with cytosine in a **tRNA<sup>Lys</sup>** molecule.

- (i) Name this type of mutation.  
(1 mark)

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6(d) continued.

- (ii) Explain how this mutation could affect the structure of the **tRNA<sup>Lys</sup>** molecule shown in the diagram.  
(2 marks)

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6(d) continued.

- (iii) Explain how this mutation could affect the role of the **tRNA<sup>Lys</sup>** molecule.  
(2 marks)

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(Total for Question 6 = 11 marks)

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- 7 Coal tits, blue tits and great tits are three species of bird found in the UK all year round.

Look at the images for Question 7 in the Diagram Booklet. They show a photograph and a line drawing of a blue tit.

These birds all have mitochondria in their red blood cells.

- (a) More than **90%** of **ATP** is produced by mitochondrial respiration.

- (i) Describe how the remaining **ATP** is produced.  
(2 marks)

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7(a) continued.

- (ii) In the mitochondria, **ATP** is synthesised on the inner mitochondrial membrane.

Leakage of protons ( $\text{H}^+$ ) across the inner mitochondrial membrane reduces **ATP** synthesis and generates more heat. This is called leaked respiration.

Explain why leakage of protons reduces **ATP** synthesis.  
(3 marks)

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**7(a)(ii) continued.**

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**7 continued.**

**(b) Look at the table for Question 7(b) in the Diagram Booklet. It shows some information about adult coal tits, blue tits and great tits.**

**(i) Look again at the image of the blue tit for Question 7 in the Diagram Booklet. Calculate the magnification of the photograph of the blue tit.**

**Measure from the top of the head to the tip of the tail.**

**(1 mark)**

**Answer \_\_\_\_\_**

**7(b) continued.**

- (ii) Look again at the table for Question 7(b) in the Diagram Booklet. Calculate the length from head to tail : mass ratio for the GREAT TIT.**

**Give your answer to ONE DECIMAL PLACE.  
(1 mark)**

**Answer \_\_\_\_\_**

**(continued on the next page)**

**7 continued.**

- (c) The generation of heat by red blood cell mitochondria in these birds in autumn and winter was investigated.**

**The mean air temperature in autumn was  $10.7^{\circ}\text{C}$  and in winter  $7.2^{\circ}\text{C}$**

**Look at the flowchart for Question 7(c) in the Diagram Booklet. It shows some of the stages in this investigation.**

- (i) Explain why well-stocked bird feeders containing nuts were available throughout this investigation.  
(2 marks)**

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**7(c)(i) continued.**

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**7(c) continued.**

**\*(ii) Look at the three graphs for Question 7(c)(ii) in the Diagram Booklet. They show the results of this investigation.**

**Explain the results of this investigation.**

**Use all the information in the question to support your answer.**

**(6 marks)**

**Answer space continues on the next 2 pages.**

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**7(c)(ii) continued.**

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**Turn over**

**7(c)(ii) continued.**

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**(Total for Question 7 = 15 marks)**

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- 8 Changes must occur to mammalian sperm cells as they pass through the female reproductive tract, if successful fertilisation is to take place.

Capacitation results in changes to the sperm cell membrane and increased motility.

The acrosome reaction (**AR**) must follow capacitation but not too soon nor too late.

- (a) Explain why the timing of the **AR** is important for successful fertilisation.  
(3 marks)

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**8(a) continued.**

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8 continued.

- (b) A protein is involved in the timings of capacitation and the **AR**.

This protein exists in two forms: protein **G** and protein **G-P**.

Protein **G-P** results in the stimulation of capacitation and protein **G** results in the inhibition of the **AR**.

Protein **G-P** is located in the midpiece (neck) and flagellum of the sperm.

Protein **G** is located in the head region of the sperm.

The levels of these two forms of protein change just before capacitation, during capacitation and just before the **AR**.

Look at the diagram for Question 8(b) in the Diagram Booklet.

Complete the table to show which form of protein is present and which is absent.

If the protein is present put a tick (✓) in the box and if the protein is absent put a cross (✗) in the box.  
(4 marks)

8 continued.

- (c) In some infertile males, the gene coding for protein **G** is methylated.

Explain why **DNA**-methylation of this gene could result in infertility.

(3 marks)

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**8(c) continued.**

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**8 continued.**

**(d) Scientists have used ‘knockout’ mice to investigate the effect of protein **G** on fertility.**

**(i) State the meaning of the term ‘knockout’ mice, as used in this context.  
(2 marks)**

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**(continued on the next page)**

**8(d) continued.**

- (ii) In an investigation, female mice and ‘knockout’ mice were housed together.**

**Describe how this investigation should be designed to confirm that protein **G** affects fertility.**

**(3 marks)**

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**8(d)(ii) continued.**

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**(Total for Question 8 = 15 marks)**

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- 9 The structure of haemoglobin changes as the embryo develops into a fetus and after the child is born.**
- (a) Look at the graph for Question 9(a) in the Diagram Booklet. It shows the changes in the synthesis of four globin subunits (beta, gamma, delta, epsilon) during these stages of development.**
- (i) Explain why there is no synthesis of globin subunits in the first few days after fertilisation. (3 marks)**

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**9(a)(i) continued.**

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**(continued on the next page)**

**9(a) continued.**

- (ii) Analyse the data to describe conclusions that can be made about globin subunit synthesis during the 14 months following fertilisation.  
(4 marks)**

**Answer space continues on the next page.**

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**9(a)(ii) continued.**

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**(continued on the next page)**

**9(a) continued.**

- (iii) Calculate the rate of decrease in percentage of gamma globin subunit synthesis from 7·6 to 10 months after fertilisation.**

**Give your answer to TWO DECIMAL PLACES with appropriate units.**

**(2 marks)**

**Answer \_\_\_\_\_**

**(continued on the next page)**

**Turn over**

**9 continued.**

**(b) Sickle cell disease (SCD) is an inherited disorder.**

**A new treatment for SCD is being developed that involves genetic modification.**

**Look at the diagram for Question 9(b) in the Diagram Booklet. The flowchart shows some of the stages in this process.**

**(i) There are approximately 67 million people in the UK, 15000 of these people are affected by SCD.**

**Calculate the ratio of the number of people WITHOUT SCD to the number of people WITH SCD in the UK.**

**Express your answer in WHOLE NUMBERS.  
(2 marks)**

**(continued on the next page)**

**9(b)(i) continued.**

**Answer \_\_\_\_\_**

**(continued on the next page)**

9(b) continued.

- \*(ii) The product of the **BCL11A** gene regulates the switch from the synthesis of fetal to adult globin subunits.

Analyse all the information in this question to discuss how this approach could provide a cure for **SCD** and the ethical issues surrounding this treatment.

Use your own knowledge to support your answer.  
(6 marks)

Answer space continues on the next 2 pages.

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Turn over

**9(b)(ii) continued.**

[illegible]

**Turn over**

**9(b)(ii) continued.**

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**(Total for Question 9 = 17 marks)**

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**TOTAL FOR PAPER = 90 MARKS**  
**END OF PAPER**