

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

Total Marks
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**Wednesday 7 June 2023 – Afternoon**

**Time: 1 hour 45 minutes**

**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.**

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

**(continued on the next page)**

**INFORMATION continued.**

**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.**

**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 Plants take up inorganic ions from the soil.**

**These ions include calcium, phosphate and potassium.**

**(a) (i) Name the molecule that contains calcium ions in the cell walls of a plant.  
(1 mark)**

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**(continued on the next page)**

**1(a) continued.**

**(ii) How many of the following statements are correct?**

**(1 mark)**

- **phosphate ions are used to make DNA and RNA**
- **phosphate ions are used in the structure of the cell membrane**
- **the element potassium is part of a peptide bond**

☐ **A none**

☐ **B one only**

☐ **C two only**

☐ **D three**

**(continued on the next page)**

**1 continued.**

- (b) The uptake of potassium ions by plant seedlings in anaerobic and aerobic conditions was investigated.**

**The seedlings were grown in a mineral ion solution containing a low concentration of potassium ions for 30 hours. The conditions were anaerobic for the first 15 hours and aerobic for the second 15 hours.**

**Look at the graph for Question 1(b) in the Diagram Booklet. It shows the results of this investigation.**

**Explain the changes in the concentration of potassium ions in the cells in the roots of the seedlings during this investigation.  
(4 marks)**

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**1(b) continued.**

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**(Total for Question 1 = 6 marks)**

**Turn over**

**2 Living organisms are divided into three domains: Archaea, Bacteria and Eukaryota.**

**(a) Look at the table for Question 2(a) in the Diagram Booklet. It shows some characteristics of organisms in the domain Archaea.**

**Explain why these organisms have NOT been classified in either of the other two domains.  
(2 marks)**

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**(continued on the next page)**

**Turn over**



**2 continued.**

- (b) Some Archaea have the enzyme adenylate kinase (AK).**

**This enzyme is similar to AK enzymes found in humans.**

**There are two types of this enzyme in humans, AK1 and AK3.**

**Look at the table for Question 2(b) in the Diagram Booklet. It gives some information about these two enzymes.**

- (i) The tertiary structures of AK1 and AK3 are very similar but not identical.**

**Analyse the information to deduce why there are two AK enzymes.  
(3 marks)**

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

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**Turn over**

**2(b)(i) continued.**

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**(continued on the next page)**

**2(b) continued.**

- (ii) Some types of Archaea have only one type of AK enzyme.**

**This enzyme can catalyse both the reactions shown in the table.**

**The tertiary structure of this enzyme is different from AK1 and AK3.**

**Explain why Archaea have a different type of AK enzyme.  
(2 marks)**

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

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**2(b)(ii) continued.**

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**(Total for Question 2 = 7 marks)**

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**3 Xylem and phloem tissues transport molecules and ions through plants.**

**(a) Give the meaning of the term TISSUE.  
(1 mark)**

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**(b) Look at the table for Question 3(b) in the Diagram Booklet. It gives some information about the structures of xylem and phloem tissues.**

**For each statement, put ONE cross ☒ in the appropriate box, in each row, to show whether these statements are true for both types of tissue, xylem tissue only, phloem tissue only or neither type of tissue.**

**(3 marks)**

**(continued on the next page)**

**3 continued.**

- (c) Aphids are insects that can be used to study the transport of sugars in the phloem.**

**Look at the diagram for Question 3(c)(i) in the Diagram Booklet. It shows how this is done.**

- (i) Which disaccharide is transported in the phloem?  
(1 mark)**

☐ **A fructose**

☐ **B glucose**

☐ **C lactose**

☐ **D sucrose**

**(continued on the next page)**

**3(c) continued.**

- (ii) In an experiment, the time between radioactivity appearing in aphid A and aphid D was 210 minutes.**

**The distance between these two aphids was 50 cm.**

**Calculate the rate of flow of phloem contents between these two aphids, in  $\text{cm hour}^{-1}$ .  
(1 mark)**

**Answer \_\_\_\_\_  $\text{cm hour}^{-1}$**

**(continued on the next page)**

**3(c) continued.**

**(iii) Describe how sugars are transported through the phloem.**  
**(3 marks)**

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

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**Turn over**



**3(c)(iii) continued.**

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**(Total for Question 3 = 9 marks)**

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**4 Influenza is an infectious disease caused by a virus.**

**(a) The influenza virus is an RNA virus and has an envelope.**

**Which pair of viruses also have RNA and an envelope?**

**(1 mark)**

- ☐ **A Ebola and human immunodeficiency virus**
- ☐ **B Ebola and tobacco mosaic virus**
- ☐ **C human immunodeficiency virus and  $\lambda$  phage**
- ☐ **D tobacco mosaic virus and  $\lambda$  phage**

**(b) Which of the following is the predominant method of transmission of the influenza virus?**

**(1 mark)**

- ☐ **A contaminated surfaces**
- ☐ **B contaminated food**
- ☐ **C respiratory droplets**
- ☐ **D insect vectors**

**(continued on the next page)**

**Turn over**

**4 continued.**

- (c) Symptoms of influenza appear some time after a person is infected with the virus.**

**Explain why there is a time delay between infection and the symptoms appearing.  
(3 marks)**

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

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**4(c) continued.**

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**4 continued.**

- (d) In some countries, people take antibiotics without a prescription.**

**In a survey, 77% of people who had taken antibiotics had taken them without a prescription.**

**Some of the people who took antibiotics without a prescription had influenza.**

- (i) Calculate the ratio of the number of people who took antibiotics without a prescription to the number of people who took antibiotics with a prescription.**

**Give your answer to two decimal places.  
(1 mark)**

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

**(continued on the next page)**

**Turn over**

**4(d) continued.**

- (ii) Explain why antibiotics should not be taken by people with viral infections.  
(2 marks)**

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**(Total for Question 4 = 8 marks)**

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- 5 Some forms of infertility are due to the female producing antibodies to sperm cells.**

**Contraceptives are being developed that use these antibodies.**

- (a) Antibodies can be injected into a person to give immunity.**

**Which type of immunity develops from the injection of antibodies?  
(1 mark)**

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

**(continued on the next page)**

**5 continued.**

- (b) In the development of these contraceptives, an agglutination assay was performed.**

**Antibodies were mixed with sperm cells and the time taken for 100% of the sperm cells to agglutinate was recorded.**

**Different concentrations of antibody were tested.**

**The number of sperm cells that escaped from the sperm cell agglutinates, at each concentration of antibody, was also recorded.**

- (i) Each test used  $2\mu\text{l}$  of a sperm cell suspension at a concentration of  $3.0 \times 10^6$  cells per  $\text{cm}^3$ .**

$$1\mu\text{l} = 10^{-6}\text{dm}^3$$

**Calculate the number of sperm cells used in each test.**

**(1 mark)**

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



**5(b) continued.**

- (ii) Look at the graphs for Question 5(b)(ii) in the Diagram Booklet. They show the results of this assay.**

**Analyse the data to comment on these results.  
(3 marks)**

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**5(b)(ii) continued.**

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**(iii) Observation of the sperm cells agglutinated by these antibodies showed that some were joined head to head, some head to flagellum and some flagellum to flagellum.**

**Explain these observations.  
(3 marks)**

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

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**Turn over**

**5(b)(iii) continued.**

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**(continued on the next page)**

**5 continued.**

- (c) In the development of these contraceptives, the effect of the concentration of sperm cells on the time taken to agglutinate was also investigated.**

**Explain why agglutination could take longer at low and at high concentrations of sperm cells.  
(2 marks)**

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

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**6 Scientists have removed thylakoids from chloroplasts to make artificial chloroplasts.**

**(a) Look at the diagram for Question 6(a) in the Diagram Booklet. It shows part of a chloroplast.**

**(i) Draw and label THREE other structures found in a chloroplast.**

**(3 marks)**

**(ii) Chloroplasts can be  $3\mu\text{m}$  in length.**

**Calculate the magnification of this diagram for a chloroplast that is  $3\mu\text{m}$  in length.**

**Give your answer to two significant figures.**

**(2 marks)**

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

**6(a)(ii) continued.**

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

**(continued on the next page)**

**6 continued.**

- (b) Explain the importance of the thylakoid membranes in the light-dependent stage of photosynthesis.  
(4 marks)**

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**6(b) continued.**

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**6 continued.**

- (c) The artificial chloroplasts made by the scientists consisted of thylakoids removed from spinach leaves, and enzymes involved in carbon fixation.**

**These components were put into water, forming a suspension.**

**This suspension was dropped into a medium containing oil.**

**The suspension formed cell-sized droplets of water containing the thylakoids and the enzymes.**

- (i) Name the enzyme that fixes carbon dioxide in the light-independent stage of photosynthesis.  
(1 mark)**

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**6(c) continued.**

- (ii) Explain why it is necessary to keep the thylakoids and enzymes together within droplets.  
(2 marks)**

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**(Total for Question 6 = 12 marks)**

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- 7 The Yap Trench is an area of very deep water in the Pacific Ocean.**

**In 2017, a new species of fish was caught in the Yap Trench. This was named the Yap hadal snailfish.**

**The photograph shows a different species of snailfish, the Mariana hadal snailfish.**



**(continued on the next page)**

**7 continued.**

- (a) The Yap hadal snailfish was caught in a deep sea trench, at a depth of 7 000 m below sea level.**

**Hydrostatic pressure increases 100 kPa with every 10 m of depth.**

**Calculate the hydrostatic pressure at 7 000 m.**

**Give your answer in standard form.  
(1 mark)**

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

**(continued on the next page)**

**Turn over**

**7 continued.**

**(b) Analysis of the genome of the Yap hadal snailfish and the Mariana hadal snailfish showed that they were closely related.**

**(i) The DNA from the Yap hadal snailfish contained 725 608 564 bases and 204 202 736 of these bases were adenines.**

**Calculate the number of guanine bases in the DNA of this fish.**

**(2 marks)**

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

**7(b) continued.**

- (ii) Look at the Venn diagram for Question 7(b)(ii) in the Diagram Booklet. It shows unique and shared gene families in the genomes of three species of snailfish and a zebrafish.**

**Calculate the percentage of gene families in the Yap hadal snailfish that are shared with the Mariana hadal snailfish.**

**Give your answer to one decimal place.  
(2 marks)**

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

**(continued on the next page)**

**Turn over**

**7(b) continued.**

- (iii) Look at the diagram for Question 7(b)(iii) in the Diagram Booklet. It shows the evolutionary relationship between three species of snailfish and a zebrafish.**

**Analyse the diagram to describe the evolutionary relationship between these four species of fish.**

**(3 marks)**

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**Turn over**

**7(b)(iii) continued.**

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**\*(iv) The Mariana hadal snailfish and the Yap hadal snailfish were caught in separate trenches hundreds of kilometres apart.**

**Explain how these fish evolved to become separate species.  
(6 marks)**

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**7(b)(iv) continued.**

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**7(b)(iv) continued.**

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**(Total for Question 7 = 14 marks)**

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- 8 Vaccines are being developed to stimulate the immune response to destroy cancer cells.**

**Some of these vaccines contain mRNA that codes for specific antigens found on cancer cells.**

- (a) These vaccines deliver the mRNA into antigen presenting cells, such as macrophages.**

**Describe how the delivery of mRNA into macrophages results in antigen presentation by these cells.**

**(4 marks)**

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**8(a) continued.**

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**(continued on the next page)**

**8 continued.**

- (b) Antigen presentation results in the stimulation of both the humoral immune response and the cell-mediated immune response.**

**Compare and contrast the humoral immune response with the cell-mediated immune response.  
(4 marks)**

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**Turn over**

**8(b) continued.**

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**(continued on the next page)**

**8 continued.**

- (c) These vaccines stimulate both the humoral immune response and the cell-mediated immune response.**

**Explain how the products of these responses result in the destruction of cancer cells.**

**(4 marks)**

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**Turn over**

**8(c) continued.**

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**(Total for Question 8 = 12 marks)**

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**9 The photograph shows a shortfin molly.**



**This fish has adapted to survive in environments where levels of hydrogen sulfide ( $\text{H}_2\text{S}$ ) are toxic to other organisms.**

**(a) Hydrogen sulfide can interrupt mitochondrial respiration by inactivating cytochrome c oxidase, one of the proteins in the electron transport chain.**

**(i) Where is the electron transport chain located in mitochondria?  
(1 mark)**

- ☐ **A inner membrane**
- ☐ **B intermembrane space**
- ☐ **C matrix**
- ☐ **D outer membrane**

**(continued on the next page)**

**Turn over**

**9(a) continued.**

**(ii) Explain why inactivating cytochrome c oxidase could be fatal.  
(3 marks)**

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**Turn over**

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

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**(b) The adaptation of these fish to H<sub>2</sub>S in their environment is thought to be due to epigenetic modification by DNA methylation.**

**(i) State the meaning of the term epigenetic modification.  
(1 mark)**

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**(continued on the next page)**

**9(b) continued.**

**(ii) Which of the following is another type of EPIGENETIC modification?  
(1 mark)**

- ☐ **A deletion mutation**
- ☐ **B histone modification**
- ☐ **C translation**
- ☐ **D translocation**

**(continued on the next page)**

**9 continued.**

**\*(c) The effect of hydrogen sulfide ( $\text{H}_2\text{S}$ ) on DNA methylation in these fish was investigated.**

**Look at the flow diagram for Question 9(c) in the Diagram Booklet. It shows part of the method used in this investigation.**

**All the fish kept in the laboratory were in water with no  $\text{H}_2\text{S}$ .**

**A CpG site is a region of DNA where a cytosine nucleotide is followed by a guanine nucleotide on the sense strand.**

**The DNA was analysed for the number of DNA-methylated regions (DMRs) at areas of DNA with different CpG densities. The numbers of DMRs for each group of fish were then compared.**

**Look at the graphs for Question 9(c) in the Diagram Booklet. They show the increase in the number of DNA-methylated regions (DMRs) in each group of fish.**

**Discuss the results of this investigation.  
(6 marks)**

**(continued on the next page)**

**Turn over**

**9(c) continued.**

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**Turn over**

**9(c) continued.**

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**(Total for Question 9 = 12 marks)**

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

## **Source information:**

### **Question 7**

**(Source: © Adisha Pramod/Alamy Stock Photo)**

### **Question 9**

**(Source: © WILDLIFE GmbH/Alamy Stock Photo)**