

X007/701

NATIONAL
QUALIFICATIONS
2001

MONDAY, 21 MAY
9.00 AM – 11.30AM

BIOLOGY
ADVANCED HIGHER

SECTION A—Questions 1–25 (25 marks)

Instructions for completion of Section A are given on *Page two*.

SECTIONS B, C AND D

The answer to each question should be written in the answer book provided. Square-ruled paper (if used) should be placed inside the front cover of the answer book.

Rough work should be scored through.

Section B (30 marks)

Both questions should be attempted.

Section C (30 marks)

Questions 1 and 2 in this section each contain a choice.

Section D (15 marks)

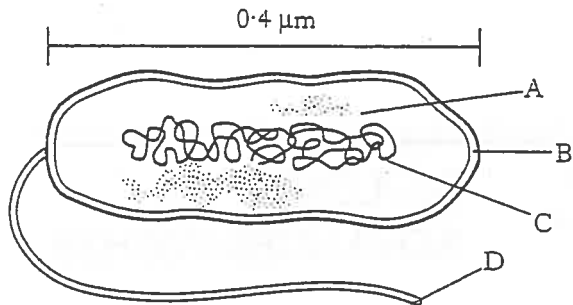
This section contains a choice. Only one of the six questions should be answered.

SECTION A

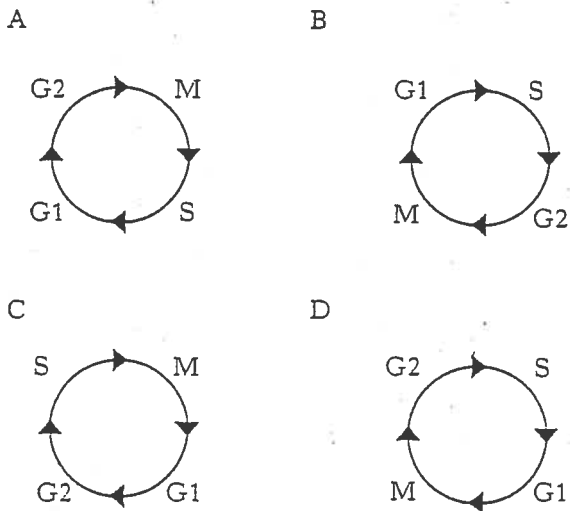
All questions in this section should be attempted.

Answers should be given on the separate answer sheet provided.

Questions 1 and 2 refer to the following diagram showing a typical prokaryotic cell.



- Which structure would contain peptidoglycan?
- The length of this organism in millimetres (mm) is
 - A 0.4
 - B 0.04
 - C 0.004
 - D 0.0004.
- Which of the following diagrams best represents the sequence of phases involved in the cell cycle?



- The cell cycle is believed to be monitored at checkpoints where specific conditions must be met for the cycle to continue.

- condition 1: chromosome alignment
- condition 2: successful DNA replication
- condition 3: cell size

Which line in the table shows the condition fulfilled at each checkpoint?

	<i>G1</i>	<i>G2</i>	<i>M</i>
A	2	3	1
B	3	2	1
C	2	1	3
D	3	1	2

- The following stages occur during the culture of mammalian cells.
 - W Spreading out
 - X Division
 - Y Becoming confluent
 - Z Adhesion

Which line below shows the correct sequence of stages?

- A X → W → Y → Z
- B Z → W → X → Y
- C Z → Y → W → X
- D X → Y → Z → W

[Turn over

6. To make cell culture growth medium containing 10% fetal bovine serum (FBS) you would combine

- A 450 cm³ of medium + 50 cm³ of FBS
- B 495 cm³ of medium + 5 cm³ of FBS
- C 500 cm³ of medium + 5 cm³ of FBS
- D 500 cm³ of medium + 50 cm³ of FBS.

7. An undifferentiated mass of plant tissue is known as

- A a callus
- B an explant
- C a protoplast
- D a hybrid.

8. Which of the following is a component of the cytoskeleton?

- A Glycoprotein
- B Phospholipid
- C Tubulin
- D Peptidoglycan

9. The following table shows the approximate number of bases in the genomes of three different species.

Organism	Genome Size (number of bases)
Fruit fly	1.5×10^8
Human	3.0×10^9
Tobacco plant	4.5×10^9

From the information provided which of the following statements about genome size is correct?

- A Human genome size is two times that of the fruit fly.
- B Tobacco plant genome size is three times that of the fruit fly.
- C Human genome size is twenty times that of the fruit fly.
- D Tobacco plant genome size is three hundred times that of the fruit fly.

10. Enzymes that catalyse the transfer of phosphate from one protein to another are called

- A nucleases
- B proteases
- C ATPases
- D kinases.

11. The following stages are involved in producing a DNA profile from a sample of isolated DNA.

- W Gel electrophoresis
- X Hybridisation with a probe
- Y Restriction enzyme digestion
- Z Blotting DNA onto a filter

These stages would be carried out in the order

- A Y, W, X, Z
- B Y, W, Z, X
- C W, Y, X, Z
- D W, Y, Z, X.

12. During the production of transgenic tomato plants, plasmids can be used to transfer recombinant DNA from

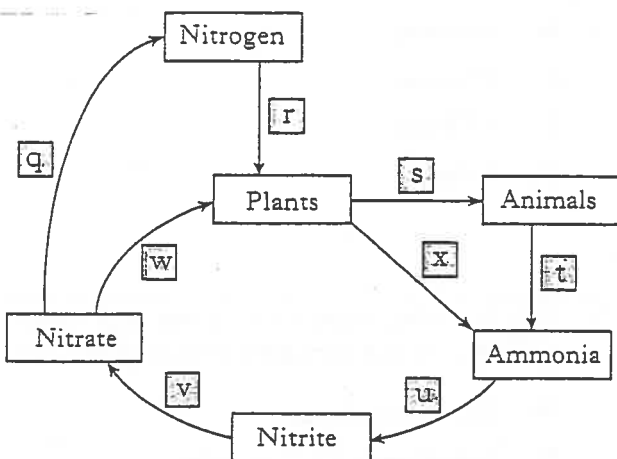
- A *Agrobacterium* to plant cell protoplasts
- B *Agrobacterium* to differentiated plant cells
- C *Rhizobium* to plant cell protoplasts
- D *Rhizobium* to differentiated plant cells.

13. A river ecosystem receives about 7 000 000 kJ m⁻² year⁻¹ of solar energy. Of this energy 98.5% is not used in photosynthesis.

Which of the following shows the amount of energy (kJ m⁻² year⁻¹) captured by the producers in this ecosystem?

- A 105 000
- B 689 000
- C 1 050 000
- D 6 895 000

Questions 14 and 15 refer to the diagram below which shows the nitrogen cycle.



14. Which letter in the diagram represents denitrification?

- A w
- B s
- C x
- D q

15. Which line in the table correctly identifies the micro-organisms involved at the stages shown?

	r	u	v
A	<i>Nitrosomonas</i>	<i>Nitrobacter</i>	<i>Rhizobium</i>
B	<i>Rhizobium</i>	<i>Nitrobacter</i>	<i>Nitrosomonas</i>
C	<i>Nitrobacter</i>	<i>Rhizobium</i>	<i>Nitrosomonas</i>
D	<i>Rhizobium</i>	<i>Nitrosomonas</i>	<i>Nitrobacter</i>

16. Productivity of aquatic ecosystems is most likely to be limited by

- A ammonium
- B calcium
- C phosphate
- D sulphate.

17. A biotic interaction between two species that does not benefit either is called

- A parasitism
- B mutualism
- C commensalism
- D competition.

18. A quadrat with 50 cm long sides was used to estimate the density of a plant species in two areas X and Y. Five random samples were taken in each of the two areas and the results are given below.

Quadrat Number	Number of plants	
	Area X	Area Y
1	27	15
2	19	16
3	39	42
4	19	31
5	11	16

The mean density per square metre in each of the two areas is

	Area X	Area Y
A	23	24
B	46	48
C	92	96
D	115	120

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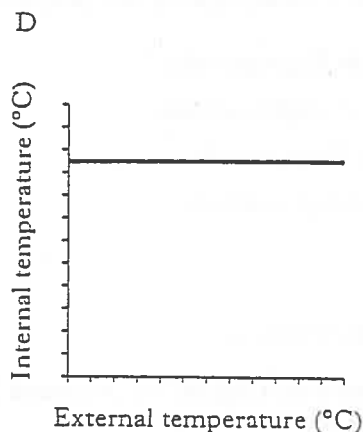
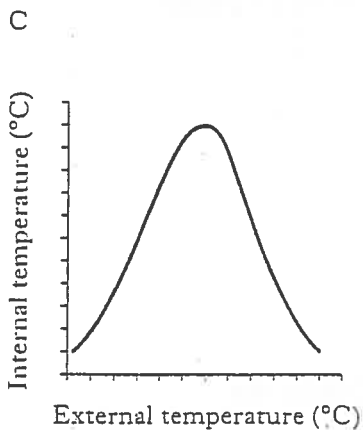
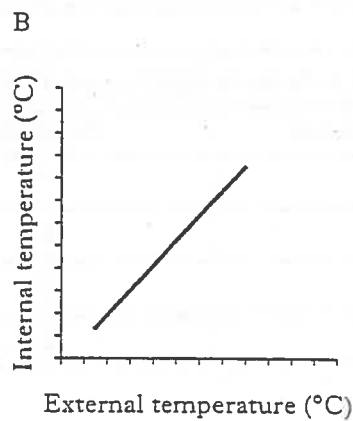
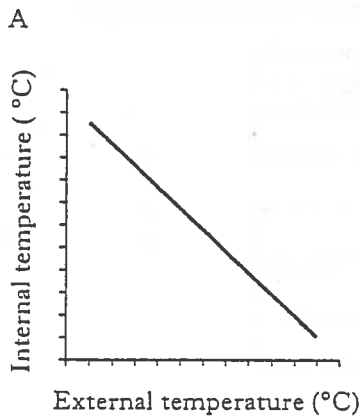
19. The table below shows how carrot production and weed growth are influenced by planting density.

Spacing between rows (cm)	Yield of Carrots (kg m ⁻²)	Weed Density (weeds m ⁻²)	Leaf cover carrots (cm ²)	Leaf cover weeds (cm ²)
30	3.4	0.4	90.9	5.1
60	2.4	0.8	63.4	14.0

Which of the following conclusions based on the data is correct?

- A When the spacing is doubled there is a 50% increase in weed density.
- B The yield of carrots increases by about 42% as the planting density increases.
- C The leaf cover of carrots drops by about 33% when planting density increases.
- D The leaf cover of weeds increases by about 64% when spacing is increased.

20. Which of the following graphs best represents perfect thermal control in a homeotherm?



21. Succession arising from a major geophysical event, such as a hurricane, is described as

- A secondary
- B autogenic
- C allogenic
- D degradative.

22. Which of the following gases is associated with the greenhouse effect?

- A Water vapour
- B Oxygen
- C Nitrogen
- D Sulphur dioxide

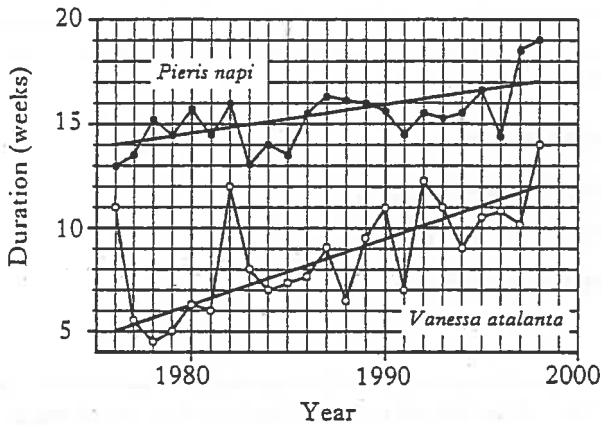
23. Which of the following does not result in loss of complexity in ecosystems?

- A Predation
- B Monoculture
- C Eutrophication
- D Toxic pollution

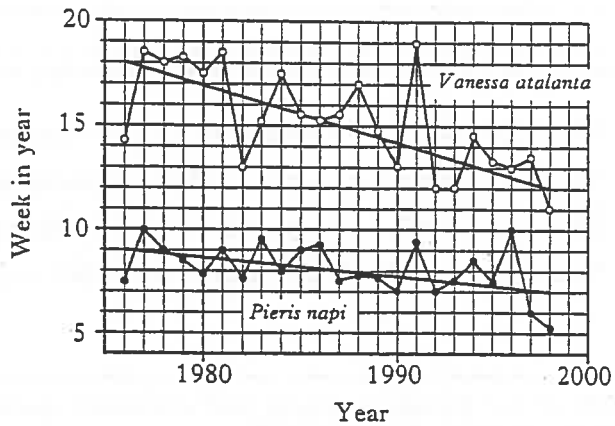
Questions 24 and 25 are based on the information given below.

The duration of the flight periods of two species of butterfly, *Vanessa atalanta* and *Pieris napi*, were recorded from 1976 to 1998 (Graph 1). The first sightings of the two species were also noted (Graph 2). Lines of best fit were calculated and drawn through the data.

Graph 1: Duration of flight period



Graph 2: Week of first sighting



24. From the lines of best fit, which row in the table best summarises the changes in flight period during the study?

	<i>Changes in duration of flight period (weeks)</i>	
	<i>Vanessa atalanta</i>	<i>Pieris napi</i>
A	3	7
B	6	2
C	7	3
D	2	6

25. Which of the following conclusions about the butterfly species can be drawn from the graphs?
- A They are appearing earlier and have longer flight periods.
 - B They are appearing earlier and have shorter flight periods.
 - C They are appearing later and have longer flight periods.
 - D They are appearing later and have shorter flight periods.

[END OF SECTION A]

Candidates are reminded that the answer sheet MUST be returned INSIDE the front cover of the answer book.

[Turn over

SECTION B

Both questions in this section should be attempted.

Cell and Molecular Biology

1. Although all body cells take up glucose from the blood, the liver is responsible for storing glucose arising from digestion and then regulating how much is released into circulation. When glucose enters cells it is immediately converted to glucose 6-phosphate (G 6-P), which is unable to diffuse back out. This substance has a variety of roles in cells, for example it can enter glycolysis or it can be used in the formation of glycogen.

All cells contain the enzyme *hexokinase* to carry out the conversion of glucose to G 6-P. Liver cells, however, also contain *glucokinase*, an enzyme that carries out the same reaction but which is specific for glucose molecules, whereas hexokinase acts on a number of six-carbon sugars. The Figure below compares the responses of hexokinase and glucokinase from liver to increasing glucose concentrations.

When blood glucose concentration starts to fall, more glucose is released automatically by liver cells into the circulation. The liver can produce this glucose from two sources. It can synthesise new glucose from a variety of materials, or it can bring some out of storage by breaking down glycogen.

Glycogen is broken down in the same way in all cells. About ninety percent of the product is glucose 1-phosphate (G 1-P), created mainly by the enzyme *glycogen phosphorylase*; the remainder is glucose. The enzyme *phosphoglucomutase* converts G 1-P to G 6-P. Significantly, unlike most body cells, liver cells possess *glucose 6-phosphatase*, the enzyme which converts G 6-P back to glucose. The Table shows the substrates used by the liver to make glucose before and during exercise.

Figure: The effect of glucose concentration on the activity of two liver enzymes.

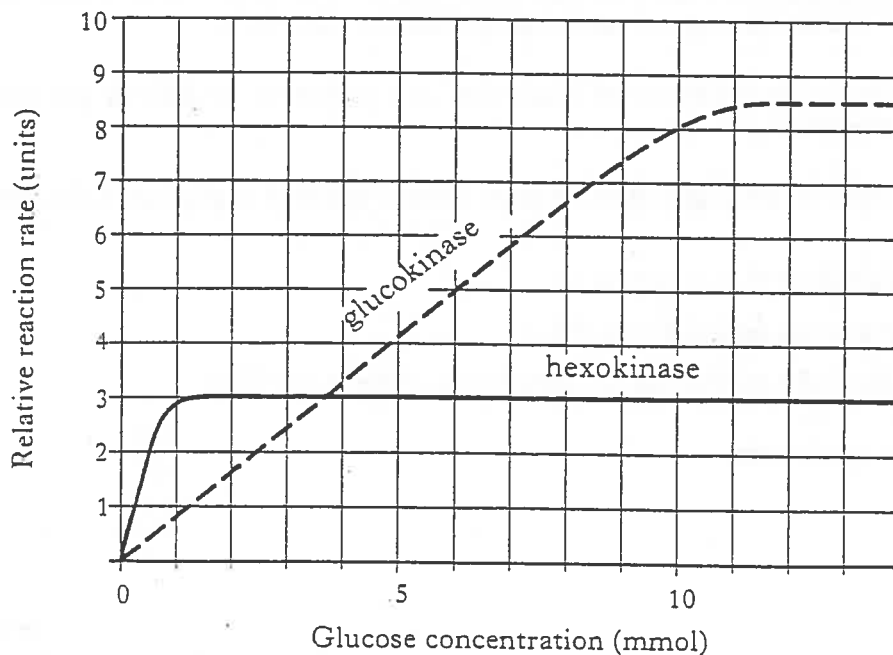


Table: Substrates used to form the glucose released by liver after different levels of activity.

Level of Activity	Liver glucose output (mmol min^{-1}) from different substrates				
	glycogen	amino acids	glycerol	pyruvic acid	lactic acid
Rest	0.55	0.05	nil	nil	0.20
40 minutes exercise	1.30	0.05	0.03	nil	0.20
240 minutes exercise	0.75	0.12	0.25	0.03	0.30

Marks

- (a) Glycogen is made up of glucose monomers joined by glycosidic bonds. Briefly describe the formation of the glycosidic bond when two glucose molecules are joined. 2
- (b) Explain the term *specificity* as it applies to the two kinase enzymes. 1
- (c) Compare the effect of glucose concentration on the activity of the two kinase enzymes shown in the Figure. 3
- (d) Explain the significance for cell water balance of storing carbohydrate as polysaccharide rather than monosaccharide molecules. 1
- (e) State one structural difference between starch and glycogen. 1
- (f) What information in the Table suggests that the activity of glycogen phosphorylase, phosphoglucomutase and glucose 6-phosphatase have increased after a short period of exercise? Outline the reactions that would lead to this effect. 3
- (g) Suggest a reason for the presence of glycerol as a substrate for making glucose after prolonged exercise. 1
- (h) A person with Type 1 glycogen storage disease inherits a glucose 6-phosphatase deficiency.

Predict the effect of this condition on

- (i) blood glucose level between meals
- (ii) the effect of a normal diet on glycogen storage in the liver.

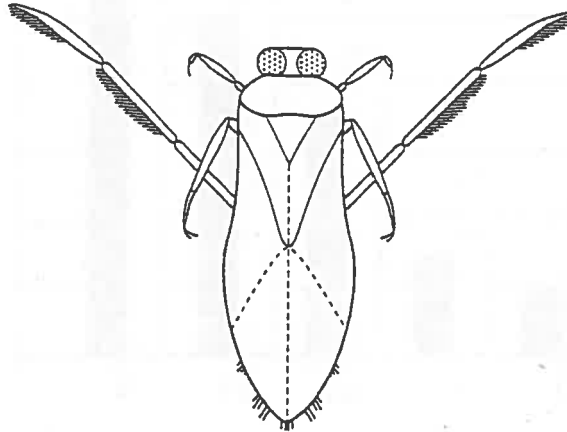
Justify your predictions.

3
(15)

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2. Water boatmen (Figure 1) are important insect predators in freshwater habitats such as ponds and ditches. The distributions of two species, *Notonecta maculata* and *Notonecta obliqua* were studied in a series of small ponds in the Peak National Park in Derbyshire. The Table shows the number of ponds occupied by the two species in relation to the amount of submerged vegetation, as measured by percentage cover.

Figure 1: Water boatman of the genus *Notonecta*.



Different species of *Notonecta* are described as having considerable "trophic niche overlap". Laboratory experiments were carried out to investigate whether the feeding rate of *Notonecta* nymphs (immature stages) was affected by environmental complexity. Containers having either artificial aquarium weed (complex environment) or no artificial weed (simple environment) were set up. The feeding rates of nymphs at different stages of development (instars) in both simple and complex environments were measured by counting the number of water fleas eaten by each nymph in two hours. The results are shown in Figure 2.

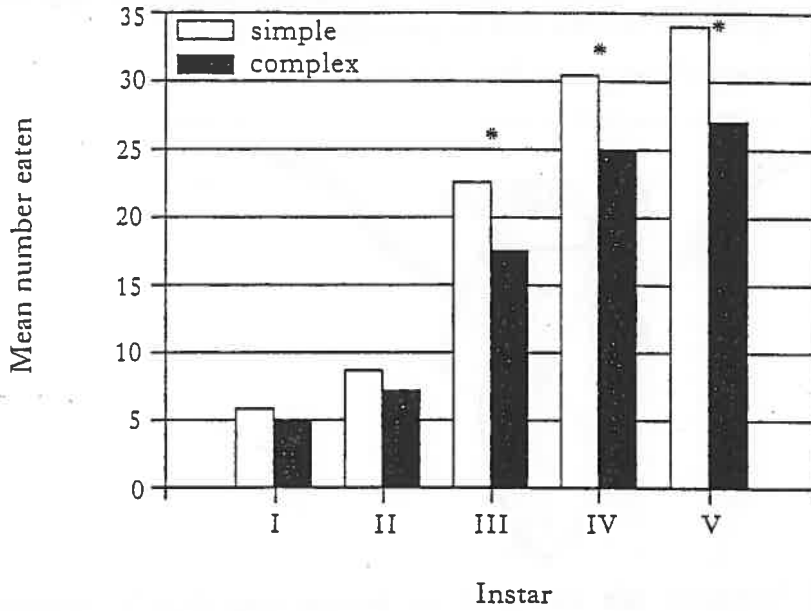
Table: Number of ponds occupied by species of *Notonecta* in relation to the percentage cover of submerged vegetation.

Percentage cover of submerged vegetation	Total number of ponds	Number of ponds occupied	
		by <i>N. maculata</i>	by <i>N. obliqua</i>
0-9	53	22	7
10-19	3	1	3
20-29	3	1	3
30-39	2	1	2
40-49	1	0	1
50-59	1	0	1
60-69	1	0	1
70-79	1	0	1
80-89	1	0	✓ 1
90-100	1	0	0

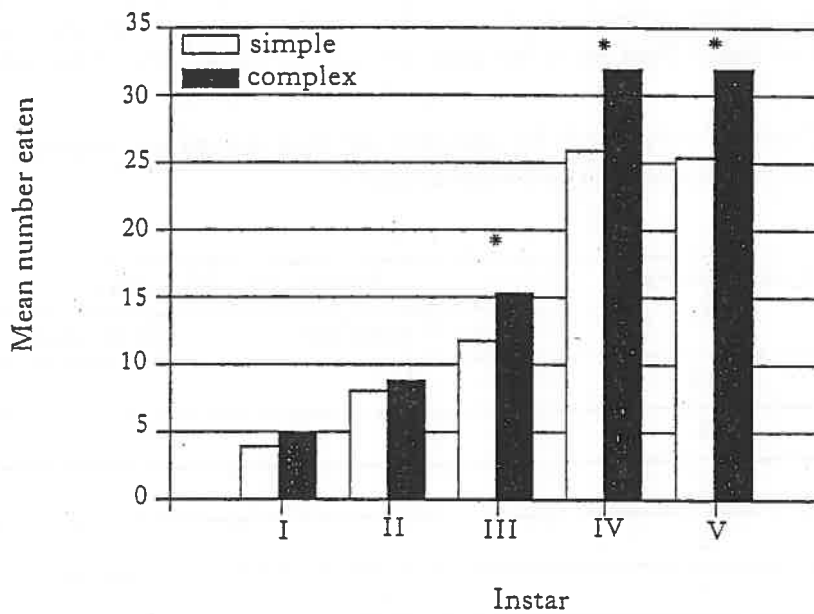
SECTION B (continued)

Figure 2: Mean numbers of water fleas eaten in two hours by nymphs of (A) *N. maculata* and (B) *N. obliqua* in two different environments.

(A)



(B)



The asterisks (*) indicate where means differ significantly within instars.

[Turn over

Question 2 (continued)

Marks

- (a) With reference to the two species of water boatmen:
- (i) explain what is meant by the term "trophic niche overlap"; 1
 - (ii) suggest why their interaction might be described as **exploitation competition**; 1
 - (iii) suggest **one** possible effect of this competition. 1
- (b) Using the data in the Table:
- (i) describe the distributions of each of the two species; 3
 - (ii) calculate the percentage of ponds occupied by *N. maculata*. 1
- (c) From the data given in Figure 2:
- (i) compare the feeding rates of the oldest nymphs in both species; 2
 - (ii) outline the evidence which indicates that stage of development affects feeding rates; 1
 - (iii) suggest how the results in Figure 2 may help to explain the distribution patterns shown in the Table. 2
- (d) Water boatmen may show forms of dormancy such as diapause in winter.
Explain why this behaviour would be beneficial to them. 1
- (e) Suggest **one** way in which the experimenters may have minimised error or undesirable variation in the laboratory experiments. 1
- (f) Suggest a biotic interaction, other than competition, which may influence the distribution of water boatmen in freshwater ponds. 1
- (15)

[END OF SECTION B]

SECTION C

Both questions in this section should be attempted.

Note that each question contains a choice.

Labelled diagrams may be used where appropriate.

Cell and Molecular Biology

1. Answer either A or B. *Marks*
- A. Discuss the biological significance of extracellular signalling. Use named examples to describe the mechanisms of hydrophobic and hydrophilic signalling. 15
- OR
- B. Describe the four levels of protein structure and give a brief account of the functions of proteins in membranes. 15

Environmental Biology

2. Answer either A or B.
- A. Discuss the fixation and flow of energy in ecosystems. 15
- OR
- B. Outline problems of air pollution associated with increased demand for energy. Explain the process of biological magnification using named examples of pollutants. 15

[Turn over

SECTION D

Note this section contains a choice.

Answer ONE of the following questions.

Labelled diagrams may be used where appropriate.

Marks

Biotechnology

1. Outline the problems associated with the production of fruit juice and discuss the use of enzymes to overcome these problems. 15
OR
2. Discuss the recently developed techniques used to enhance nitrogen fixation in plants. 15
OR

Animal Behaviour

3. Describe social hierarchies in vertebrates. How does social interaction benefit these animals? 15
OR
4. Discuss the roles of both innate and learned behaviour in the lives of animals. Use examples of named species to illustrate your answer. 15
OR

Physiology, Health and Exercise

5. Describe methods available for measuring human body composition and discuss the limitations associated with each method. 15
OR
6. Discuss the protective effects of exercise and outline how endurance training improves the performance of the heart. 15

[END OF QUESTION PAPER]

