THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

BIOLOGY

Microbiology and Biotechnology

2805/04

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator
- Ruler (mm/cm)

Wednesday 17 June 2009
Afternoon

Duration: 1 hour 30 minutes

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* O C E / 1 0 9 4 2 *

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**15**	
2	**19**	
3	**18**	
4	**19**	
5	**13**	
6	**6**	
TOTAL	**90**	

Answer **all** the questions.

1 Some of the features of four genera of soil bacteria are shown in Table 1.1.

Table 1.1

bacterial genus	type of respiration	Gram type	type of nutrition	cell shape
Nitrobacter	aerobic	negative	chemoautotrophic	straight rod
Streptomyces	aerobic	positive	saprobiotic	filamentous
Rhizobium	aerobic	negative	chemoautotrophic	straight rods
Clostridium	anaerobic	positive	saprobiotic/ chemoautotrophic	straight rods

Many species of *Streptomyces* have been shown to synthesise chemicals, similar to those produced by *Penicillium*, which can kill other microorganisms.

Species of the *Clostridium* genus display a range of features. Many are important in decay while others can fix nitrogen. Some are important pathogens.

(a) Using aseptic technique, a soil sample was transferred to a flask containing nutrient broth and the flask incubated. The flask was sealed with a sterile cotton wool plug to prevent contamination but to allow air into the mixed culture of soil bacteria.

(i) Describe in detail how a slide of bacteria from a sample of the broth culture could be prepared and then stained using the **Gram staining** technique.

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(ii) Give **two** reasons why it would be relatively easy to distinguish between *Nitrobacter* and *Streptomyces* on a prepared Gram stained slide.

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(iii) Give **two** reasons why it would **not** be easy to distinguish between *Nitrobacter* and *Rhizobium* on a prepared Gram stained slide.

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(iv) Suggest why you would be unlikely to view any *Clostridium* cells on the prepared Gram stained slide.

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(b) A student suggested that a chemical released by *Streptomyces* could be used to kill *Clostridium*.

A sterile filter-paper disc was dipped into a solution of the chemical released by *Streptomyces* and dried. A lawn of *Clostridium* was prepared by a spread-plate method and the disc placed centrally on the surface of the lawn.

The Petri dish, inoculated with *Clostridium*, was incubated for four days at 25°C. The results are shown in Fig. 1.1.

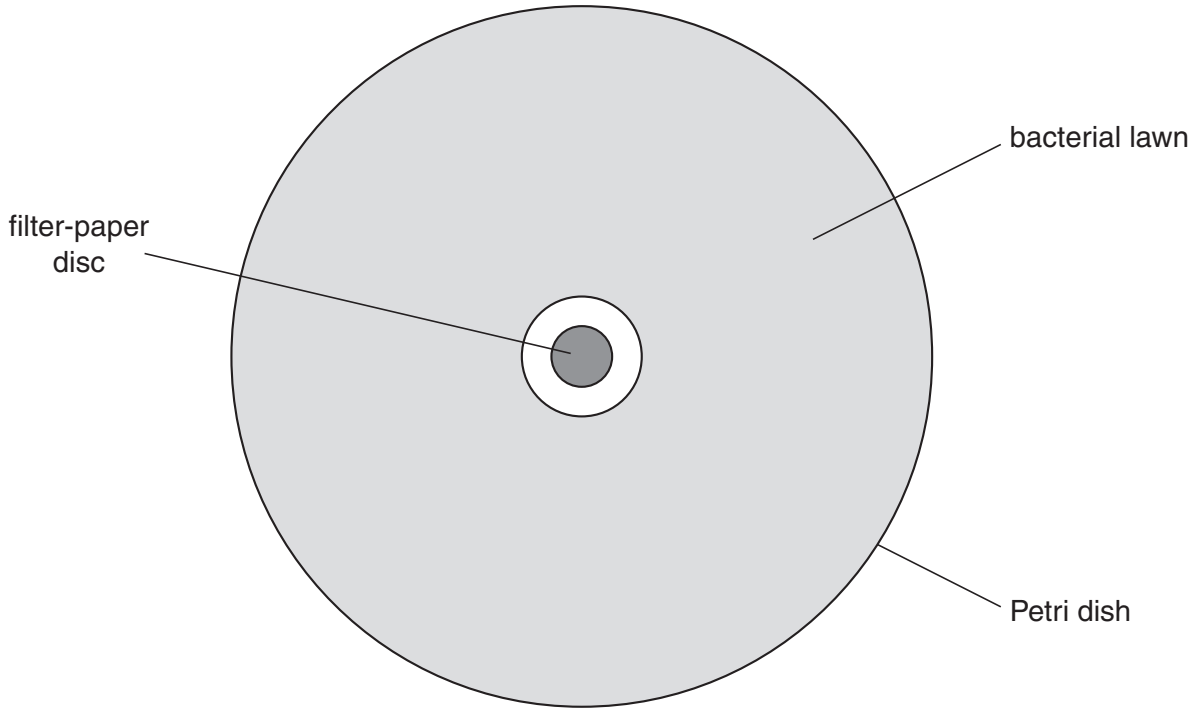

Fig. 1.1

(i) Describe **and** explain the results shown in Fig. 1.1.

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(ii) Suggest why it is useful to identify antibacterial substances that are effective in killing *Clostridium*.

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[Total: 15]

2 This question is about biotechnology and crop plants.

(a) In this question, one mark is available for the quality of use and organisation of scientific terms.

Fig. 2.1 summarises **one** method used in the genetic improvement of crop plants.

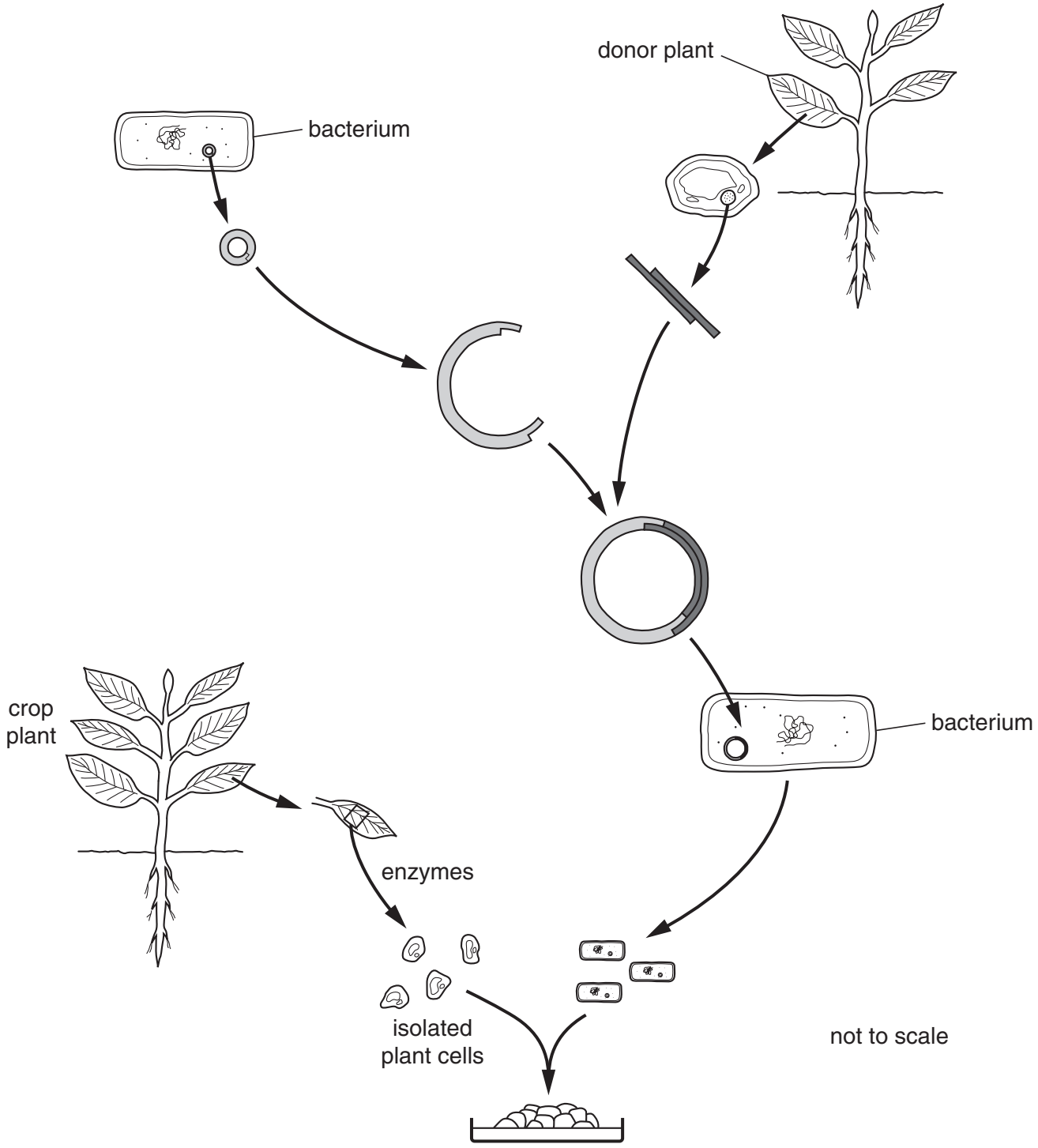

Fig. 2.1

Describe a method that can be used to transfer a gene for a **named** desirable trait to a crop plant. You may annotate Fig. 2.1 if you wish.

Details of the production of plantlets are **not** required.

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Quality of Written Communication [1]

(b) Describe **one** economic and **one** environmental benefit of producing genetically improved crop plants.

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(c) In recent years, there has been an increasing demand for fuel ethanol, which is used as a component of gasohol.

Outline the role of plant material in the production of fuel ethanol.

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(d) Biogas can be produced by mixing water, crop residues and animal dung in a biogas digester.

With reference to the microorganisms involved, outline the production of biogas in a simple biogas digester.

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[Total: 19]

3 Monoclonal antibodies that are used in pregnancy-testing kits can be produced on a large scale.

(a) Steps 1 to 6 outline one procedure for the production of monoclonal antibodies.

Step 1 Inject a small mammal with an antigen and leave for two weeks.
Step 2 Remove the spleen from the mammal to extract cells.
Step 3 Fuse the cells with myeloma cells.
Step 4 Clone the successfully fused cells in a special culture medium.
Step 5 Screen the fused cells for the production of the desired antibody.
Step 6 Culture the cells to obtain monoclonal antibody.

(i) Explain why the small mammal is left for two weeks (step **1**) before the spleen is removed (step **2**).

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(ii) Name the cells removed from the spleen in step **2**.

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(iii) Explain why the cells from the spleen need to be fused with myeloma cells in step **3**.

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(iv) Name the cells produced from the fusion that occurs in step **3**.

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(v) Suggest why fused cells are screened for the production of the desired antibody (step **5**) before proceeding to large-scale production.

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(vi) State, with a reason for your choice, a type of fermenter design that could be used successfully in the large-scale production of monoclonal antibody.

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(b) In this question, one mark is available for the quality of spelling, punctuation and grammar.

Fig. 3.1 shows monoclonal antibodies incorporated into an absorbent plastic strip used in home pregnancy testing.

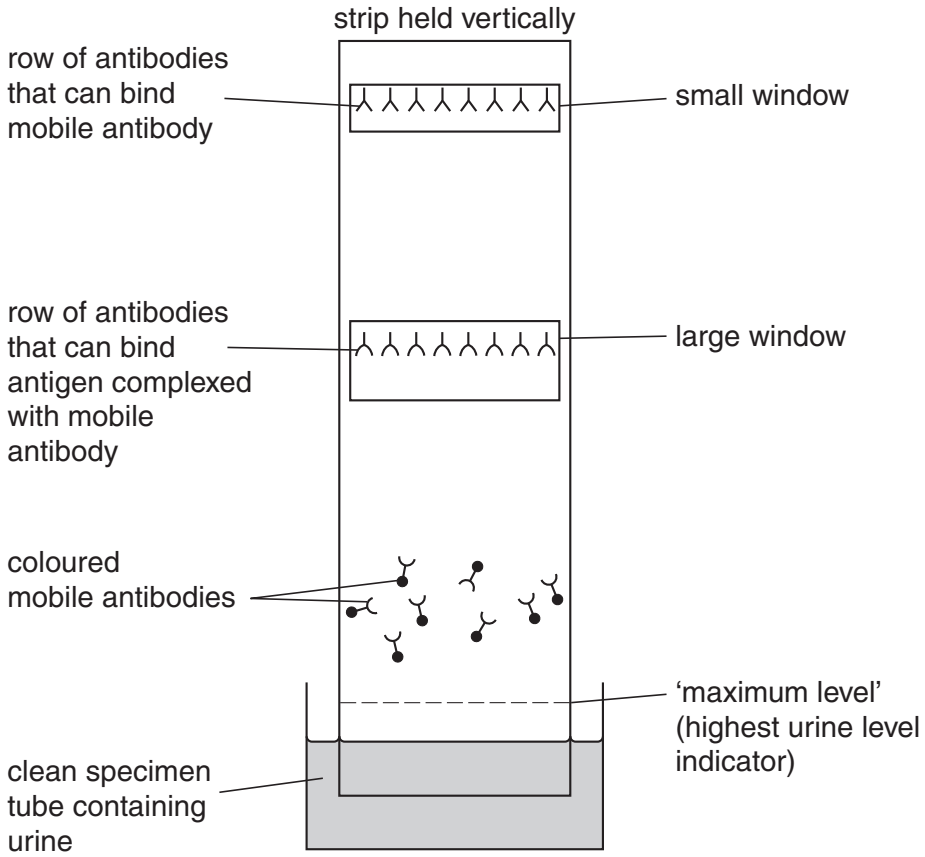

Fig. 3.1

Fig. 3.2 shows three different results, appearing on home pregnancy test strips of the same design as shown in Fig. 3.1.

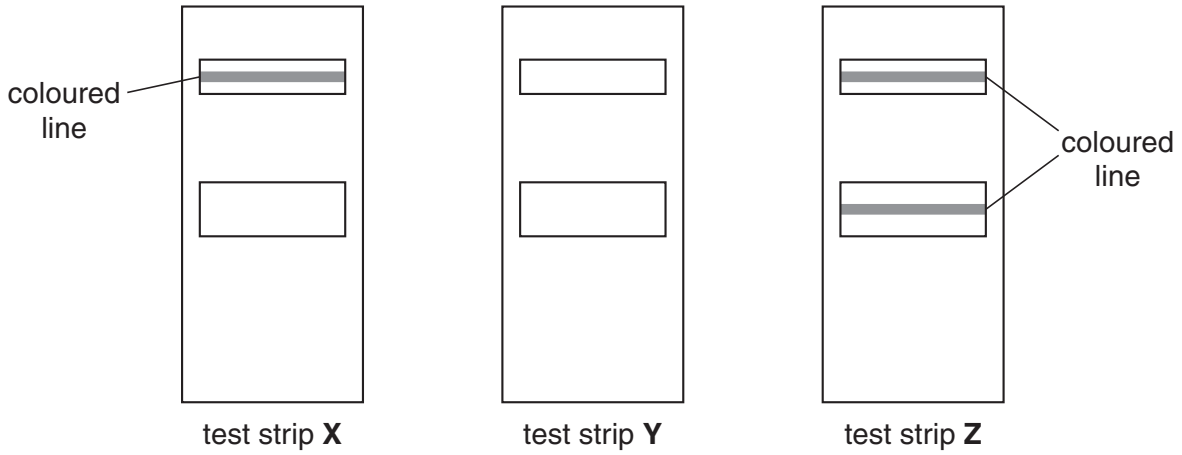

Fig. 3.2

Interpret and explain the results obtained from each of the three different test strips, **X**, **Y** and **Z**.

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Quality of Written Communication [1]

[Total: 18]

4 Microorganisms can be broadly classified according to their temperature ranges for growth. The minimum and maximum growth temperatures are the lowest and the highest temperatures at which the microorganism will grow.

Fig. 4.1 shows the growth rate and the temperature ranges for the growth of four different bacterial species, **A** to **D**:

- species **A** is a psychrophile (cryophile)
- species **B** is a mesophile
- species **C** is a thermophile
- species **D** is a hyperthermophile.

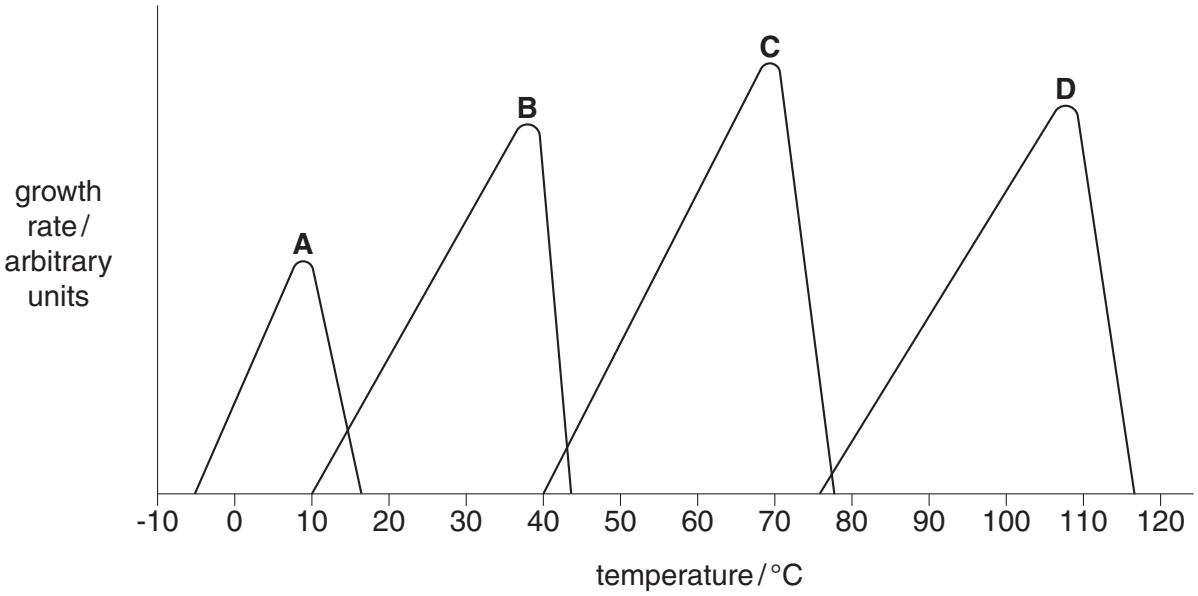

Fig. 4.1

(a) Bacterial species **E** is a psychrotroph. Psychrotrophs are microorganisms that:

- are not able to grow in freezer temperatures
- are capable of growth at temperatures lower than mesophiles
- have higher optimum growth temperatures than psychrophiles (cryophiles), but lower than mesophiles
- cannot grow above 35°C to 40°C.

(i) **On Fig. 4.1**, sketch a curve to represent the growth rate and temperature range for growth of a psychrotroph. **[2]**

(ii) Suggest why the plasma (cell surface) membranes of psychrotrophic and psychrophilic (cryophilic) organisms generally have higher levels of unsaturated fatty acids compared to the plasma membranes of mesophilic organisms.

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(b) An investigation was carried out under controlled conditions to determine the effect of temperature on growth of four different bacterial species. Table 4.1 shows the results of the investigation.

Table 4.1

bacterial species	growth temperature / °C		
	minimum	optimum	maximum
Agrobacterium tumefaciens	0	27	37
Escherichia coli	10	36	45
Pseudomonas fluorescens	4	25	40
Mycobacterium tuberculosis	31	37	42

Having studied the information and data in the completed Fig. 4.1 and in Table 4.1, a student made observations **(i)** to **(vi)**.

State, with reasons, whether the student was justified in making each observation.

(i) The temperature **range** for growth of bacteria has a spread of 30 to 35 degrees, with the temperature optimum being closer to the maximum than to the minimum.

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(ii) *E. coli* and *P. fluorescens* are mesophiles, whereas *A. tumefaciens* is a psychrotroph.

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(iii) *M. tuberculosis* is a thermophile, as it has a high minimum growth temperature.

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(iv) Psychrophiles (cryophiles) do not grow well in low temperatures, but they do grow well compared to other microorganisms.

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(v) Psychrophiles (cryophiles) are unlikely to cause diseases in humans, but they can cause spoilage of refrigerated food.

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(vi) Thermophiles and hyperthermophiles are unlikely to be human pathogens.

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[10]

(c) Thermophiles and hyperthermophiles are found in diverse locations such as compost heaps and deep-sea hydrothermal vents, where other microorganisms are unable to live.

In biotechnology, these microorganisms and their enzymes have a role in a range of applications, for example genetic engineering, fermentation technology and other industrial processes.

Discuss the usefulness of thermophiles and hyperthermophiles to humans.

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[Total: 19]

5 Typical fermenters used in the large-scale production of penicillin and mycoprotein are shown in Fig. 5.1.

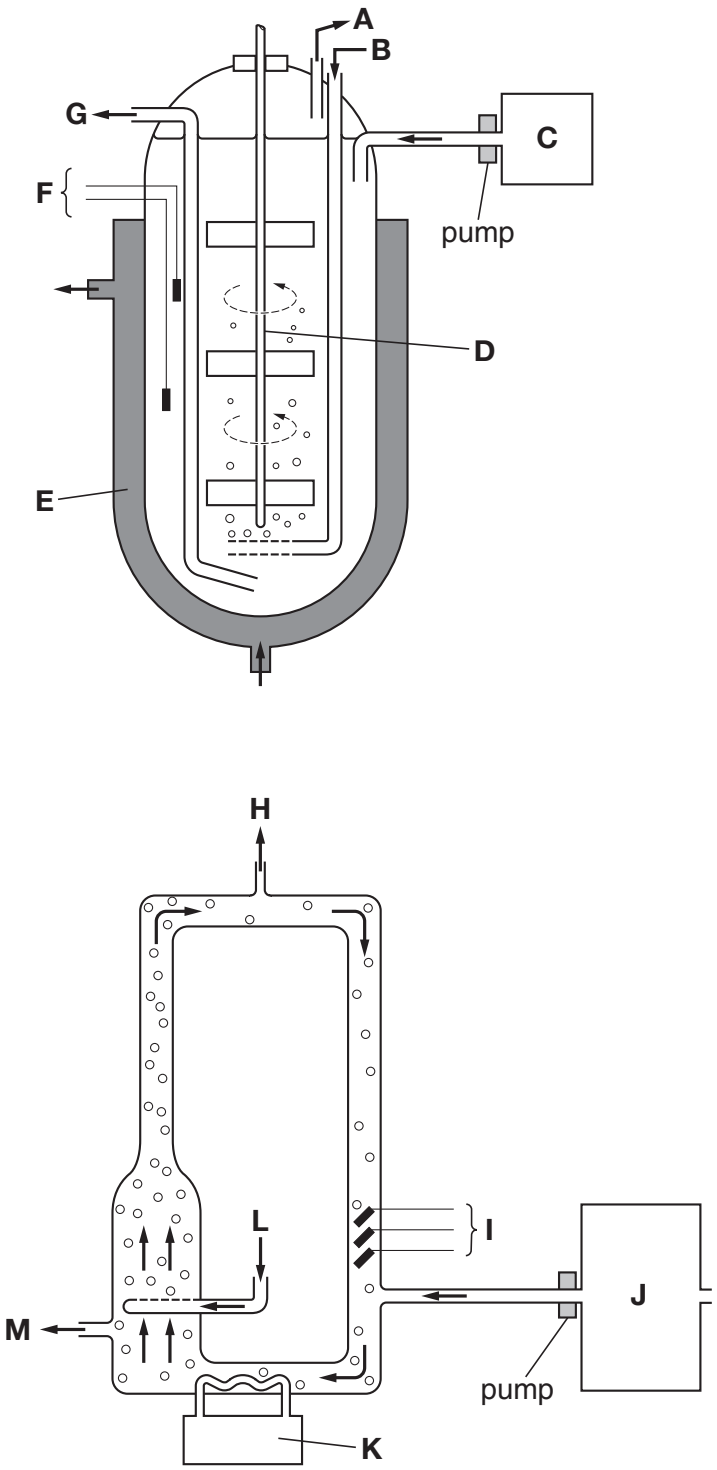

Fig. 5.1

(a) The following statements are associated with operational features in mycoprotein or penicillin production. For each feature:

- state the production process to which the feature is referring, using the letter **M** for mycoprotein, **P** for penicillin or **B** for both mycoprotein and penicillin
- give a label letter, from Fig. 5.1, for the correct design feature that enables the operational feature to occur

operational feature	production process	design feature
oxygen is supplied to enable aerobic respiration to occur		
environmental conditions are constantly monitored so that they are maintained at the optimum		
small volumes of lactose are added periodically		
controlled venting of waste gases avoids pressure build-up **and** allows the culture to circulate		
the excess heat generated by respiration and by the motor-driven stirrer is removed		
ammonia is added as a source of nitrogen		
nutrients are added continuously at a constant rate		

[7]

(b) Many fermentation processes use stainless steel fermenters for large-scale production.

Explain the benefits of using stainless steel fermenters.

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(c) In both mycoprotein and penicillin production, RNA is produced by the organism.

Suggest why RNA reduction during downstream processing is only carried out for mycoprotein production.

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[Total: 13]

6 For work experience, a student spent a week in the kitchen of a restaurant that specialised in menus that included home-made produce.

A diary that was submitted at the end of the week recorded the student's experiences in the production of their home-made yogurt, cheese and beer, and in the preparation of the meals.

In the written feedback that the student received, more information was requested.

Write a reply to each of the requests in the space provided.

(a) State the name of the enzyme that caused the milk to coagulate when you made the cheese.

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(b) State the final pH that you obtained when you tested the yogurt that you made.

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(c) State the name of the ingredient that you added to give the bitter flavour to the beer.

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(d) Explain why you did not discard the spent brewers' yeast after the fermentation stage.

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(e) Explain the function of the chemical 'meat tenderiser' that you used when you helped prepare the meals.

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[Total: 6]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE