Fill in these boxes and read what is printed below.

<table>
<thead>
<tr>
<th>Full name of centre</th>
<th>Town</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forename(s)</th>
<th>Surname</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of birth</th>
<th>Scottish candidate number</th>
<th>Number of seat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>Month</td>
<td>Year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SECTION A** (25 marks)

Instructions for completion of **Section A** are given on page two.
For this section of the examination you must use an **HB pencil**.

**SECTION B AND SECTION C** (75 marks)

1. (a) All questions should be attempted.
   (b) It should be noted that in **Section C** questions 1 and 2 each contain a choice.
2. The questions may be answered in any order but all answers are to be written in the spaces provided in this answer book, and **must be written clearly and legibly in ink**.
3. Additional space for answers will be found at the end of the book. If further space is required, supplementary sheets may be obtained from the Invigilator and should be inserted inside the **front** cover of this book.
4. The numbers of questions must be clearly inserted with any answers written in the additional space.
5. Rough work, if any should be necessary, should be written in this book and then scored through when the final copy has been written. If further space is required, a supplementary sheet for rough work may be obtained from the Invigilator.
6. Before leaving the examination room you must give this book to the Invigilator. If you do not, you may lose all the marks for this paper.
SECTION A

Read carefully
1 Check that the answer sheet provided is for Biotechnology Intermediate 2 (Section A).
2 For this section of the examination you must use an HB pencil and, where necessary, an eraser.
3 Check that the answer sheet you have been given has your name, date of birth, SCN (Scottish Candidate Number) and Centre Name printed on it.
   Do not change any of these details.
4 If any of this information is wrong, tell the Invigilator immediately.
5 If this information is correct, print your name and seat number in the boxes provided.
6 The answer to each question is either A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).
7 There is only one correct answer to each question.
8 Any rough working should be done on the question paper or the rough working sheet, not on your answer sheet.
9 At the end of the examination, put the answer sheet for Section A inside the front cover of this answer book.

Sample Question
Which of the following foods contains a high proportion of fat?
   A Butter
   B Bread
   C Sugar
   D Apple

The correct answer is A—Butter. The answer A has been clearly marked in pencil with a horizontal line (see below).

Changing an answer
If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to D.
1. Which of the following is found in bacterial cells?
   A Vacuole
   B Chloroplast
   C External capsule
   D Nucleus

2. Which line in the table below describes correctly the structure of a yeast cell?

<table>
<thead>
<tr>
<th>Nucleus</th>
<th>Cell wall</th>
<th>Chloroplast</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>B</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>C</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>D</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>

3. In algae, starch granules are formed from
   A sugars synthesised in respiration
   B sugars synthesised in photosynthesis
   C sugars broken down in respiration
   D sugars broken down in photosynthesis.

4. The enzyme amylase
   A breaks down proteins into amino acids
   B builds up starch from sugars
   C builds up proteins from amino acids
   D breaks down starch into sugars.

5. Saprophytic micro-organisms obtain food from
   A living and dead organisms
   B living organisms only
   C dead and decaying organisms
   D dead organisms only.

6. A culture contained 40 000 yeast cells at the start of an experiment. Yeast cells divide once every 12 minutes.
   Calculate the number of yeast cells, which would be present after 1 hour.
   A 200 000
   B 240 000
   C 640 000
   D 1 280 000

7. Which of the following bacteria fix nitrogen in the root nodules of legumes?
   A Rhizobium
   B Saccharomyces
   C Penicillium
   D Zygomonas
8. The figure below shows four stages in an enzyme-controlled chemical reaction.

Which line in the table below identifies correctly structures W, X and Y?

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>substrate</td>
<td>product</td>
<td>enzyme</td>
</tr>
<tr>
<td>B</td>
<td>enzyme</td>
<td>product</td>
<td>substrate</td>
</tr>
<tr>
<td>C</td>
<td>product</td>
<td>substrate</td>
<td>enzyme</td>
</tr>
<tr>
<td>D</td>
<td>substrate</td>
<td>enzyme</td>
<td>product</td>
</tr>
</tbody>
</table>

9. The following list refers to some aspects about good practice in the biotechnology laboratory.

W Closing laboratory doors and windows
X Selecting a smooth, non-absorbent work area
Y Washing and drying hands
Z Wiping work area with disinfectant

Which of these steps is part of the preparation required for a person in a biotechnology laboratory?

A W
B X
C Y
D Z

10. Facultative bacteria

A sometimes use oxygen
B always use oxygen
C never use oxygen
D are killed by oxygen.
Questions 11 and 12 refer to the diagram below which shows some of the stages in the nitrogen cycle.

11. Stage X is
   A absorption
   B nitrogen fixation
   C denitrification
   D nitrification.

12. Which of the following involves micro-organisms?
   A X only
   B W and X
   C Z only
   D Y and Z

13. A mycorrhizal association is between a plant and a
   A parasite
   B fungus
   C bacterium
   D saprophyte.
14. The graph below shows the effect of light intensity on the rate of glucose production during photosynthesis by algae.

Identify the factor which could be limiting photosynthesis between points X and Y.

A  Carbon dioxide concentration
B  Oxygen concentration
C  Glucose concentration
D  Light intensity
Questions 15 and 16 refer to the graph below, which shows the number of bacteria in two separate *E.coli* cultures grown at different temperatures.

![Graph showing bacterial growth at different temperatures](image)

15. After 5 hours, the simple whole number ratio of cells at 30 °C to 25 °C is
   A  72 : 12
   B  1 : 6
   C  6 : 1
   D  12 : 72.

16. A third culture of the same bacteria was grown at 15 °C.
    Predict the number of cells in this culture after 10 hours.
   A  100 million per cm$^3$
   B  94 million per cm$^3$
   C  92 million per cm$^3$
   D  80 million per cm$^3$
17. Which line in the table below describes correctly continuous flow processing?

<table>
<thead>
<tr>
<th>Raw materials</th>
<th>Immobilised cells used</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Added at start only</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>Added at start only</td>
<td>No</td>
</tr>
<tr>
<td>C</td>
<td>Added during process</td>
<td>No</td>
</tr>
<tr>
<td>D</td>
<td>Added during process</td>
<td>Yes</td>
</tr>
</tbody>
</table>

18. Which three variables require to be controlled during the commercial production of the antibiotic penicillin?

A Nutrient concentration, temperature and oxygen concentration
B Oxygen concentration, light intensity and nutrient concentration
C Light intensity, carbon dioxide concentration and pH
D pH, temperature and light intensity

19. The table below shows the conditions in four individual fermenters containing the same genetically engineered bacterium which is producing a hormone.

<table>
<thead>
<tr>
<th>Fermenter</th>
<th>Oxygen concentration (%)</th>
<th>Temperature (°C)</th>
<th>pH of medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>10</td>
<td>30</td>
<td>5.4</td>
</tr>
<tr>
<td>X</td>
<td>10</td>
<td>15</td>
<td>6.0</td>
</tr>
<tr>
<td>Y</td>
<td>20</td>
<td>30</td>
<td>5.4</td>
</tr>
<tr>
<td>Z</td>
<td>20</td>
<td>15</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Which of the following should be used to find the effect of oxygen concentration on the production of the hormone?

A W and X
B W and Z
C X and Z
D Y and Z

20. During vinegar production, *Acetobacter* can be immobilised onto wood shavings. Identify two advantages of this type of cell immobilisation from the list below.

1 *Acetobacter* can be re-used to produce more vinegar.
2 Wood shavings convert ethanol to vinegar.
3 *Acetobacter* gain a useful substrate from wood for respiration.
4 Vinegar can be separated much easier at the end of production.

A 1 and 2
B 1 and 4
C 2 and 3
D 3 and 4

21. Complete breakdown of organic waste during sewage treatment requires the action of

A aerobic micro-organisms only
B aerobic and anaerobic micro-organisms
C anaerobic micro-organisms only
D neither aerobic nor anaerobic micro-organisms.
Questions 22 and 23 refer to the diagram below showing a bacterial sample viewed under a microscope in a biotechnology laboratory.

22. The total magnification used above was ×800.
   The magnification was increased by using a ×100 objective lens with the same ×10 eyepiece lens.
   Which statement describes correctly what would be seen at the new magnification?
   A  ×900 total magnification and an increased number of bacteria visible
   B  ×900 total magnification and a decreased number of bacteria visible
   C  ×1000 total magnification and an increased number of bacteria visible
   D  ×1000 total magnification and a decreased number of bacteria visible

23. Two samples were viewed:
    Sample 1  yogurt containing bacilli only
    Sample 2  pond water containing spirilla and bacilli only.
    A valid conclusion is that the diagram above shows micro-organisms from
    A  sample 1
    B  sample 2
    C  neither sample
    D  both sample 1 and sample 2.
Questions 24 and 25 refer to the diagram below showing an investigation into the effect of two types of salt solutions, potassium chloride and sodium chloride, on the preservation of a variety of peas called “Margot’s Delight”. All tubes were incubated at 25 °C for 48 hours.

24. Which two tubes should be compared to draw a valid conclusion about the effect of type of salt solution on the preservation of peas?

A  P and S  
B  Q and R  
C  P and Q  
D  Q and S  

25. Which variable is not controlled in this investigation?

A  Incubation temperature  
B  Variety of peas  
C  Time  
D  Volume of salt solution  

Candidates are reminded that the answer sheet for Section A MUST be returned INSIDE the front cover of this answer book.
[Turn over for SECTION B on Page twelve
SECTION B

All questions in this section should be attempted.
All answers must be written clearly and legibly in ink.

1. The diagram below shows the structure of a micro-organism with some parts labelled.

(a) (i) Name this type of micro-organism.

(ii) Identify parts W, X and Y in this micro-organism.

W ____________________________ 1

X ____________________________

Y ____________________________

(iii) Give a reason why food vacuoles contain enzymes.

(iv) State the function of the contractile vacuole.

(b) This cell was viewed at a total magnification of $\times 2\ 000$.

Calculate the actual length of this micro-organism in micrometres (µm).
$(1\ mm = 1\ 000\ µm)$

Space for calculation

$\mu m$ 1
2. The diagram below shows two agar plates produced by a student, viewed from above and the side.

(a) Suggest a reason for the appearance of the plates.

Plate W ____________________________ 1

Plate X ____________________________ 1

(b) State one disadvantage of storing agar plates in a fridge.

__________________________ 1

(c) Explain why smooth, non-absorbent bench surfaces are essential for working with micro-organisms.

__________________________ 1

(d) Other than sterilising equipment, why is it good practice to work close to a Bunsen flame?

__________________________ 1

(e) Decide if the following statements about sub-culturing micro-organisms are True or False and tick (√) the correct box.

If the answer is False, write the correct word(s) in the Correction box to replace the word underlined in the statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>True</th>
<th>False</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A sterile <strong>scalpel</strong> can be used to transfer micro-organisms from liquid to solid medium.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streak plating can be used to obtain <strong>isolated</strong> colonies.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visible differences in a mixed culture can be seen only in <strong>liquid</strong> medium.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Algae are micro-organisms capable of fixing energy to produce fuel.

In Japan, biotechnologists have grown algae in shallow, open tanks which receive a waste gas from a power station, as shown in the diagram below.

(a) (i) Name the process used by algae in this process of energy fixation.

(b) Give one advantage of producing fuel in this way.
3. (continued)

(e) The table below compares fuel production from different photosynthesising organisms.

<table>
<thead>
<tr>
<th>Name of organism</th>
<th>Fuel production rate (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower</td>
<td>4</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>6</td>
</tr>
<tr>
<td>Oil palm</td>
<td>24</td>
</tr>
<tr>
<td>Algae</td>
<td>48</td>
</tr>
</tbody>
</table>

Present the information in the table as a bar chart below.
(Additional graph paper, if required, can be found on Page thirty-two.)
4. Fungi produce an enzyme which breaks down proteins. This enzyme is released into the surrounding culture medium.

An investigation was set up to compare the activity of this enzyme produced by three different species of fungi.

The following procedure was carried out.

1. A liquid culture of each species of fungus (P, Q and R) was prepared.
2. The cultures were incubated for 24 hours.
3. Liquid from each culture was transferred to separate wells punched in a protein agar plate.
4. The protein agar plate was incubated for 48 hours.

Protein agar plates are cloudy. The fungal enzyme breaks down protein making the agar clear.

The diagram below shows the appearance of the plate after 48 hours.

(a) (i) Name one factor, not mentioned above, which should be kept the same when setting up the agar plate in this experiment.

(ii) Describe a method of measuring the clear zone around well P.
4. (a) (continued)

(iii) Describe the contents of the control well.

[Blank space] 1

(iv) Give **one** conclusion from the results of this investigation.

[Blank space] 1

(v) The enzyme produced by these fungi only break down proteins; it has no effect on starch.

What term is used to describe this characteristic of an enzyme?

[Blank space] 1

(b) Many species of fungi live in soil and release enzymes into their surroundings.

(i) Name the term given to such enzymes.

[Blank space] 1

(ii) Explain the reason why fungi release enzymes into the soil.

[Blank space] 2

[Turn over]
5. The flow chart below shows steps in the commercial production of human insulin by bacteria.

- **Step 1**: Produce bacteria containing a human insulin gene
- **Step 2**: Clean fermenter and add culture medium
- **Step 3**: Add the bacteria to fermenter
- **Step 4**: Allow the bacteria to increase in number
- **Step 5**: Separate and break open bacteria to release human insulin
- **Step 6**: Purify and package human insulin

(a) Step 1 is the production of bacteria containing a human insulin gene.

(i) The process involves inserting a human insulin gene into a bacterial structure.
   Name this structure.
   ____________________________  1

(ii) Name a bacterium used in this process.
   ____________________________  1

(b) Steps 2 and 3 involve a fermenter.
   Explain why the fermenter is cleaned before bacteria containing human insulin gene are added.
   ____________________________  1

(c) Step 4 involves the bacteria reproducing.
   Name this method of asexual reproduction.
   ____________________________  1
5. (continued)

(d) (i) The insulin obtained after step 6 can be used to treat humans. Name a medical condition that insulin is used to treat.

(ii) Describe one advantage of using human insulin produced by the process shown in the flow chart.

(e) The table below shows global information about insulin.

<table>
<thead>
<tr>
<th>Percentage of population requiring insulin (%)</th>
<th>Percentage of world insulin used (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed World</td>
<td>35</td>
</tr>
<tr>
<td>Rest of the World</td>
<td>65</td>
</tr>
</tbody>
</table>

The annual global production of insulin is 6 000 kg. Calculate the number of kilograms of insulin used by the developed world.

Space for calculation

[Turn over]
6. *H. fulvum* is a fungus which damages tomato crops.

An investigation was carried out into the effect of humidity and temperature on fungal growth.

This involved the transfer of agar blocks of *H. fulvum* to the centre of sterile agar plates. Three of these plates were incubated at each humidity and temperature. At the end of incubation, the diameter of fungal growth on each plate was measured and averaged.

The tables below show the results of this investigation.

<table>
<thead>
<tr>
<th>Relative humidity (%)</th>
<th>Average diameter of fungal growth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>45</td>
</tr>
<tr>
<td>70</td>
<td>24</td>
</tr>
<tr>
<td>30</td>
<td>14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Average diameter of fungal growth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>35</td>
<td>18</td>
</tr>
<tr>
<td>40</td>
<td>12</td>
</tr>
</tbody>
</table>

(a) In this investigation, the size of the agar blocks was kept the same.

(i) Suggest one other variable which should be kept the same to make this investigation valid.

(ii) What feature of the experimental design makes this investigation's results reliable?

(iii) Identify one limitation of using diameter as a measure of fungal growth.
6. (continued)

(b) Complete the following sentences on fungal damage of tomatoes, by underlining one of the options in each pair.

As fungal growth increases, the damage to tomatoes \( \left\{ \begin{array}{l}
\text{increases} \\
\text{decreases}
\end{array} \right. \). The results’ tables suggest that the minimum damage of tomatoes will occur at relative humidity of \( \left\{ \begin{array}{l}
30\% \\
100\%
\end{array} \right. \) and temperature of \( \left\{ \begin{array}{l}
10 \, ^\circ\text{C} \\
30 \, ^\circ\text{C}
\end{array} \right. \).

(c) Predict the average diameter of fungal growth at 50 °C.

\[ \text{mm} \]

(d) (i) Name a metal instrument which could be used to transfer the agar blocks of fungus.

\[ \text{Describe how this metal instrument is sterilised.} \]

\[ \text{Describe how this metal instrument is sterilised.} \]
7. The graph below shows the production of citric acid by *Aspergillus niger*, using dried peat moss as a raw material, at 30°C.

![Graph showing citric acid production]

(a) (i) Describe the production of citric acid over 10 days.

(ii) State which two day period the citric acid concentration increased at the fastest rate.

Space for calculation

__________ day to __________ day
7. (continued)

(b) During this process, *Aspergillus niger* and dried peat moss are added to the fermenter on day 0. The process is stopped at day 10 and citric acid is separated. Name this type of processing.

______________________________

(c) What type of micro-organism is *Aspergillus niger*?

______________________________

(d) Name a raw material, other than dried peat moss, that *Aspergillus niger* could use in the production of citric acid.

______________________________

(e) Give **one** use of citric acid in the food industry.

______________________________
A sample from the infected wound is taken and fixed to a microscope slide. This
sample is then treated with a sequence of stains and observed under a microscope.
This staining technique results in different species of bacteria appearing a different
colour.

(a) (i) Describe how you would fix the sample from the infected wound.

(ii) State why bacteria need to be fixed to a microscope slide.

(iii) Give one advantage of staining bacteria.

(b) The diagram below shows the colours and shapes of the fixed and stained
bacteria in the wound sample.

(i) State the term used to describe the shape of bacteria P.

(ii) Label a coccus on the diagram with the letter Q.
8. (continued)

(c) The patient with the infected wound was treated with a broad spectrum antibiotic.

Using information from the diagram, give two reasons why this patient was treated with a broad-spectrum antibiotic.

Reason 1

Reason 2

(d) Explain why it is important that broad spectrum antibiotics used to treat patients are stable in acid.

[Turn over]
9. Aphids (also known as greenfly) are plant pests that feed on plant sap. They cause significant damage to crops and reduce farmers’ yields.

Wheat plants have been altered with a gene that allows them to produce a chemical that prevents aphids from feeding.

(a) (i) Identify the process in which a gene from one species is inserted into another species.

Underline the correct answer.

- genome mapping
- genetic modification
- selective breeding

(b) Scientists hope that this technique will produce wheat yields of 20 tonnes per hectare by 2020. The current wheat yield (2014) is 8 tonnes per hectare.

Calculate the predicted percentage increase in wheat yield by 2020.

Space for calculation

%
1. Answer either A or B.

A. The diagram below shows reproduction in the fungus *Mucor*.

(a) Identify structures X and Y.

(b) Describe the events that occur during asexual and sexual reproduction in *Mucor*.

OR

B. The diagram below shows a micro-organism.

(a) Identify this type of micro-organism and structure Q.

(b) Describe the steps in the replication of this micro-organism.
SPACE FOR ANSWER TO QUESTION 1

Please complete the box below to indicate which part, A or B, you are answering.

☐
2. Answer either A or B.

A. Silage is made by a biotechnological process.
   Name a species of bacterium involved in silage production. Describe the process and conditions required by these bacteria to produce silage for winter feed.

   OR

B. Single cell protein (SCP) is made by a biotechnological process.
   Name the type of micro-organism involved in SCP production. Describe the process of SCP production to include raw material used, benefits of the process and uses of the product.
SPACE FOR ANSWER TO QUESTION 2

Please complete the box below to indicate which part, A or B, you are answering.

☐
ADDITIONAL SPACE FOR ANSWERS

Additional graph paper for use in Question 3(e)

Name of organism