1. Plants can be cloned artificially by taking cuttings.

Which of the following are important steps when cloning a plant by taking a cutting?

1 Keep it regularly watered.
2 Add rooting hormones to agar jelly.
3 Sterilise a small sample of plant material.

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer ☐ **[1]**

2. Microorganisms can be used to produce food.

Which option is **not** seen as an advantage of using microorganisms to produce food compared to traditional food production methods?

A Microorganisms grow more rapidly than plants or animals.
B Production can be easily varied to meet demand.
C Production can occur at low temperatures and pressures.
D There are no animal welfare issues.

Your answer ☐ **[1]**

3. Aseptic conditions are important when culturing microorganisms.

Which option is **not** a correct part of the procedure for spreading bacteria on an agar-filled Petri dish?

A Remove the lid of the Petri dish and rest it upside-down on the work surface.
B Replace the lid of the Petri dish and secure it with tape.
C Sterilise the area surrounding the experiment with disinfectant.
D Work near a Bunsen flame to create an upward draft of air.

Your answer ☐ **[1]**

4. A standard growth curve for a population of bacteria of the same species in a closed system involves a death phase.

Which option explains the death phase?

A Interspecific competition for nutrients, such as glucose, is high.
B Intraspecific competition for resources, such as oxygen, begins.
C Production of toxic waste products is at its highest level.
D Reproduction stops due to exhaustion of resources.

Your answer ☐ **[1]**

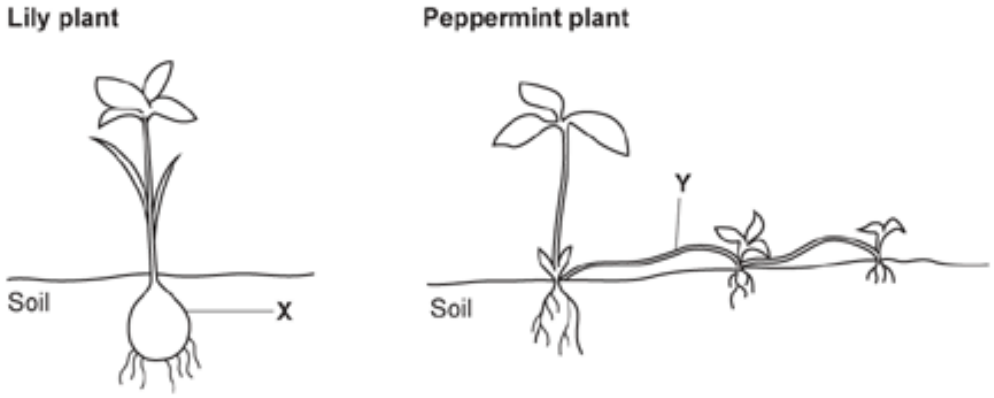
5(a). Plants can be cloned and propagated in horticulture and agriculture.

Describe how artificial clones of plants are produced using micropropagation.

---

[4]

(b). The diagram shows a lily plant and a peppermint plant.



i. State the name of structure **X and** outline how a gardener could produce many cloned plants from structure **X**.

---**[2]**

ii. State the name of structure **Y and** describe the process by which a new plant can form naturally from structure **Y**.

---**[2]**

6(a). *Escherichia coli* is a bacterium that is used widely in scientific experiments and in biotechnology.

A student carries out a serial dilution of an *E. coli* culture.

This is the method the student uses:

- Transfer 10 cm^3 of *E. coli* culture to a sterilised test tube from an original culture that has a volume of 50 cm^3.
- Carry out four 10-fold serial dilutions. Each dilution involves transferring 1 cm^3 of culture from one test tube to another test tube containing 9 cm^3 of distilled water.
- Transfer 1 cm^3 of the final 10 cm^3 diluted culture to an agar plate. Evenly spread 1 cm^3 of liquid across the plate using a sterilised spreader.
- Use a micropipette for each transfer.
- Incubate the agar plates for 24 h.
- Count the number of colonies that develop on the plate. Each colony is assumed to develop from a single bacterium.
- Estimate the *E. coli* population in the original 50 cm^3 culture.

i. Describe **two** improvements to the student's method, **other than** using different equipment, that could improve the accuracy of their population estimate.

1 _____

2 _____ **[2]**

ii. The student counts 22 colonies on the agar plate.

Calculate the total number of *E. coli* cells in the original 50 cm^3 culture.

Give your answer in standard form.

Total number of *E. coli* cells in 50 cm^3 = ... **[3]**

(b). *E. coli* can be genetically modified to produce useful proteins.
State **two** other reasons why *E. coli* is a suitable microorganism to use in biotechnology.

1 _____

_____

2 _____ **[2]**

7. Many organisms undergo asexual reproduction by mitosis.

Asexual reproduction is also known as cloning.

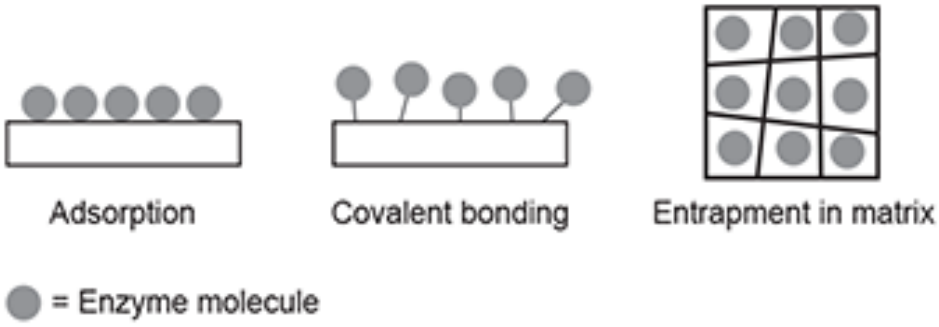
Many organisms can be artificially cloned for commercial purposes.

Discuss the arguments for **and** against artificial cloning in plants **and** animals.

[6]

8(a). Immobilised enzymes are often used for industrial processes.

The figure below shows three methods for immobilising enzymes.



State **one** other method for immobilising enzymes.

_____

_____ **[1]**

(b). One advantage of using immobilised enzymes is that the enzyme can be reused many times. However, the process of immobilisation can reduce the activity of enzymes.

With reference to the figure, explain why the activity of immobilised enzymes might be lower than that of enzymes that are free in solution.

_____

_____

_____

_____

_____ **[2]**

(c). Invertase is an enzyme that catalyses the following reaction:

sucrose ⟶ glucose + fructose.

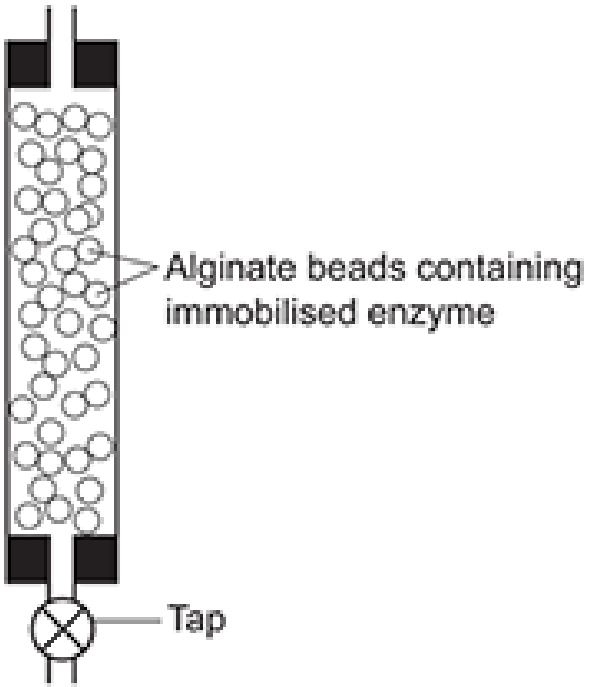
Invertase is present in cells of baker's yeast, a type of fungus. It is possible to immobilise invertase and it is also possible to immobilise yeast cells.

i. Suggest **one** reason why using immobilised yeast might be more expensive than using immobilised invertase.

_____

_____ **[1]**

ii. Investigations involving immobilised enzymes can be carried out using equipment like that shown in the figure below. A glass column with an outlet at the bottom is filled with alginate beads containing immobilised enzyme. The substrate can be added at the top and the product collected at the bottom.



A student wanted to compare the ability of immobilised invertase and immobilised yeast cells to hydrolyse sucrose.

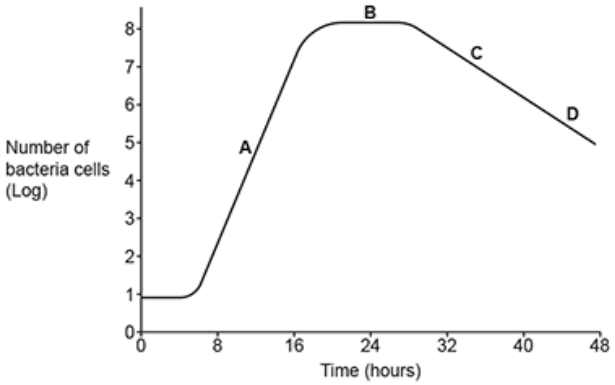
The student had access to the following:

- sucrose solution
- alginate beads containing invertase
- alginate beads containing yeast cells
- glass columns such as the one shown in the figure
- standard laboratory equipment and reagents.

Outline a valid method the student could use to compare the activity of immobilised invertase and immobilised yeast cells.

[6]

9. The graph below shows the population of viable bacteria in a flask over 48 hours.

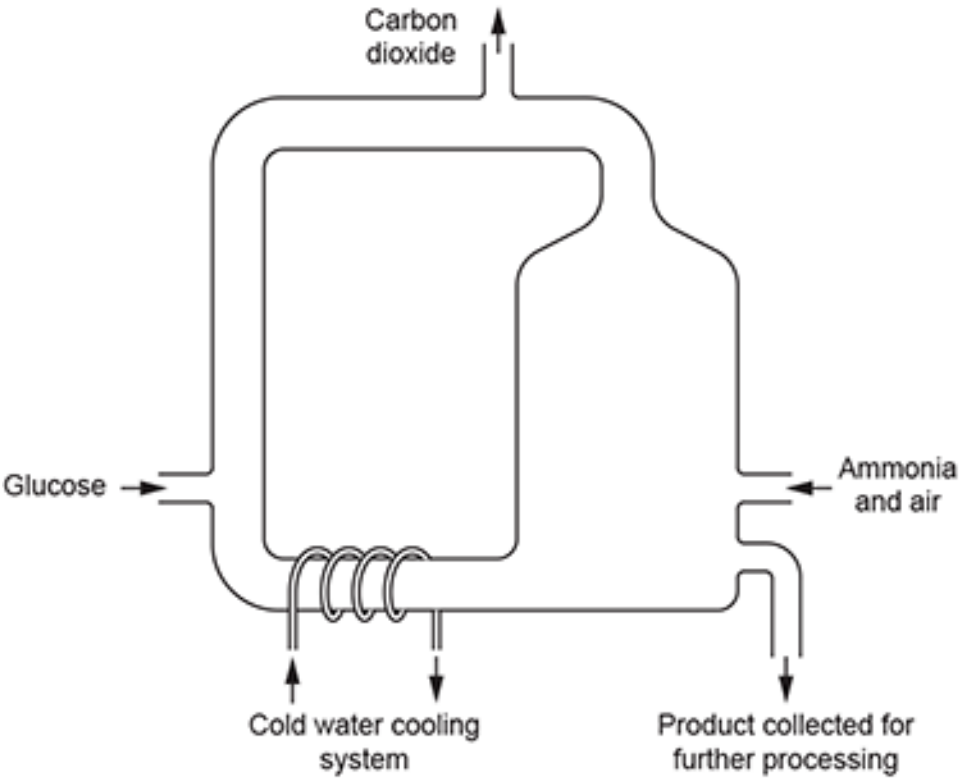


Which time, **A** to **D**, has the highest bacterial death rate?

Your answer ☐ **[1]**

10(a). The microorganism that is used to produce mycoprotein is a fungus.

The diagram is of a fermenter used for mycoprotein production.



i. Use the diagram to name the type of fermentation process used for mycoprotein production.

Justify your answer.

Name _____

Justification _____

_____

[1]

ii. Suggest and explain why a cooling system is necessary.

_____

_____

_____

_____

[2]

iii. The air inlet provides the fungus with oxygen for respiration, and ammonia.

Suggest and explain why the fungus is provided with ammonia.

[2]

(b). Microorganisms can be used to produce a variety of food products.

Microorganisms have simple nutrient requirements, which helps to reduce production costs.

List **two** other advantages of using microorganisms in food production.

1

2

[2]

(c). Yoghurt is a food produced from milk using microorganisms.

Yoghurt production involves two bacteria: *Lactobacillus delbrueckii* and *Streptococcus thermophilus*.

i. The bacteria convert the lactose present in milk into lactic acid.

Lactic acid is an important contributor to the flavour of yoghurt. Lactic acid also helps to give yoghurt a longer shelf life than milk.

Suggest how lactic acid helps to extend the shelf life of yoghurt.

[2]

ii. Both bacteria also break down some of the protein casein, which is present in milk.
Name the product of protein breakdown and describe the type of reaction that takes place.

Product _____

Reaction _____

_____

[2]

11(a). Some students investigated the effect of time on the growth of bacterial populations.

The students prepared a large flask of bacterial culture.

They divided this large culture into a number of smaller flasks each containing 50 cm^3 of bacterial culture.

They then incubated the smaller flasks at 20 °C for up to 48 h.

Every 4 h the students removed one of the flasks and counted the bacteria.

The students recorded the total number of bacteria and the number of viable bacteria in each flask.

When growing bacteria in culture, it is important that aseptic techniques are used.

i. State why it is important that the technique used for culturing microorganisms be aseptic.

_____

[1]

ii. The students prepared the culture by adding a suspension of bacteria to a flask containing nutrient broth.

List **two** precautions that should be taken when preparing a bacterial culture in order to ensure that the procedure is aseptic.

1 _____

2 _____

[2]

(b). When counting the number of bacteria, the students performed serial dilutions on samples removed from each small flask. In each serial dilution, the students removed 0.1 cm^3 and added it to 9.9 cm^3 of water.

To estimate the total number of bacteria, the students used a light microscope to count the number of bacterial cells in a 0.01 cm^3 sample of the final serial dilution.

To estimate the number of viable bacteria, the students spread 0.1 cm3 of the final serial dilution on an agar plate and counted the number of colonies that had grown after 24 h.

i. The students shook each flask before they removed the samples for counting.

Suggest why the students shook the flasks.

[1]

ii. It can be more difficult to count bacterial cells using a light microscope than it is to count human cells.

Suggest **one** reason why bacterial cells are difficult to count using a light microscope.

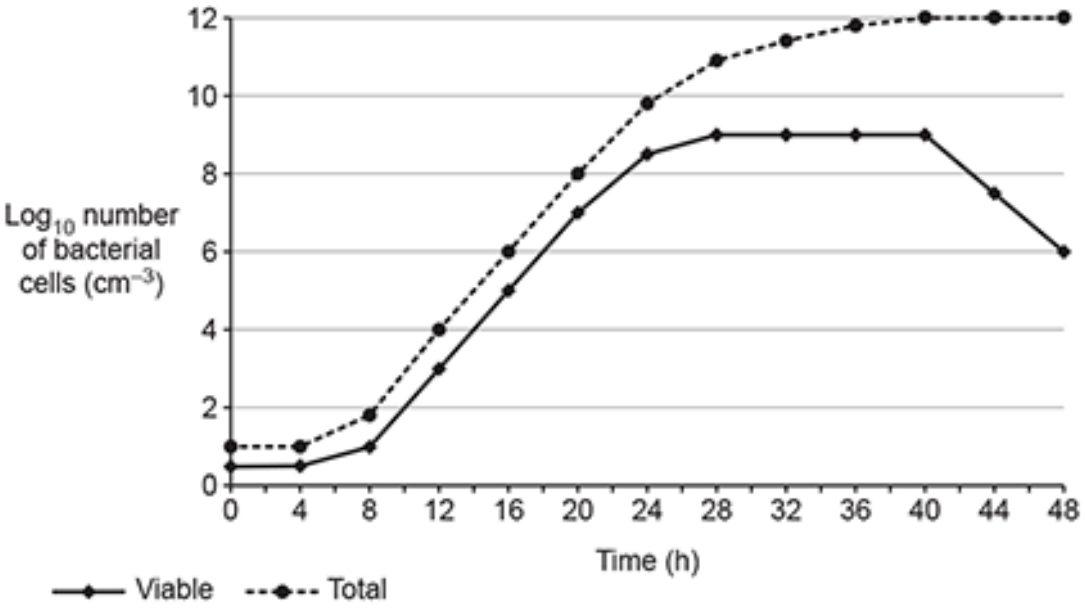
[1]

iii. In one 0.01 cm3 sample the students counted 52 bacterial cells under the microscope.

Describe the calculation steps the students would then need to make to estimate the total number of bacteria in the small flask.

[3]

(c). The graph shows the students' results.



i. Explain, with reference to the graph, why the students used a logarithmic scale on the *y*-axis.

[2]

ii. Calculate the percentage decrease in the viable population between 40 h and 48 h.

Give your answer to **3** significant figures.

Percentage decrease = ... % **[3]**

(d). Explain, with reference to the graph, the decrease in the population of viable bacteria between 40 h and 48 h.

[4]

12(a). Both *A. aerophoba* and *S. fasciatum* reproduce sexually, but under particular conditions they are both able to reproduce asexually.

In asexual reproduction in *A. aerophoba*:

- clumps of diploid cells detach from the body of the sponge
- the cells reattach to a surface and grow into new, adult sponges.

In asexual reproduction in *S. fasciatum*:

- meiosis occurs in a female
- two of the haploid cells produced by meiosis fuse to form a diploid cell
- the diploid cell develops into a new shark.

A student stated, 'When they reproduce asexually, both animals produce clones of themselves.'

Evaluate the student's statement.

[3]

(b). *Humans can produce artificial clones of animals.

Describe **two** methods for producing artificial clones of animals.

[6]

Additional answer space if required.

13. A student wrote a method for taking a cutting to clone a plant:

- Select a stem with many flowers and leaves.
- Make a slanting cut in the stem, below some leaves.
- Dip the cut stem in rooting powder.
  Plant the cutting in watered compost.
-

Describe and explain how the student's procedure could be improved.

[3]

14. Many industrial processes use immobilised enzymes.

Which of the options is **not** an advantage of using immobilised enzymes rather than free enzymes?

A Enzymes can be reused.
B Enzymes remain active over a wider range of temperatures.
C Set-up costs are low.
D The product is not contaminated by enzymes.

Your answer ☐ **[1]**

END OF QUESTION PAPER