FOR OFFICIAL USE

Total for Sections B and C

X008/301

NATIONAL QUALIFICATIONS 2007

THURSDAY, 17 MAY
1.00 PM – 3.30 PM

BIOTECHNOLOGY
HIGHER

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth
Day Month Year

Scottish candidate number

Number of seat

SECTION A (30 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 (100 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.

(c) Question 8 is on pages 24, 25 and 26. Question 9 is on page 27 and Question 10 is on pages 28 and 29. Pages 26 and 27 are fold-out pages.

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 fair 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 Higher (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 exam, put the **answer sheet for Section A inside the front cover of this answer book**.

Sample Question

What name is given to a culture of micro-organisms which contains more than one species of organisms?

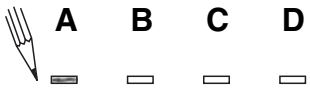
A Mixed

B Pure

C Simple

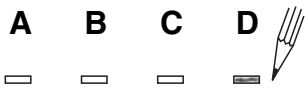
D Complex

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



Changing an answer

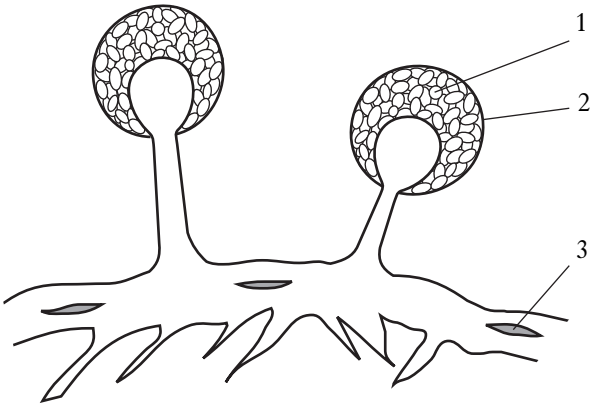
If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



SECTION A

All questions in this Section should be attempted.

1. The following diagram represents *Mucor*.



Which line in the table below identifies correctly the structures labelled 1, 2 and 3?

	1	2	3
A	sporangium	spore	nucleus
B	spore	sporangium	nucleus
C	nucleus	sporangium	spore
D	nucleus	spore	sporangium

2. Which of the following are required for glycolysis?

A Oxygen and ATP

B Water and ATP

C Enzymes and oxygen

D ATP and enzymes

3. A bacterial culture contains 10 000 cells. If the doubling time for this bacterium is 30 minutes, how many cells will be present after 3 hours?

A 60 000

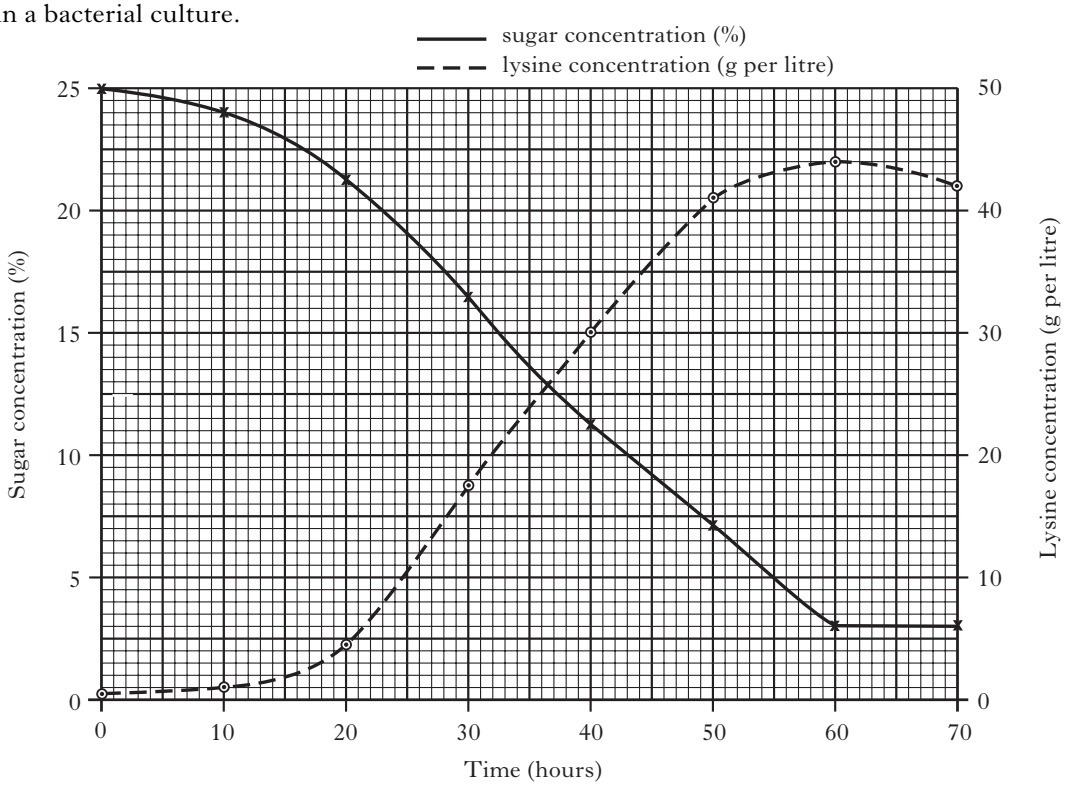
B 80 000

C 320 000

D 640 000

[Turn over

4. The graph below shows the results of the fermentation of sugar and the production of the amino acid lysine in a bacterial culture.



What is the lysine concentration (g per litre) in the culture when the sugar concentration is 8%?

A 4

B 16

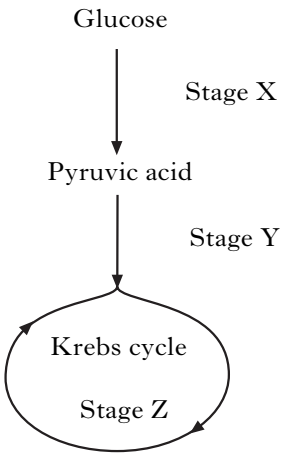
C 34

D 39

5. Which line in the table matches a reaction site in the mitochondrion with its correct end products?

	Site of reaction in mitochondrion	*End products*
A	Cristae	Water and ATP
B	Cristae	CO_2 and ATP
C	Matrix	Water and ATP
D	Matrix	CO_2 and ATP

6. The following chart shows stages in the complete breakdown of glucose in aerobic respiration.



At which stage, or stages, is carbon dioxide released?

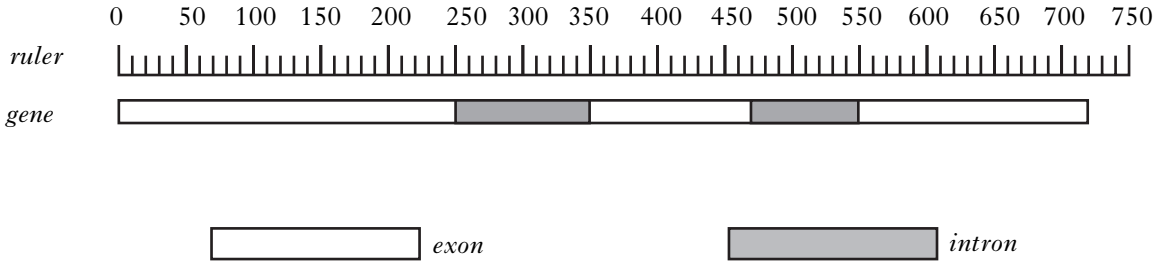
A Stages X and Z

B Stages X and Y

C Stages Y and Z

D Stage Z only

7. The diagram below shows a eukaryotic gene containing introns and exons. A ruler showing sizes in base pairs is also shown.



What length is the mature mRNA transcribed from this gene?

A 180 base pairs

B 540 base pairs

C 550 base pairs

D 720 base pairs

8. Which line in the table identifies correctly features of cloning vectors?

	Can add sugars	*Can replicate in host cells*	*Can accept foreign DNA*
A	Yes	No	Yes
B	No	Yes	No
C	No	Yes	Yes
D	Yes	Yes	No

9. A section of DNA with 1000 base pairs contains 280 thymine molecules. How many adenine, guanine and cytosine molecules does it contain?

	adenine	*guanine*	*cytosine*
A	140	110	110
B	280	220	220
C	140	220	220
D	280	720	720

10. The base sequence of a piece of DNA is shown below.

C G C T A T C G

During DNA replication a substitution mutation took place.

Which of the following sequences represents correctly the mRNA produced from the mutated DNA strand?

A G C G A T G G C

B G C G A U G G C

C G C G A U A G C

D G C G A T A G C

11. An operon in a bacterial chromosome is

A a cloned fragment of DNA

B a non-coding region of DNA

C a cluster of genes with related functions

D a circle of self-replicating DNA.

12. Which of the following engulf bacteria?

A Antibodies

B Lymphocytes

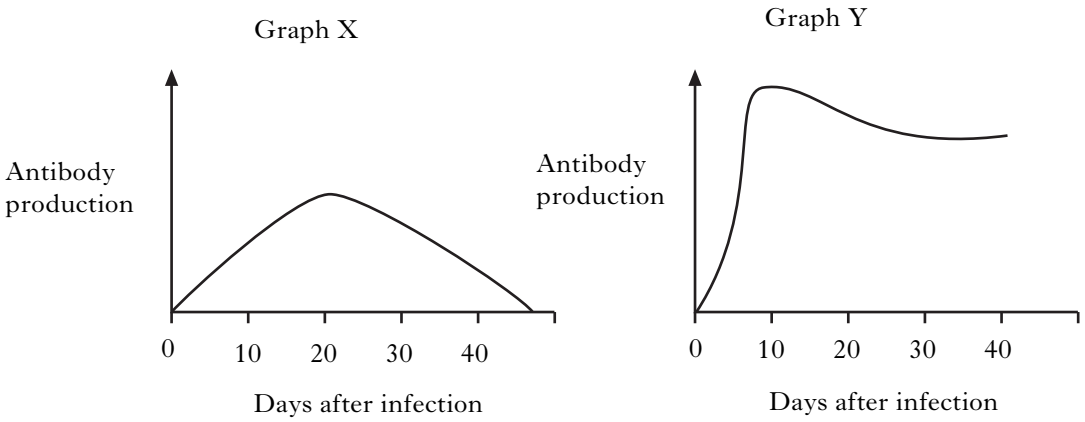
C Macrophages

D Antigens

[Turn over

13. Graph X shows a child's primary response to a viral infection.

Graph Y shows the child's secondary response to infection by the same virus one year later.



Which of the following accounts for the difference in the two responses?

A Some antibodies remain from the primary response

B The body has gained passive resistance to the infection

C B lymphocytes cause rapid antibody production

D Some antigens remain from the primary response

---

14. A volume of antibiotic was added to a broth culture of *Staphylococcus epidermidis*. Growth stopped immediately.

What further experiment could be carried out to determine whether the effect of the antibiotic was biocidal or biostatic?

A Add more antibiotic to the culture

B Transfer a loopful of culture to fresh medium

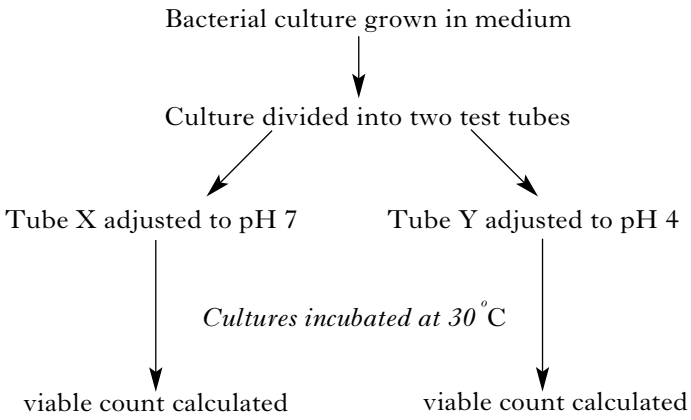
C Count the number of cells with a haemocytometer

D Repeat the experiment with a different antibiotic

15. Which line in the table below identifies correctly the most suitable method for sterilising each item?

	Broth culture	*Glass pipette*	*Plastic pipette*
A	autoclave	dry heat	gamma irradiation
B	gamma irradiation	dry heat	dry heat
C	autoclave	gamma irradiation	autoclave
D	dry heat	gamma irradiation	autoclave

16. The experiment shown below was set up to investigate the effect of pH on growth of bacteria.



The results of the viable count are shown below.

Tube X	$3{\cdot}9 \times 10^{6}$ cells per cm^{3}
Tube Y	$1{\cdot}2 \times 10^{7}$ cells per cm^{3}

Which of the following statements is supported by the results?

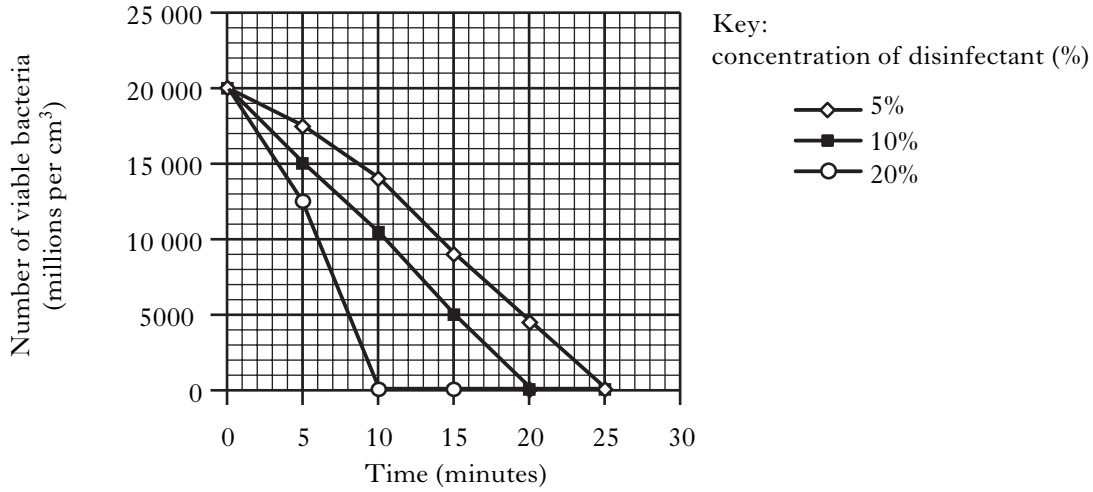
A The bacteria grow better in alkali conditions

B The bacteria grow better in neutral conditions

C The bacteria grow better in acid conditions

D The bacteria are unaffected by changes in pH

17. The graph shows the effect of different concentrations of disinfectant on the number of viable bacteria in liquid culture.



What is the percentage of bacteria killed by 20% disinfectant after 5 minutes?

A 25

B 37·5

C 62·5

D 75

[Turn over

18. Which of the techniques below could be used to work out the total and viable counts of yeast culture?

	Total count	*Viable count*
A	haemocytometer	plate count
B	spectrophotometer	direct count
C	direct count	haemocytometer
D	plate count	spectrophotometer

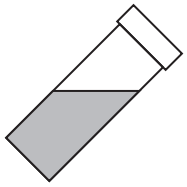
19. Which line in the table below identifies correctly the order chemicals are added when carrying out a Gram stain?

	1	2	3	4
A	pink stain	alcohol	iodine	crystal violet
B	pink stain	crystal violet	alcohol	iodine
C	crystal violet	alcohol	pink stain	iodine
D	crystal violet	iodine	alcohol	pink stain

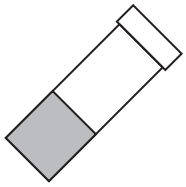
20. A bacterial culture was inoculated into tube X containing molten gelatin. A second tube (Y) containing molten gelatin received no bacteria. The gelatin in both tubes was allowed to set while the tubes were standing upright.

Both tubes were incubated overnight at 30 °C.

The following day the tubes were tilted and the results are shown below.



Tube X



Tube Y

The culture in tube X is showing

A evidence of secondary metabolism

B anaerobic fermentation

C aerobic fermentation

D extracellular digestion.

21 Which of the following can **not** be used to extract cells from liquid culture?

A Filtration

B Freeze-drying

C Centrifugation

D Distillation

22. Which of the following is precipitated from its solvent using chalk?

A Citric acid

B Penicillin

C Lysozyme

D Pectinase

23. Three methods used to immobilise enzymes are described below.

1	enzyme enclosed in sodium alginate
2	enzyme joined by covalent linkage
3	enzyme joined by non-covalent linkage

Which line in the table below identifies correctly the name of each method?

	Adsorption	*Entrapment*	*Bonding*
A	3	2	1
B	3	1	2
C	2	1	3
D	1	3	2

24. Which of the following industrial applications of enzymes would be best suited to being used in an immobilised form?

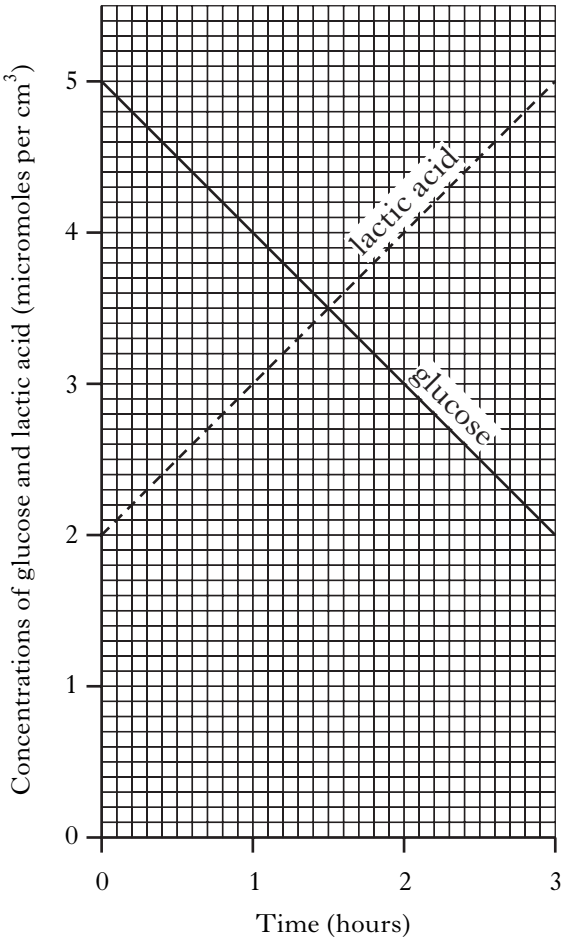
A The conversion of glucose syrup to fructose syrup

B The removal of protein residues on clothing in pre-soak treatments

C The coagulation of milk proteins in cheese manufacture

D The removal of fibrin clots after a heart attack

25. The graph shows the changes which take place in the concentrations of glucose and lactic acid in a broth culture of bacteria.



When the glucose concentration has fallen by 40%, what increase has taken place in the concentration of lactic acid?

A 1 micromole per cm^3

B 2 micromoles per cm^3

C 3 micromoles per cm^3

D 4 micromoles per cm^3

[Turn over

26. Which line in the table below identifies correctly the use of each enzyme?

	ENZYMES			
	Pectinase	*Urokinase*	*Cellulase*	*Lysozyme*
A	Clarifying fruit juices	Removal of fibrin clots after heart attacks	The disruption of bacterial cell walls	Manufacture of feedstock from waste materials
B	Removal of fibrin clots after heart attacks	Clarifying fruit juices	Manufacture of feedstock from waste materials	The disruption of bacterial cell walls
C	Clarifying fruit juices	Removal of fibrin clots after heart attacks	Manufacture of feedstock from waste materials	The disruption of bacterial cell walls
D	Removal of fibrin clots after heart attacks	Clarifying fruit juices	The disruption of bacterial cell walls	Manufacture of feedstock from waste materials

27. Which of the following is used in the production of transgenic animals?

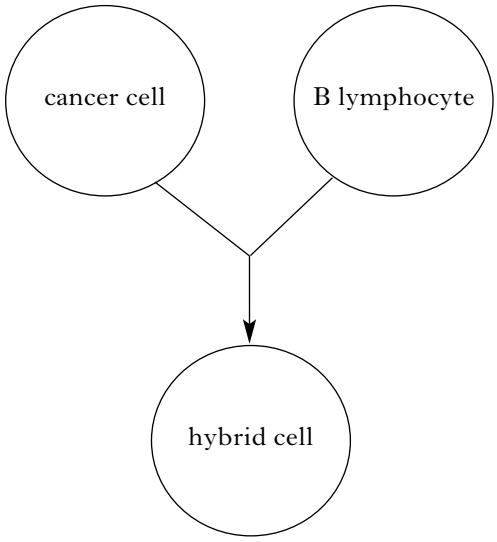
A Infection with *Agrobacterium tumifaciens*

B Microinjection of foreign DNA

C Transformation with bacterial plasmids

D Fusion with cell protoplasts

28. The diagram below shows some of the cells involved in the production of monoclonal antibodies.



Which of the cell types in the diagram produce antibodies?

A B lymphocyte and hybrid cell

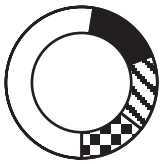
B B lymphocyte and cancer cell

C Cancer cell and hybrid cell

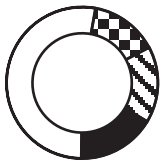
D B lymphocyte, cancer cell and hybrid cell

29. Which of the following plasmids could be used for the production of alpha–1 antitrypsin in the milk of sheep?

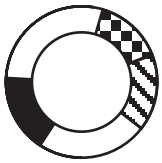
A



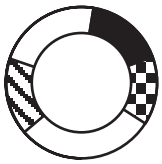
B



C



D

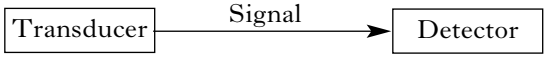


gene for milk production

gene for ampicillin resistance

gene for alpha-1 antitrypsin production

30. A biosensor contains the following components.



The signal from the transducer can be

A electrical

B an enzyme

C an antibody

D a bacterial cell.

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

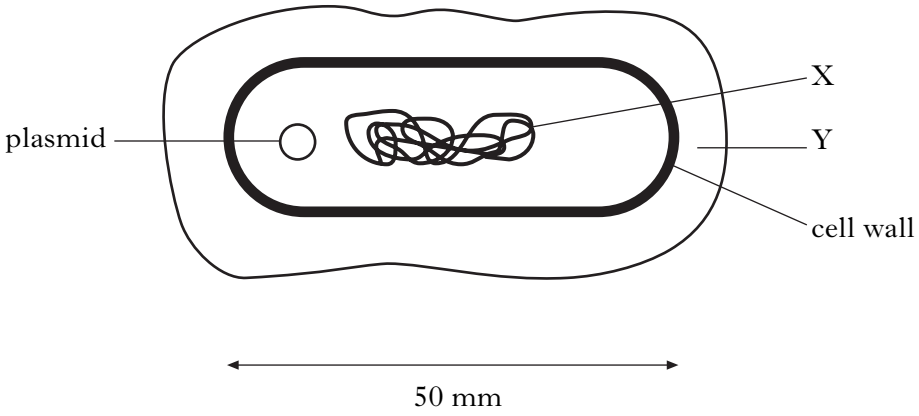
[Turn over for Section B on *Page 12*

Marks

SECTION B

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

1. The diagram below represents a bacterial cell magnified × 10000.



(*a*) Name structure X and state its function.

Name _____

Function _____ **1**

(*b*) Give an example of **one** way that structure Y protects the bacterial cell.

_____ **1**

(*c*) What advantage may bacteria gain from the presence of a plasmid?

_____

_____ **1**

(*d*) What is the actual length of the cell before magnification?

Space for calculation

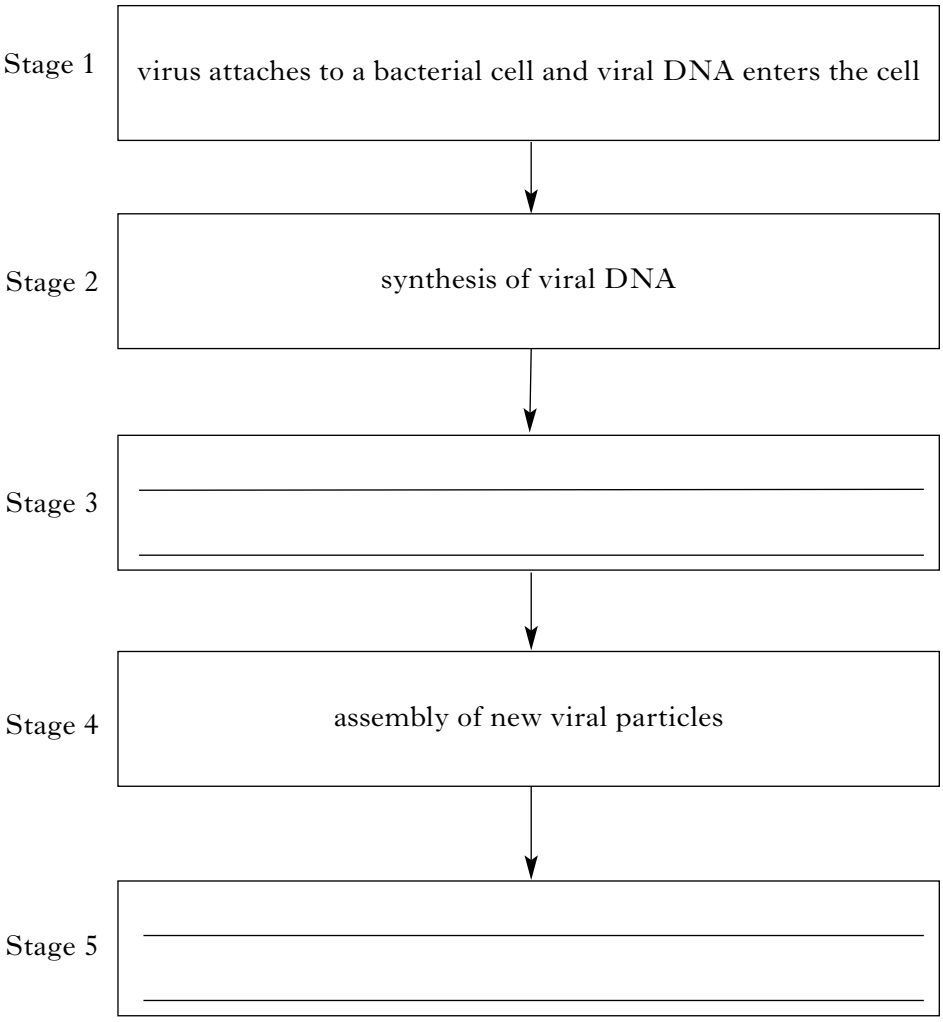
_____ **1**

(*e*) Name **one** structure found in a yeast cell that is **not** found in a bacterial cell.

_____ **1**

2. The diagram shows the stages involved in the infection of a bacterial cell by a virus.

Marks



(*a*) (i) Complete the boxes by describing what happens at stages 3 and 5. **2**

(ii) Name **two** substances provided by the bacterial cell during synthesis of viral DNA at stage 2.

1 _____

2 _____ **2**

(*b*) Give the name for the type of virus that infects bacterial cells.

_____ **1**

(*c*) Explain why a virus is described as a pathogen.

_____

_____ **1**

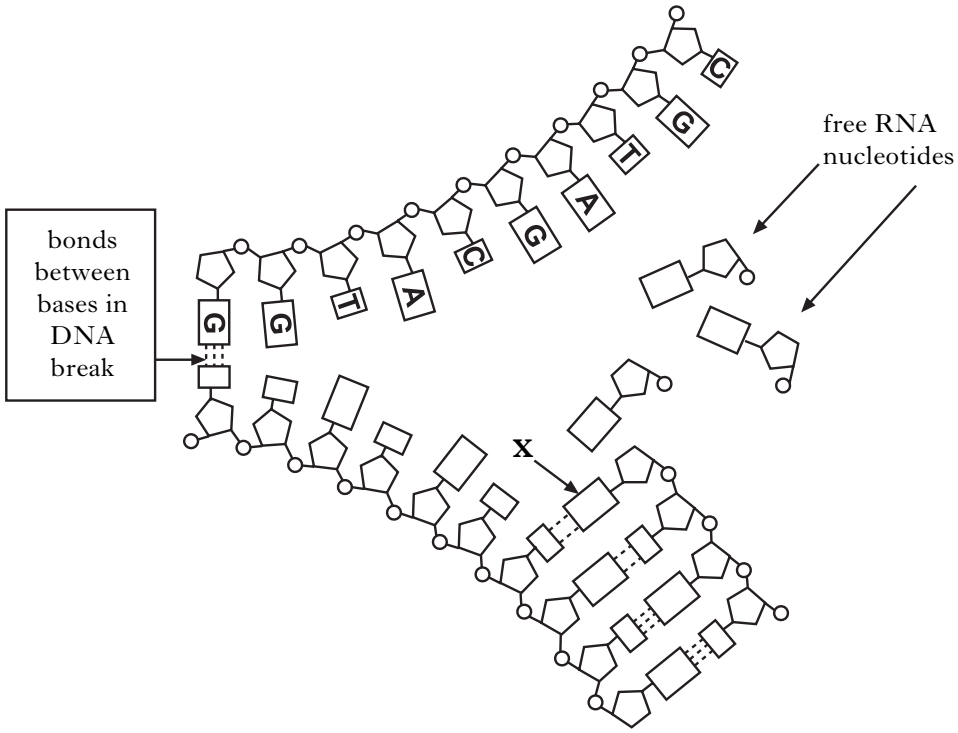
(*d*) Name the technique a scientist would use to test for viral infection in a sample of bacteria.

_____ **1**

[Turn over

Marks

3. (*a*) The diagram shows the synthesis of messenger RNA (mRNA) in a bacterial cell.



(i) Name base X.

_____ **1**

(ii) In the following sentence, **underline** one of the alternatives in each pair to make the sentence correct.

{Translation / Transcription} is the synthesis of mRNA from the {sense / antisense} strand of DNA which runs in a {3' to 5' / 5' to 3'} direction. **2**

(iii) Name an RNA molecule not shown in the diagram that is also involved in protein synthesis and describe its function.

Name _____ **1**

Function _____

_____ **1**

Marks

3. (continued)

(*b*) Part of an mRNA sequence is given below.

AUGCGGGCCGCCUACCGG

The table shows the anticodons for four amino acids

Anticodon	*Amino acid*
UAC	Met
CGG	Ala
AUG	Tyr
GCC	Arg

Using the information given, work out the sequence of amino acids in the polypeptide produced from the mRNA sequence.

_____ **1**

(*c*) What further structural changes to a bacterial polypeptide take place after its synthesis from mRNA?

_____ **1**

[Turn over

Marks

4. Gel electrophoresis is used to separate DNA fragments that have been cut with restriction enzymes.

(*a*) What determines where a restriction enzyme cuts a DNA molecule?

_____

_____ **1**

Figure 1 shows the sites where three different restriction enzymes cut a piece of DNA.

Figure 1

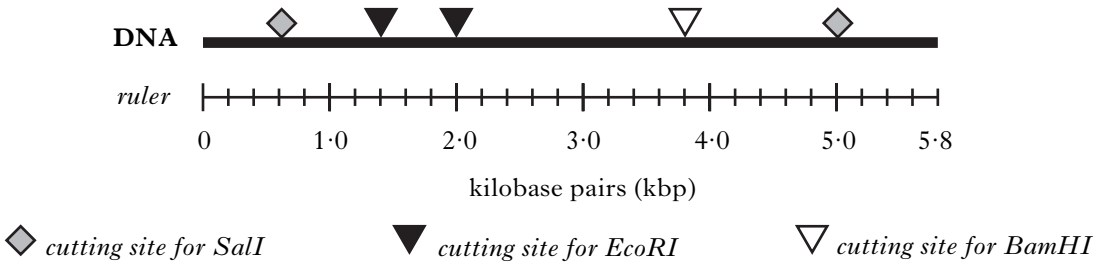
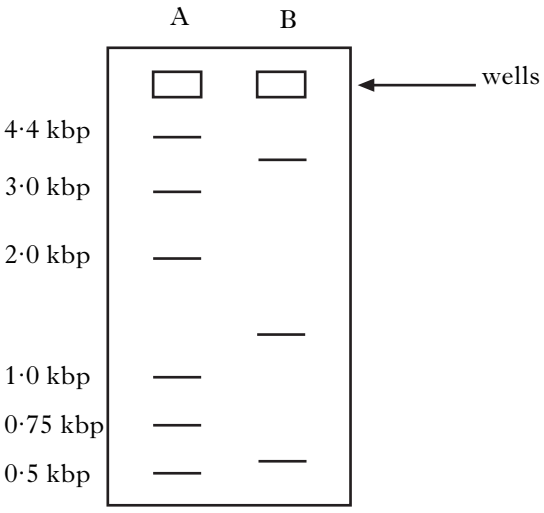


Figure 2 shows the results of electrophoresis of the DNA fragments produced by cutting with one of these enzymes.

Lane A contains marker fragments of DNA of known size. Sizes are shown to the left of the gel.

Lane B contains the cut DNA.

Figure 2



(*b*) (i) Using figures 1 and 2, state which enzyme was used to cut the DNA.

_____ **1**

(ii) How many fragments would be produced if the DNA was cut with both *EcoRI* and *SalI*?

_____ **1**

Marks

4. (continued)

(*c*) The experiment was carried out using a 1% agarose gel. Describe how the movement of fragments would be affected if a higher concentration of agarose was used.

_____ **1**

(*d*) One of the fragments in lane B contains a gene of interest. Describe how a scientist could determine which fragment contains this gene.

_____

_____

_____ **2**

(*e*) Gel electrophoresis is used in DNA profiling. Give **one** application of DNA profiling.

_____ **1**

[Turn over

Marks

5. (*a*) The bacterium *Staphylococcus aureus* has the following characteristics.

Gram stain reaction	Positive
Shape	Coccus
Spore production	No
Motility	No
Catalase production	Yes
Oxidase production	No

Answer the following questions using the information in the table.

(i) Describe the composition of the cell wall of *Staphylococcus aureus*.

_____ **1**

(ii) Would a suspension of *Staphylococcus aureus* be likely to survive being boiled at 100 °C for 15 minutes? Explain your answer.

Answer _____

Explanation _____

_____ **1**

(iii) In the space below, draw the shape of one *Staphylococcus aureus* cell.

1

(iv) What evidence suggests that *Staphylococcus aureus* is susceptible to the antibiotic penicillin?

_____ **1**

DO NOT WRITE IN THIS MARGIN

Marks

5. (continued)

(*b*) What are the substrates for the catalase test and for the oxidase test?

Catalase test _____ **1**

Oxidase test _____ **1**

(*c*) What does lack of motility suggest about the cell structure of *Staphylococcus aureus?*

_____ **1**

[Turn over

Marks

6. (*a*) What type of media would be used in the situations described below?

(i) To allow growth of one type of bacteria from a mixed culture

_____

(ii) To investigate the exact nutritional requirements of one type of bacteria

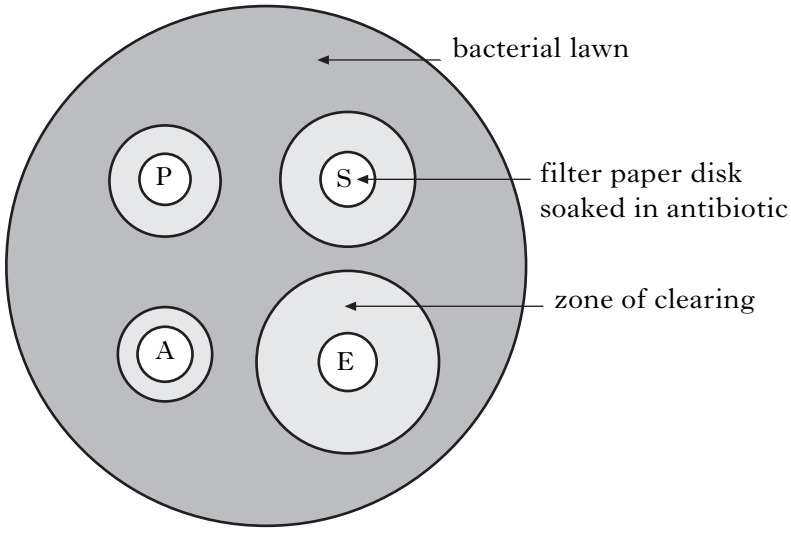
_____

(iii) To maintain bacterial stock cultures in a laboratory

_____ **3**

(*b*) A microbiologist set up an experiment to test the antibiotic sensitivity of a bacterium. Filter paper disks soaked in identical concentrations of the antibiotics were placed on a lawn of *Streptococcus pyogenes*.

The result of the experiment is shown in the diagram.



Antibiotics

P	penicillin	E	erythromycin
S	streptomycin	A	augmentin

(i) Describe how a bacterial lawn is prepared.

_____

_____

_____ **2**

Marks

6. (*b*) (continued)

(ii) Name the antibiotic to which *Streptococcus pyogenes* is most sensitive.

_____ **1**

(iii) Suggest a reason why all four antibiotics are tested on the same plate of *Streptococcus pyogenes*.

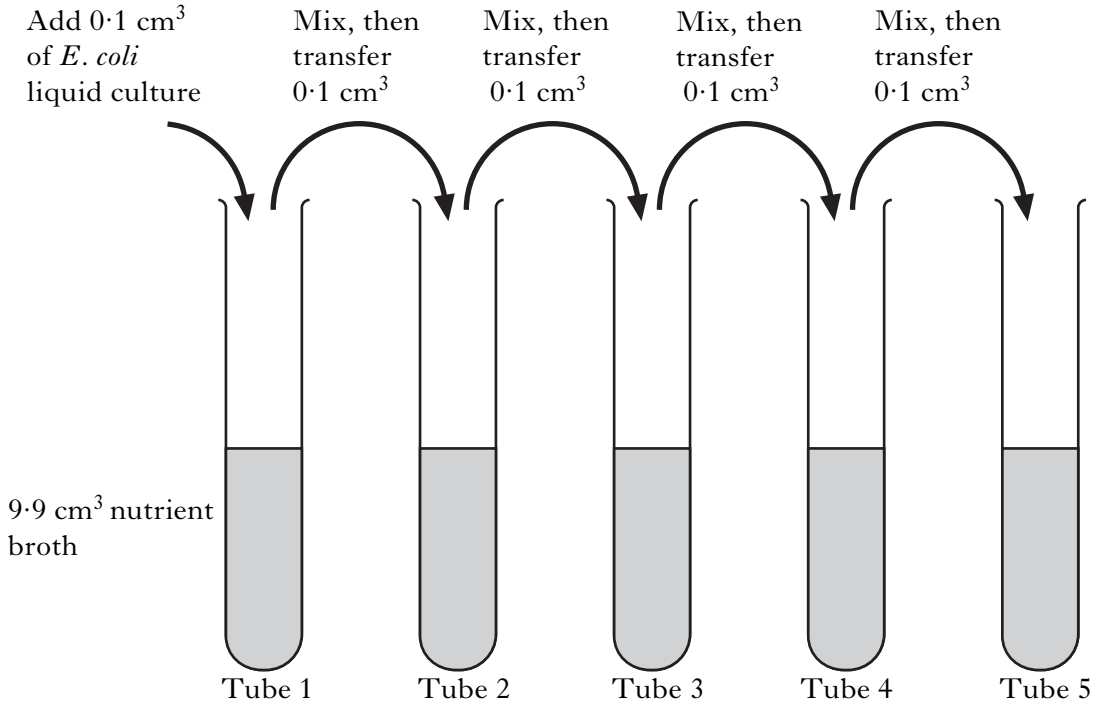
_____

_____ **1**

[Turn over

Marks

7. A biotechnologist carried out a serial dilution of a liquid culture of *E. coli* using tubes containing 9·9 cm ^{3} of nutrient broth as shown below.



(*a*) The culture added to Tube 1 contained 1 × 10 ^{12} *E. coli* cells per cm ^{3}. Calculate the concentration of cells per cm ^{3} in Tube 5.

Space for calculation

_____ cells per cm ^{3} **1**

(*b*) The biotechnologist plated out samples of known volume from tubes 1 to 5. The plates were incubated, then one was selected to be used in a viable count.

What would be taken into account when selecting a plate for a viable count?

_____

_____ **1**

Marks

7. (continued)

(*c*) The biotechnologist spilled the contents of one of the tubes onto the bench, creating a biological hazard.

(i) List the contents of a spillage kit suitable for clearing up a small scale spillage.

_____

_____

_____ **2**

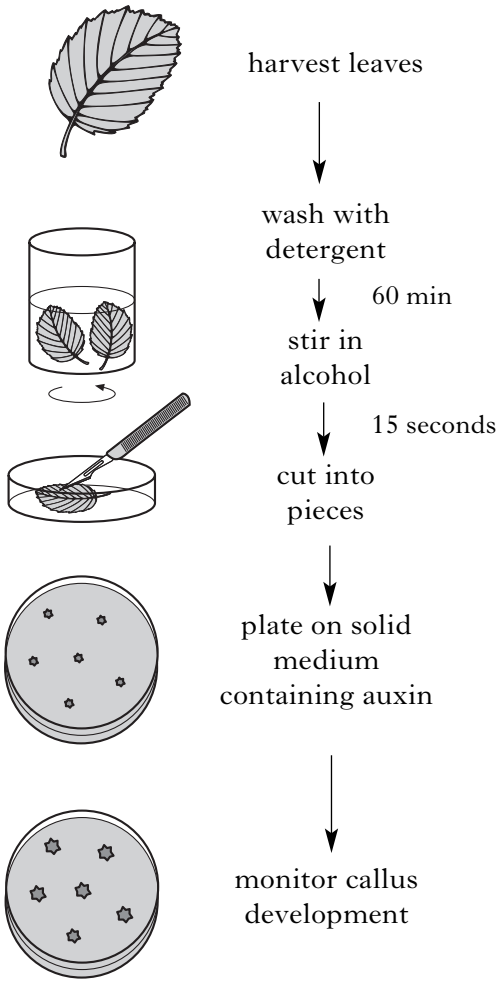
(ii) Explain the difference between a hazard and a risk.

_____

_____ **1**

[Turn over

8. (*a*) Callus tissue is produced from explants taken from plant leaves by the method shown in the diagram.



A student investigated the effect of two different concentrations of auxin on the volume of callus material produced.

The table shows the results obtained over eight days.

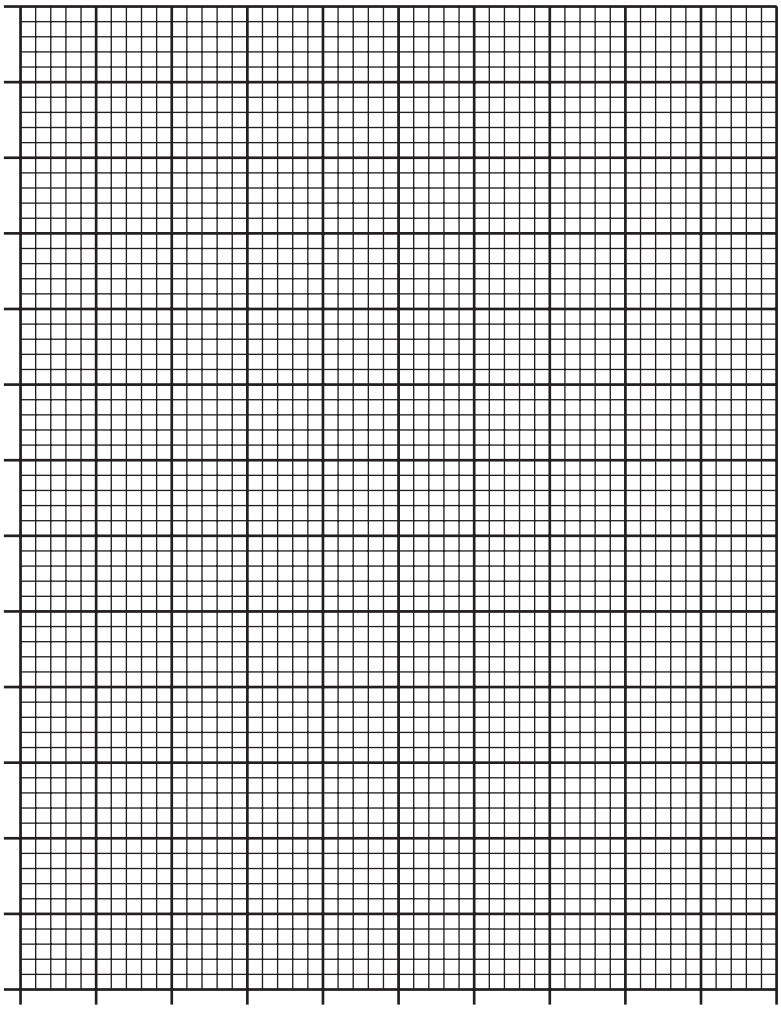
Time (days)	*Volume of callus material* (cm^3)	
	Low concentration auxin added	*High concentration auxin added*
0	1·0	1·0
1	1·2	1·4
2	1·3	1·7
3	1·5	2·6
4	1·9	4·1
5	2·4	6·0
6	3·0	8·3
7	3·9	10·6
8	5·4	12·9

Marks

8. (*a*) (continued)

(i) Plot line graphs of volume of callus material against time for each concentration of auxin. Use appropriate scales to fill most of the graph paper.

(Additional graph paper, if required, can be found on page 37)



3

(ii) Why were the leaves stirred in alcohol before being cut?

_____

_____ **1**

(iii) Suggest a suitable control for this experiment.

_____

_____ **1**

[Question 8 continues on *Page twenty-six*

Marks

8. (continued)

(*b*) Apart from auxin, name **one** other plant growth substance used in tissue culture.

_____ **1**

(*c*) Give **one** reason for including a carbon source in a plant growth medium.

_____ **1**

(*d*) State an advantage of using plant tissue culture in agriculture.

_____

_____ **1**

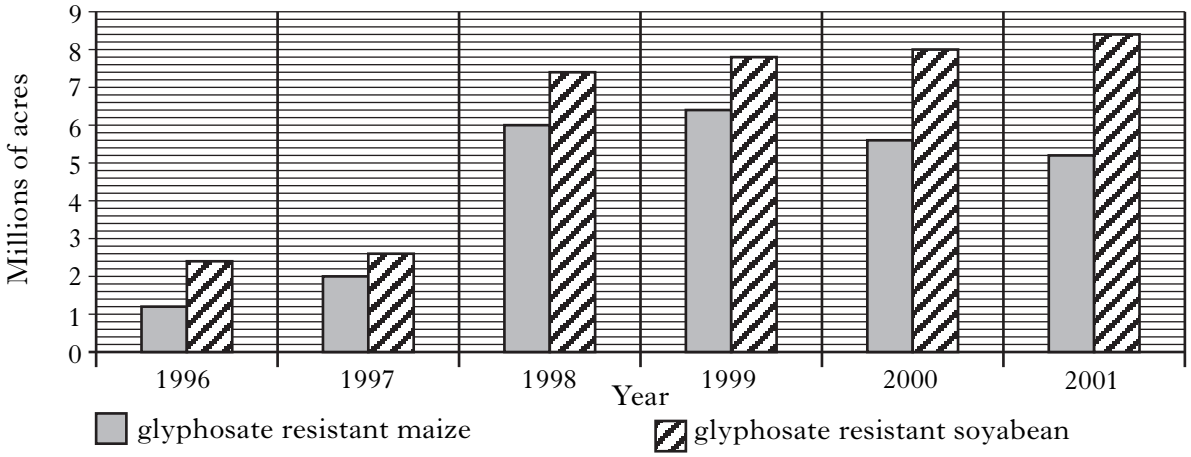
[Question 9 is on fold-out *Page twenty-seven*

Marks

9. (*a*) A maize plant was transformed by introducing a foreign gene so that it is resistant to the herbicide glyphosate. How does the presence of the foreign gene increase herbicide resistance in the maize plant?

_____ **1**

(*b*) Soya bean can also be transformed to be resistant to glyphosate. The graph below shows the acreage of glyphosate resistant maize and glyphosate resistant soya bean planted between 1996 and 2001.



Using data from the graph, compare the trend in the acreage of maize planted with that of soyabean.

_____

_____

_____ **2**

(*c*) (i) Explain how the use of herbicide resistant crops affects crop production.

_____

_____ **2**

(ii) What potential long-term disadvantage may arise from the continued use of herbicide resistant crops?

_____

_____ **1**

(*d*) Describe **two** ways in which *Bacillus thuringiensis* can be used to protect tobacco plants.

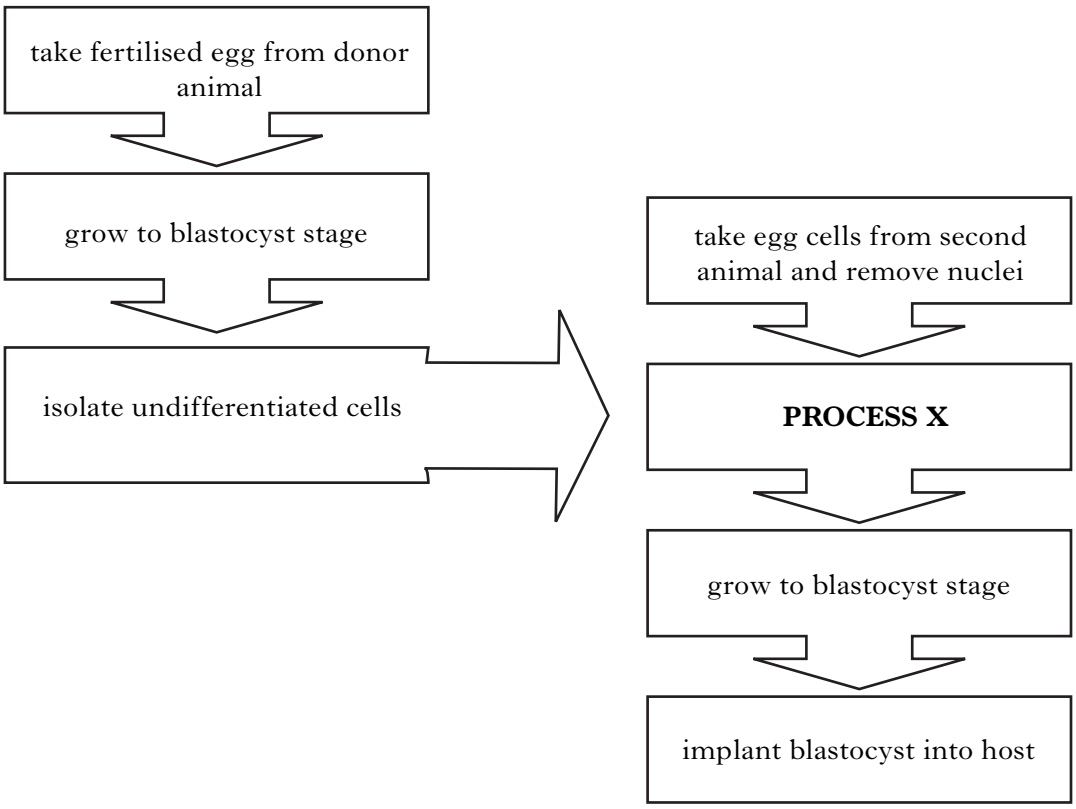
1 _____

2 _____ **2**

DO NOT WRITE IN THIS MARGIN

Marks

10. (*a*) The diagram below illustrates one strategy for embryo cloning.



(i) Describe process X.

_____

_____ **1**

(ii) What name is given to the host into which the cell is implanted?

_____ **1**

(*b*) How does somatic cell cloning differ from embryo cloning?

_____

_____ **1**

Marks

10. (continued)

(*c*) Embryo cloning can be used to produce stem cells.

(i) Give **one** possible use for stem cells.

_____ **1**

(ii) State **one** ethical concern in relation to the use of embryonic stem cells.

_____ **1**

(*d*) Embryo manipulation is another new breeding technique.

(i) Describe this technique.

_____

_____ **2**

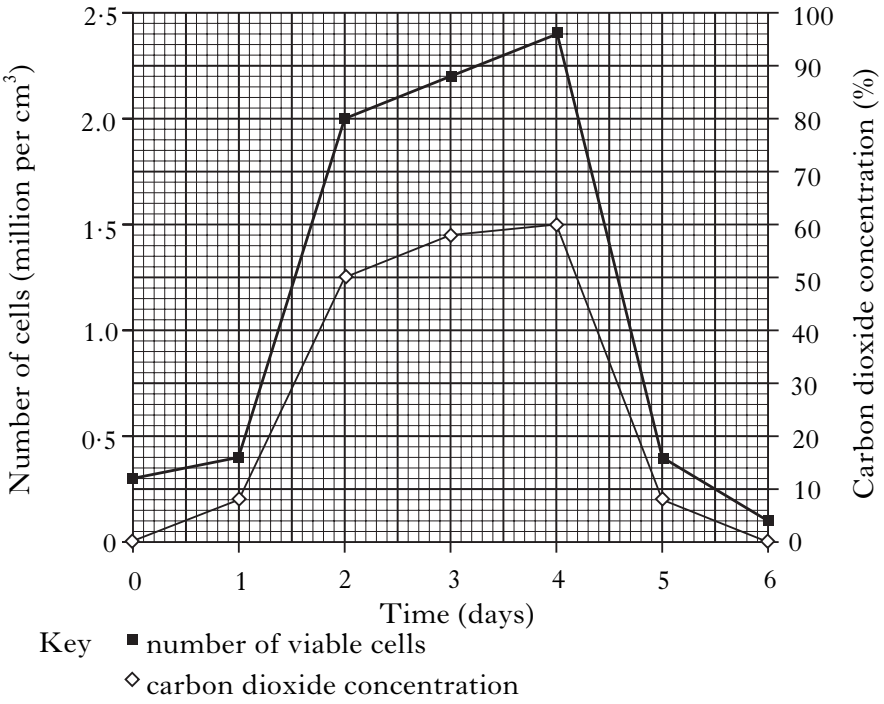
(ii) What is the benefit of using this technique?

_____ **1**

[Turn over

Marks

11. A biotechnologist investigated the use of a hydrocarbon by the bacterium *Alcanivorax* by measuring the number of viable cells and the production of carbon dioxide. The results of the investigation are shown in the graph below.



(*a*) (i) Describe the relationship between cell number and carbon dioxide production.

_____

_____ **1**

(ii) By how many times greater is the rate of cell growth from day 1 to day 2 than from day 0 to day 1?

Space for calculation

_____ **1**

Marks

11. (continued)

(*b*) The table shows the hydrocarbon concentration in the medium from day 0 to day 6 of this experiment.

Time (days)	*Hydrocarbon concentration in medium* ($\mu g/cm^3$)
0	160
1	138
2	117
3	75
4	64
5	0
6	0

(i) Use the table and graph to calculate the percentage of hydrocarbon consumed by the time that carbon dioxide production reached its highest level.

Space for calculation

_____ % **1**

(ii) Predict what would happen to the number of viable cells if more hydrocarbon was added to the medium on day 4.

_____

_____ **1**

(*c*) (i) The hydrocarbon is a major constituent of crude oil. Explain how *Alcanivorax* could be used for bioremediation.

_____

_____ **1**

(ii) Give another example of bioremediation.

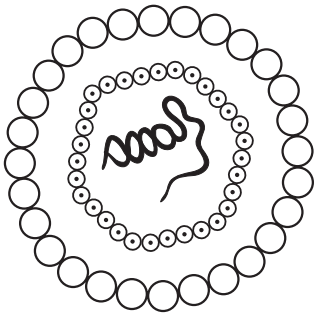
_____

_____ **1**

[Turn over

Marks

12. The diagram shows the structure of the hepatitis B virus.



Yeast cells have been genetically engineered to produce a vaccine against the hepatitis B virus.

(*a*) (i) Which part of the virus has the yeast cell been engineered to produce?

_____ **1**

(ii) Explain why hepatitis vaccine produced in this way is considered safe.

_____

_____ **1**

(*b*) Bananas can also be genetically engineered to produce vaccine. Give **two** advantages of using vaccine produced in plants.

1 _____

2 _____ **2**

(*c*) Which cells in the body respond to vaccines?

_____ **1**

SECTION C

Marks

Both questions in this section should be attempted.

Note that each question contains a choice.

Questions 1 and 2 should be attempted on the blank pages which follow.

All answers must be written clearly and legibly in ink.

Supplementary sheets, if required, may be obtained from the invigilator.

Labelled diagrams may be used where appropriate.

1. Answer **either** A **or** B.

A. Give an account of bacterial growth in liquid culture under the following headings:

(*a*) phases of bacterial growth; **6**

(*b*) factors affecting growth rate. **4**

(10)

OR

B. Give an account of immunity under the following headings:

(*a*) acquired immunity; **6**

(*b*) role of B and T lymphocytes. **4**

(10)

In Question 2 ONE mark is available for coherence and ONE mark is available for relevance.

2. Answer **either** A **or** B.

A. Describe the components of an industrial fermenter and their functions. **(10)**

OR

B. Describe the advantages of using laboratory models in biotechnology processing and the factors that should be considered when scaling up. **(10)**

[*END OF QUESTION PAPER*]

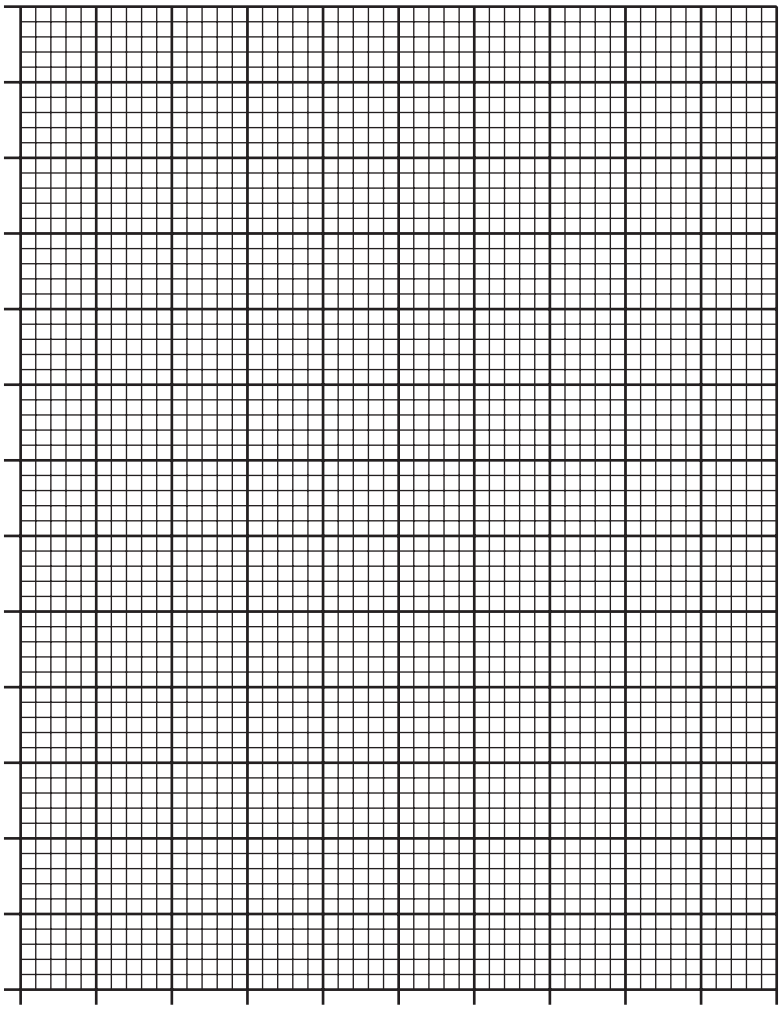
SPACE FOR ANSWERS

SPACE FOR ANSWERS

SPACE FOR ANSWERS

SPACE FOR ANSWERS

ADDITIONAL GRAPH PAPER FOR USE IN QUESTION 8 (*a*) (i)



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