Answer **all** the questions.

1 Fig. 1.1 is a flow diagram showing the main stages involved in making cheese. The starting material is milk, which contains the protein, casein.

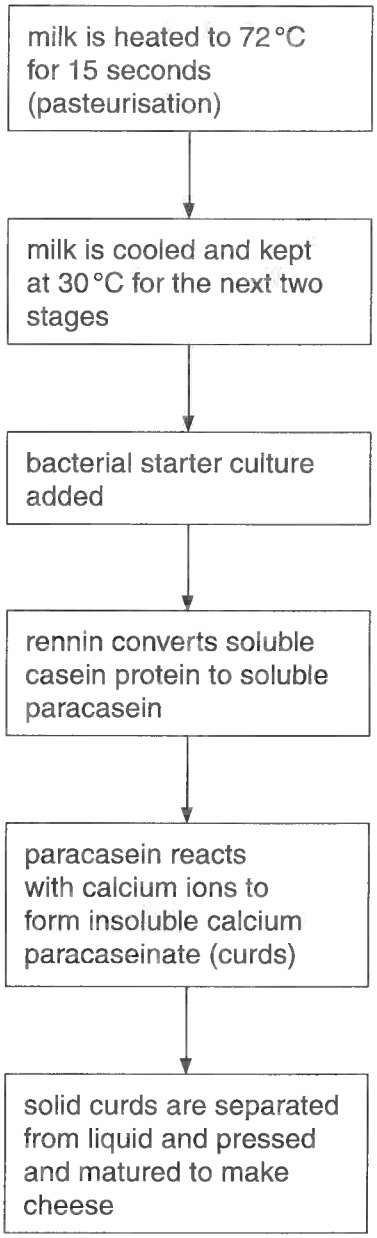

Fig. 1.1

(a) (i) Explain why making cheese can be described as a biotechnological process.

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..... [2]

(ii) Suggest **two** benefits of the pasteurisation stage.

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..... **[2]**

(b) (i) Rennin is a protein that can be obtained from the stomach lining of calves. It is used in the cheese-making process in the ratio one part rennin to 10 000 parts milk.

Suggest what type of protein rennin is **and** explain how a very small quantity of rennin is able to convert a large quantity of milk.

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..... **[3]**

(ii) Rennin could, in theory, be immobilised for use in cheese-making.

List **two** potential advantages of this.

1 .....

2 ..... **[2]**

(c) Rennin can now be made by genetically modified microorganisms.

Outline the process by which bacteria can be genetically modified to produce rennin.

In your answer, you should make clear how the steps in the process are sequenced.

[8]

[Total: 17]

5 A batch fermenter is used during the production of beer.

Fig. 5.1(a) and Fig. 5.1(b), **on page 3 of the insert**, show some changes that take place in the fermenter over the first 6 days.

(a) (i) Describe the pattern of growth of the yeast population in this fermenter.

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..... **[4]**

(ii) Fig. 5.1(a) shows that as the sugar concentration decreases the ethanol concentration increases.

Explain this relationship.

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..... **[3]**

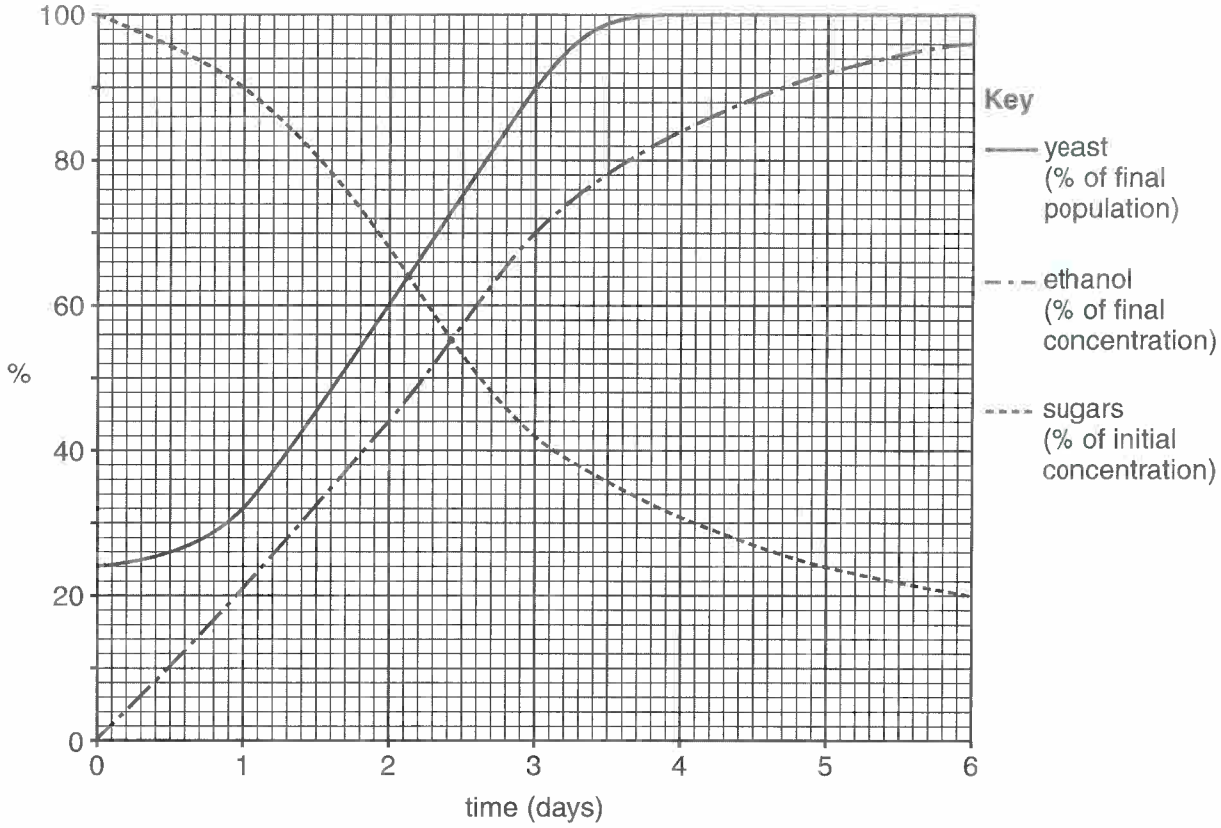
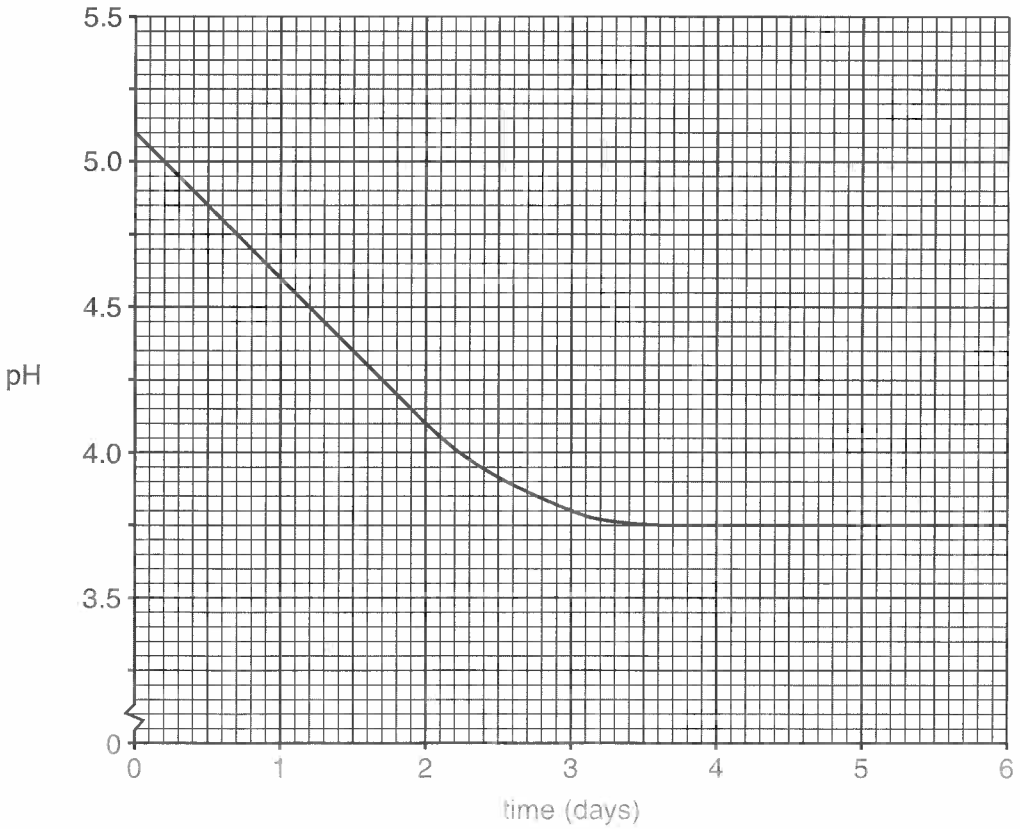

100
80
60
40
20
0
%
0
1
2
3
4
5
6
time (days)
Key
yeast (% of final population)
ethanol (% of final concentration)
sugars (% of initial concentration)

Fig. 5.1(a)


5.5
5.0
4.5
4.0
3.5
0
pH
0
1
2
3
4
5
6
time (days)

(iii) Using the information from Fig. 5.1(a), explain why ethanol is considered to be a primary metabolite of yeast.

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..... **[1]**

(iv) Using only the information from Fig. 5.1(a) and Fig. 5.1(b), outline how **two** factors may limit the maximum size of the yeast population.

1 .....

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2 .....

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[2]

(b) A mixture of three sugars is added to the batch fermenter at the beginning of the process:

- the monosaccharide glucose, which the yeast uses up first, during days 0 to 2
- the disaccharide maltose, which is used during days 1 to 5
- the trisaccharide maltotriose, which is used during days 4 to 6.

Suggest why the yeast uses the sugars in this order.

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..... **[3]**

Question 5(c) begins on page 24

(c) Ethanol is an important chemical that is manufactured on a large scale.

One large-scale process to produce ethanol uses biotechnology, with yeast acting on sugar in a fermenter.

Another large-scale process uses a chemical method instead of microorganisms. This method needs:

- ethene (obtained from oil)
- a high temperature of 300 °C
- high pressure steam.

Discuss the advantages and disadvantages of **using yeast** to make ethanol rather than using the chemical method.

In your answer you should give a balanced account of both the advantages and disadvantages.

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[Total: 19]

Answer **all** the questions.

1 Enzyme immobilisation is an important technique in biotechnology.

Figs 1.1 and 1.2 show two stages in making a bioreactor to remove lactose sugar from milk.

In Fig. 1.1 the enzyme lactase is immobilised in alginate beads.

In Fig. 1.2 milk flows over the beads and the lactose sugar is hydrolysed to two other sugars.

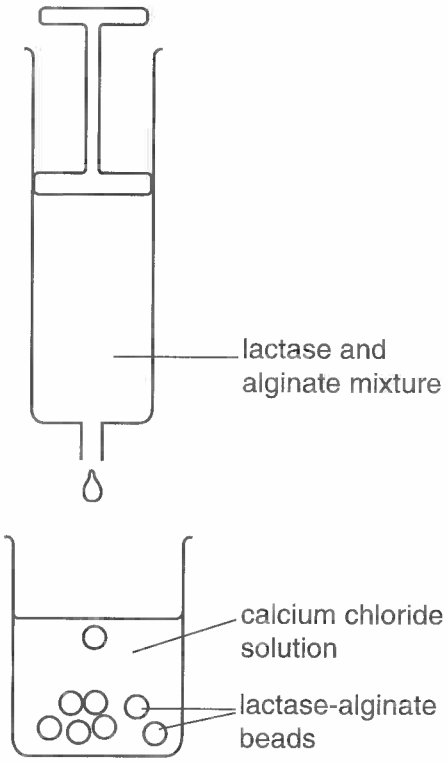

Fig. 1.1

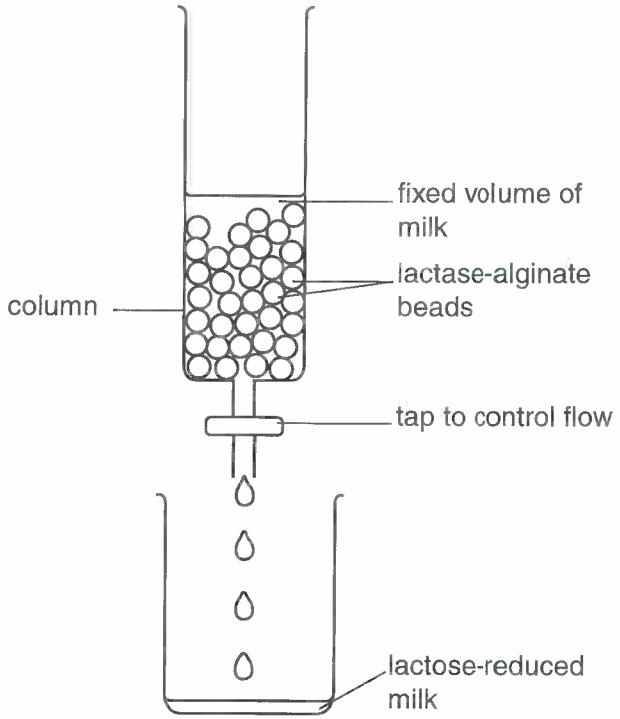

Fig. 1.2

(a) Suggest **and** explain how you might use the method shown in Fig. 1.2 to obtain milk that was **lactose-free**.

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..... [2]

(b) (i) Fig. 1.1 and Fig. 1.2 show that alginate beads can be used to immobilise an enzyme.

Outline **two other** methods of immobilising enzymes.

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..... [2]

(ii) Enzyme immobilisation is used in the biotechnology industry for the large-scale production of materials.

Discuss the benefits of using immobilised enzymes for large-scale production.

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[Total: 8]

4 Rhubarb, *Rheum x hybridum*, is a plant that is grown for its edible stems. In Spring, the stems and leaves grow from fleshy roots which survive the Winter underground.

Growers have developed many new varieties of rhubarb by growing plants from seed, choosing the best young plants and then asexually reproducing them.

Seeds are produced by sexual reproduction and the rhubarb plants that grow from seed show variation in characteristics such as stem colour, dormancy period and the concentration of oxalic acid in their leaves.

(a) Outline the events that lead to genetic variation in gametes **and** in the plants grown from seed.

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..... **[5]**

(b) Traditionally, rhubarb plants have been produced by vegetative propagation. The best young rhubarb plants are allowed to grow for three seasons until their underground root systems are large enough. They are then dug up in Winter, the roots are cut into pieces and the pieces are replanted. Each piece is then able to grow into a new rhubarb plant that is identical to the parent.

(i) State the biotechnological term for this type of vegetative propagation.

..... **[2]**

(ii) A gardener wished to multiply his rhubarb plants using the traditional method, but he discovered that his plants were infected by a virus.

Name the modern technique which allows commercial growers to produce large numbers of genetically identical plants that are also virus-free.

..... **[1]**

(iii) Rhubarb plants must spend seven to nine weeks at a temperature below 3 °C in order to break their winter dormancy and allow them to start growing stems and leaves again.

The length of the cold period that is required depends on the variety of rhubarb.

In the variety 'Timperley Early', the length of the cold period is shorter, so the plants grow and produce a crop earlier in the year than the variety 'Victoria'.

Suggest **two** ways in which the varieties may differ from one another **biochemically** to account for the difference in the length of the cold period required by each.

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..... **[2]**

Question 4(c) begins on page 10

(c) Rhubarb leaves contain oxalic acid, a relatively strong acid which is soluble in water and alcohol. High concentrations of oxalic acid makes rhubarb leaves poisonous to humans and other animals.

(i) The amount of oxalic acid in the leaves varies according to the variety of rhubarb, the age of the plant and environmental factors.

Suggest and plan an experiment to compare how the variety of rhubarb affects the amount of oxalic acid in rhubarb leaves.

Include in your plan:

- the variables that you could control
- an outline of the experimental procedure you would use
- any measurements that you would make.

In your answer you should make clear which are the independent, dependent and controlled variables.

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(ii) As rhubarb leaves are poisonous, they are cut off when the stems are harvested and may be left to decompose on the compost heap.

Outline the role of **decomposers** in the decomposition of leaves.

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..... [3]

(d) An early harvest of rhubarb stems can be obtained by placing an upturned bin over the root when it comes out of dormancy, so the emerging shoots are kept in the dark. The shoots then grow more quickly to a height suitable for picking.

Use your knowledge of **plant growth regulators** (plant hormones) to suggest why shoots kept in the dark grow taller than those left in the light.

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..... [2]

[Total: 21]

6 Microorganisms are often used in biotechnological processes.

Fig. 6.1 shows the standard growth curve for a culture of bacteria.

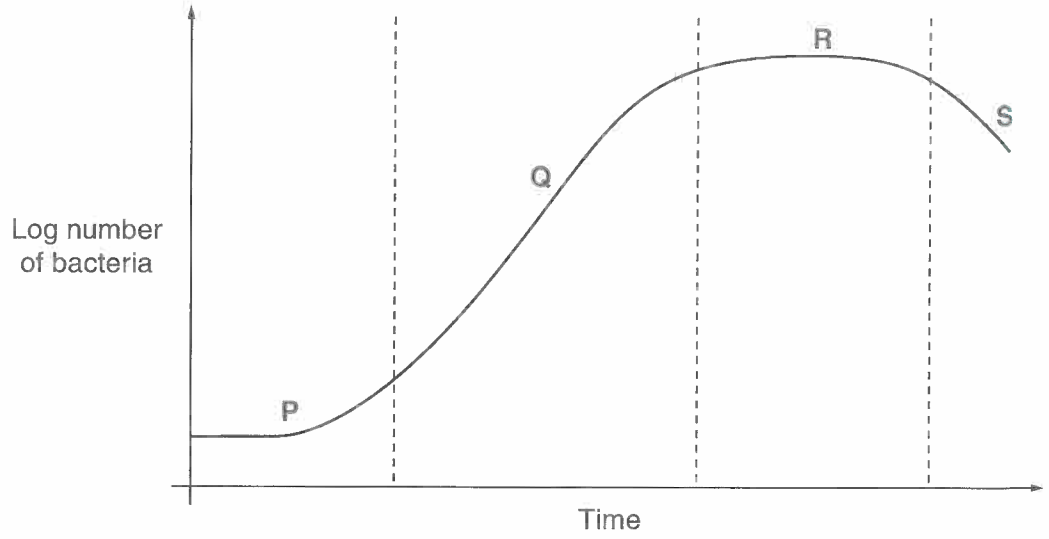

Fig. 6.1

(a) Identify the phases labelled **P**, **Q** and **R** in Fig. 6.1.

P .....

Q .....

R .....

[3]

Metabolic processes taking place in bacteria grown in a batch culture produce primary and secondary metabolites.

(b) Explain what is meant by a primary metabolite.

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..... **[2]**

(c) With reference to the information in Fig. 6.1, state the phase or phases, **P**, **Q**, **R** or **S**, when

(i) primary metabolite production is at its highest **rate**;

..... **[1]**

(ii) most secondary metabolites are produced;

..... [1]

(iii) the concentration of secondary metabolites reach a maximum.

..... [1]

(d) Some aerobic recombinant bacteria were grown in a fermenter. They synthesised the protein human growth hormone (HGH).

(i) Suggest **two** ways in which named factors inside the fermenter could be adjusted in order to maximise the yield of HGH.

1 .....

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2 .....

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[4]

(ii) HGH made in this way is given by injection to some children who have a genetic mutation. The mutation means that they do not produce enough HGH to enable them to grow at the normal rate.

Explain why injecting recombinant HGH in this way is **not** an example of gene therapy.

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..... **[3]**

[Total: 15]

4 **(a)** Microorganisms include fungi and bacteria. Fungi are eukaryotes. Bacteria are prokaryotes.

Describe **one** distinctive feature of the cell structure of each of these microorganisms.

fungal cell .....

.....

bacterial cell .....

..... **[2]**

(b) The use of microorganisms in biotechnology involves aseptic technique. Aseptic technique prevents pathogens contaminating products.

What is meant by the term pathogen?

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..... **[1]**

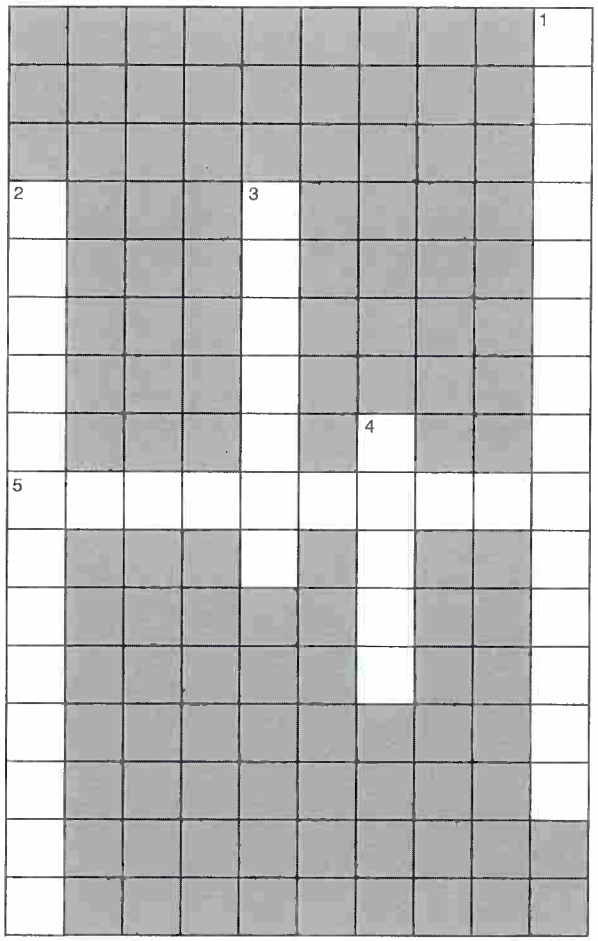
(c) State what is meant by biotechnology using suitable examples from different areas of biotechnology **and** explain why microorganisms are used in biotechnological processes.

In your answer you should give examples of products and the microorganisms used to make them, as well as the advantages of using microorganisms.

[8]

[Total: 11]

5 Fig. 5.1 is a crossword that should contain five words relating to the use of microorganisms by humans.



[5]

Fig. 5.1

Use the clues below to write the five appropriate words in the correct spaces on Fig. 5.1.

ACROSS

5 Microbial culture method in which nutrients are added and the product harvested throughout the fermentation process.

DOWN

1 Technique that makes enzymes more thermostable and allows them to be re-used.

2 The industrial use of living organisms to produce food, drugs or other products.

3 Sterile technique that prevents the growth of undesirable microorganisms.

4 Kingdom of eukaryotic microorganisms with cell walls made of chitin.

[Total: 5]

4 The antibiotic penicillin is produced by batch culture of the fungus *Penicillium chrysogenum*.

(a) Fig. 4.1 shows the concentration of penicillin, lactose and ammonia as well as the fungal biomass over time when penicillin is being produced by batch culture.

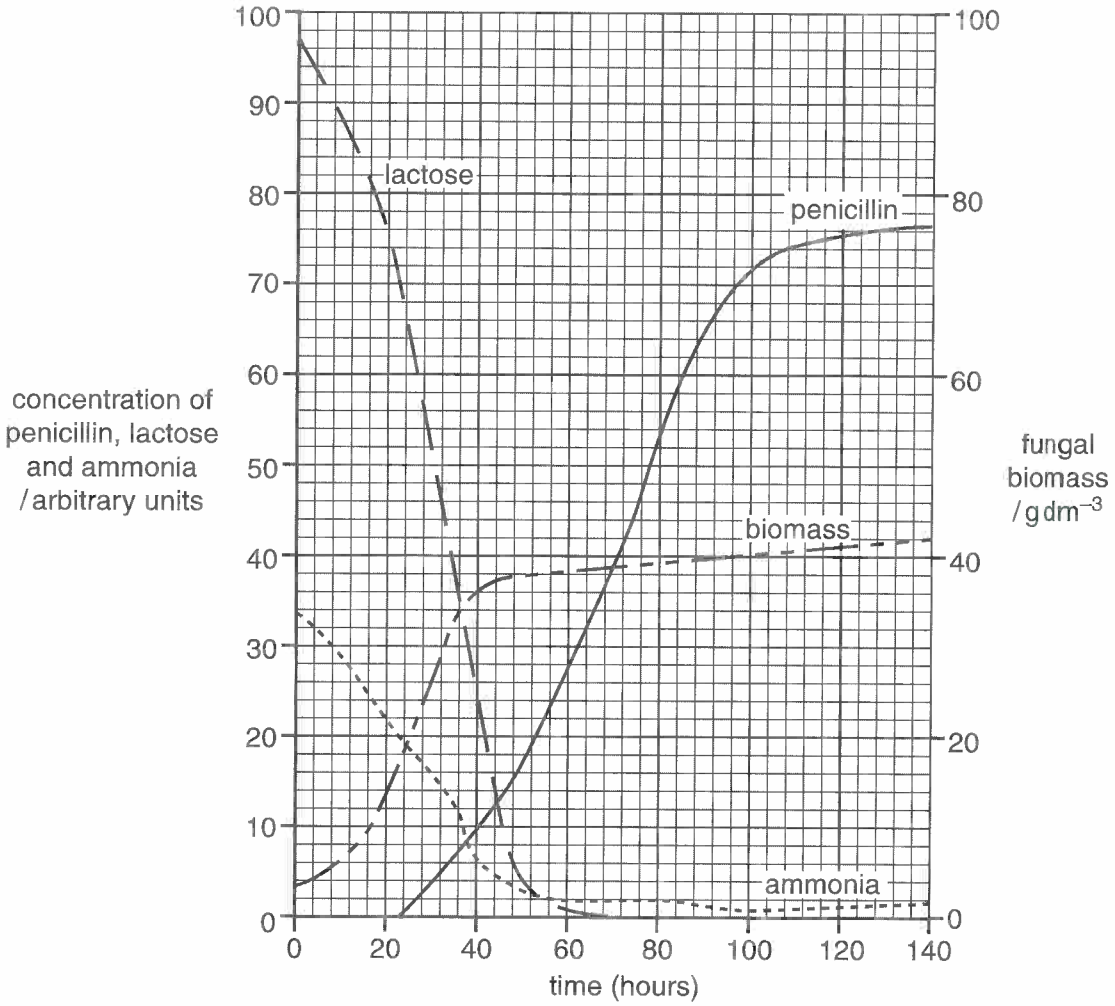


Fig. 4.1

(i) With reference to Fig. 4.1, describe and explain the changes in concentration of lactose **and** ammonia.

description .....

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explanation .....

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..... **[4]**

(ii) A student incorrectly suggested that penicillin might be produced by continuous culture fermentation instead of by batch culture.

Suggest how the curves for lactose, ammonia and biomass on Fig. 4.1 might differ in continuous culture.

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..... **[2]**

(iii) A second student said that continuous culture would not be suitable, as penicillin is a secondary metabolite.

What evidence is there in Fig. 4.1 that penicillin is a secondary metabolite?

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..... **[2]**

(b) (i) Explain the importance of maintaining aseptic conditions in manufacturing penicillin by fermentation.

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..... [3]

(ii) State **three** physical or chemical factors within the fermenter, other than nutrient levels, that need to be monitored and controlled.

For each factor, explain **why** it must be controlled.

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..... [3]

[Total: 14]