Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|

Centre Number | Candidate Number

# Pearson Edexcel Level 3 GCE

## Wednesday 18 June 2025

Morning (Time: 2 hours 30 minutes)

Paper reference **9BI0/03**

# Biology B

## Advanced

## PAPER 3: General and Practical Principles in Biology

**You must have:**
Scientific calculator, HB pencil, ruler

Total Marks

### Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

### Information

- The total mark for this paper is 120.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In question(s) marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

### Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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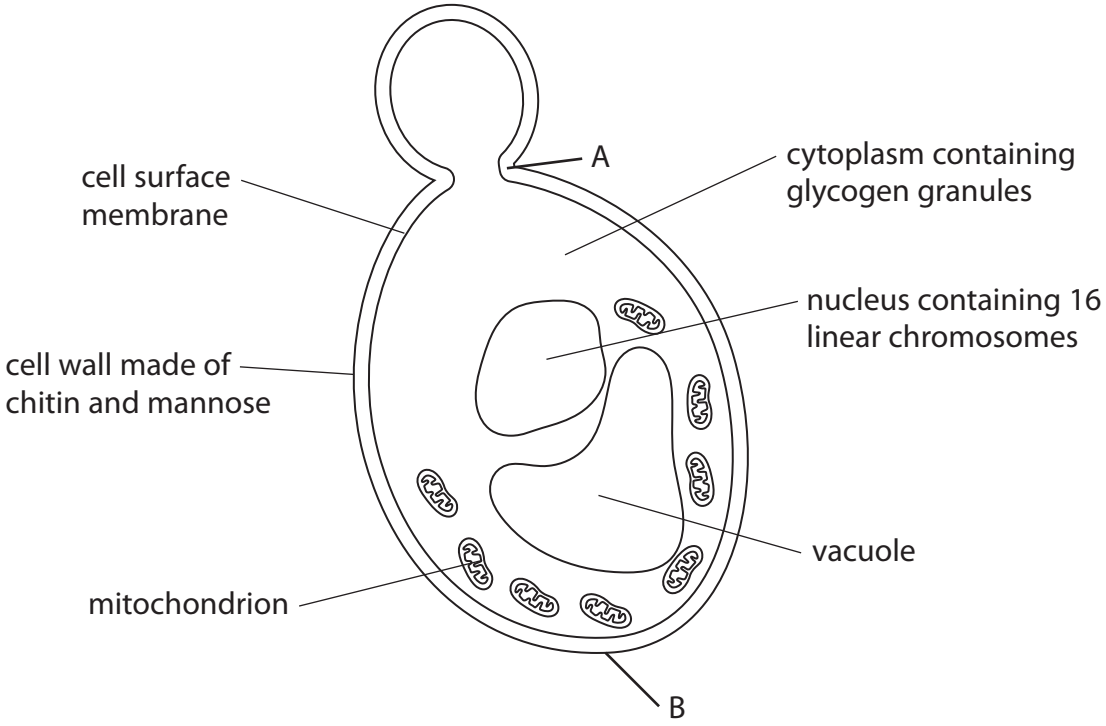
Pearson

**Answer ALL questions.**

**Write your answers in the spaces provided.**

**1** *Saccharomyces cerevisiae* (yeast) is a single-celled organism widely used in brewing and baking.

The diagram shows a drawing of a yeast cell, as seen using an electron microscope.




(a) The actual size of the cell measured from point A to point B is 6 μm.

Calculate the magnification of this yeast cell.

Give your answer to the **nearest whole number**.

**(2)**

Answer .....

(b) Draw this yeast cell as it would be seen using a light microscope at high magnification.

Labels are not required.

**(2)**

(c) The information in the diagram can be used to classify yeast.

(i) State why yeast is classified as eukaryotic not prokaryotic.

**(1)**

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(ii) State why yeast is not classified as a plant.

**(1)**

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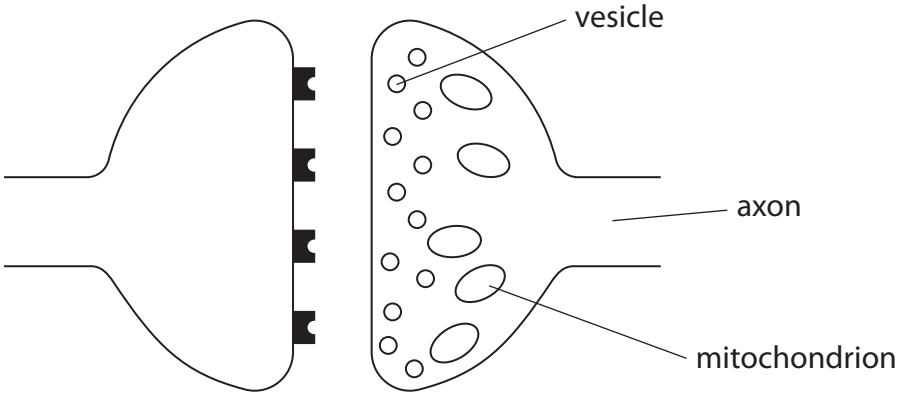
**(Total for Question 1 = 6 marks)**

**2** Where two neurones meet they are linked by a synapse.

(a) The diagram shows the structure of a synapse.




(i) Draw an arrow on the diagram to show the direction in which the nerve impulse travels.

**(1)**

(ii) Describe the role of acetylcholine in synaptic transmission.

**(3)**

(iii) State the role of the mitochondria in synaptic transmission.

**(1)**

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(b) Some neurones have a myelin sheath around them.

Explain how the myelin sheath speeds up the transmission of nerve impulses.

**(2)**

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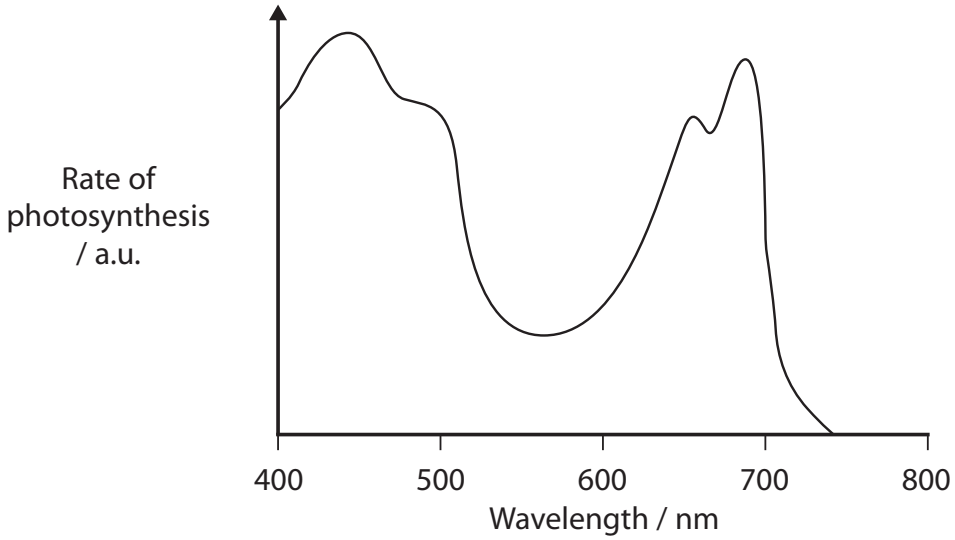
**(Total for Question 2 = 7 marks)**

**3** The wavelength of light affects the rate of photosynthesis.

(a) The graph shows an action spectrum for a filamentous green alga.




A scientist investigated the effect of wavelength of light on the rate of photosynthesis using this alga.

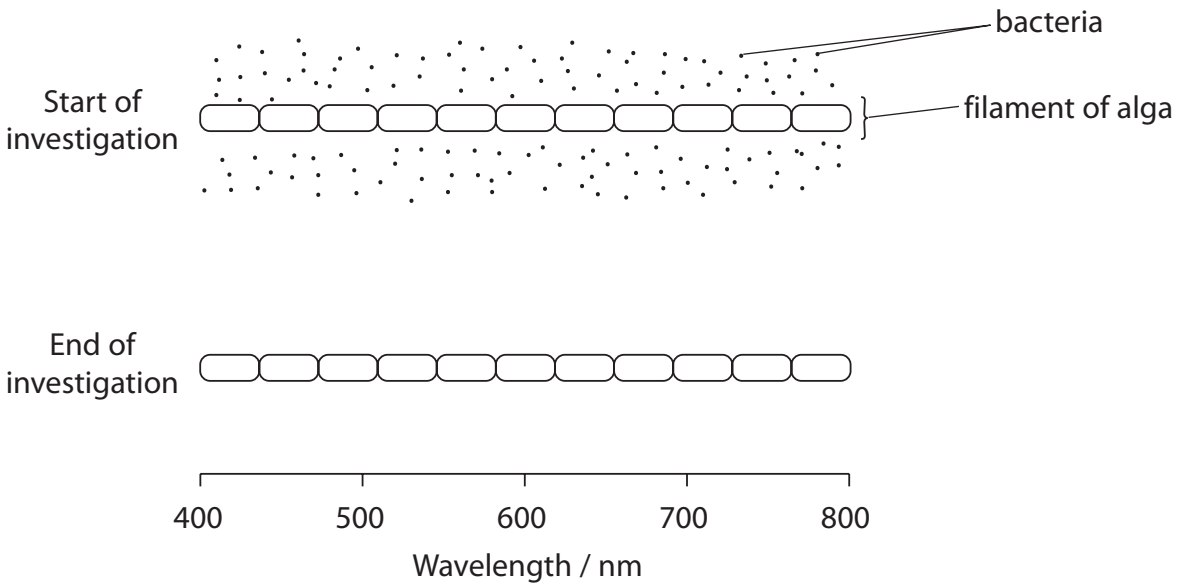
Filaments of the alga were placed on a microscope slide in water containing bacteria that move to areas of high oxygen concentrations.

Light of different wavelengths was shone onto different parts of the filament and the positions where the bacteria accumulated were recorded.

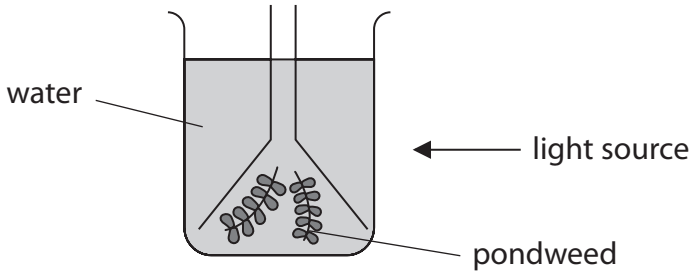
The diagram shows the position of the bacteria at the start of the investigation, and the wavelengths of light shone onto the parts of the filament.

Complete the diagram to show the position of the bacteria you would expect at the end of the investigation.

**(2)**



(b) The diagram shows apparatus that can be used to study the effect of light on photosynthesis in pondweed.




Describe how you could modify and use this apparatus to find the optimum wavelength of light for photosynthesis of the pondweed.

**(5)**

(c) Explain why plants have a variety of photosynthetic pigments.

**(2)**

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**(Total for Question 3 = 9 marks)**

**4** Red-green colour blindness is a sex-linked condition.

(a) In humans, the gene for colour vision is located on the X chromosome.

The allele for red-green vision ($X^B$) is dominant to the allele for red-green colour blindness ($X^b$).

(i) State all the possible genotypes of females.

**(1)**

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(ii) State all the possible genotypes of males.

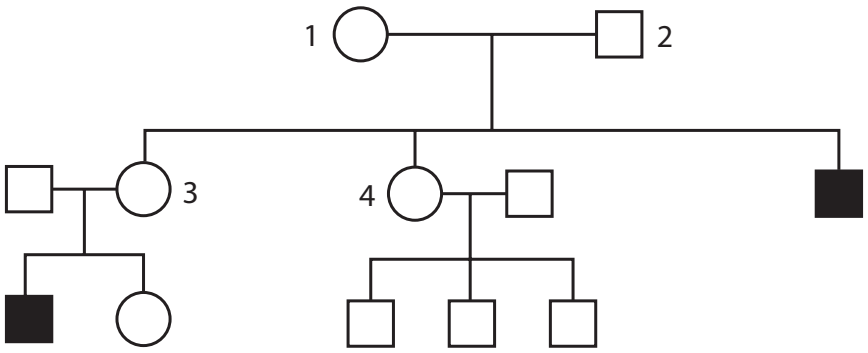
**(1)**

.....

(iii) The diagram shows a family tree for a family where some individuals have this condition.

**Key:**

- ○ Female with red-green vision
- ● Female with colour blindness
- □ Male with red-green vision
- ■ Male with colour blindness




Give all the possible genotypes for each of the following individuals.

**(4)**

1 .....

2 .....

3 .....

4 .....

(b) Squirrel monkeys are found in the forests of Central and South America.

The photograph shows a squirrel monkey.

(Source: Adrian Hepworth / Alamy Stock Photo)

Squirrel monkeys have a varied diet, including leaves, fruits and insects.

In squirrel monkeys, the production of the pigments needed for red and green vision is determined by two alleles of a single gene.

This gene is located on the X chromosome.

Female squirrel monkeys have two X chromosomes, male squirrel monkeys have one X chromosome and one Y chromosome.

The colour red can be seen only if the allele $X^R$ is present.

The colour green can be seen only if the allele $X^G$ is present.

Scientists have studied the inheritance of colour vision in squirrel monkeys.

(i) A female monkey able to see both red and green is mated with a male monkey able to see only green.

Determine the ratio of phenotypes you would expect in their offspring.

Use a genetic diagram to support your answer.

**(2)**

(ii) In separate crosses two monkeys were mated.

Half of the offspring were females with the ability to see both red and green colours and half were males able to see red only.

Determine the genotypes of these parents.

Use a genetic diagram to support your answer.

**(3)**

(iii) State why it would be an advantage for monkeys living in forests in South America to be able to see both red and green colours.

**(1)**

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(iv) In 2009, scientists successfully used gene technology on some squirrel monkeys unable to see the colour red.

The scientists identified the gene for the protein that is sensitive to red light in humans. This gene was transferred to cells in the retina of these monkeys.

Describe how the scientists may have carried out this gene technology.

**(3)**

**(Total for Question 4 = 15 marks)**

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**5** The photograph shows a germinating pollen grain, on a slide, as seen using a light microscope.

(Source: CAROLINA BIOLOGICAL SUPPLY COMPANY/SCIENCE PHOTO LIBRARY)

(a) Describe how you would use a light microscope to measure the actual length of this pollen tube.

**(2)**

(b) A scientist investigated the effect of concentration of calcium ions on the germination and growth of pollen grains.

The tables show the results from this investigation.

| Concentration of calcium nitrate / mg dm$^{-3}$ | Percentage germination of pollen grains after each hour (%) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 0 | 0 | 0 | 0 | 0 |
| 300 | 50 | 55 | 65 | 65 |
| 400 | 50 | 58 | 60 | 69 |
| 500 | 50 | 65 | 70 | 79 |

| Concentration of calcium nitrate / mg dm$^{-3}$ | Mean pollen tube length after each hour / µm | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 0 | 0 | 0 | 0 | 0 |
| 300 | 120 | 261 | 284 | 355 |
| 400 | 256 | 284 | 355 | 426 |
| 500 | 341 | 412 | 455 | 547 |

(i) Calculate the mean rate of growth of the pollen tube in the 500 mg $dm^{-3}$ calcium nitrate solution.

Give your answer in μm per minute, to **two decimal places**.

**(2)**

Answer ..... μm $minute^{-1}$

(ii) Give **three** conclusions that can be drawn from this investigation.

**(3)**

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(c) Devise a method that could have been used to collect valid data in this investigation.

**(4)**

**(Total for Question 5 = 11 marks)**

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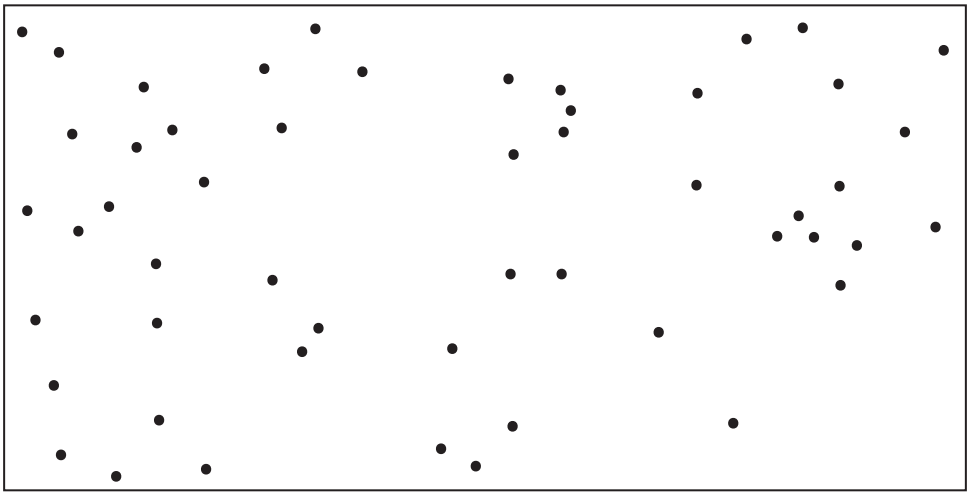
**6** (a) The photograph shows a dandelion plant.

(Source: C Hurford)

A student wanted to carry out a survey to estimate the number of dandelion plants growing in a large field.

The student carried out a pilot study on an area of grassland 5 m by 10 m, to find the size of quadrat which would give the most accurate estimate.

The diagram shows the position of each dandelion plant in the pilot study.



Three sizes of quadrat were tested:

- 1 m × 1 m (1 $m^2$)
- 0.5 m × 0.5 m (0.25 $m^2$)
- 10 cm × 10 cm (0.01 $m^2$).

The quadrats were placed randomly and the number of dandelion plants in each quadrat was recorded.

The total number for all quadrats was then calculated.

The table shows the results obtained.

| **Size of quadrat / $m^2$** | 1 | 0.25 | 0.01 |
|---|---|---|---|
| **Number of quadrats used** | 5 | 20 | 500 |
| **Total number of dandelion plants recorded** | 1 | 3 | 6 |

(i) Describe how the quadrats would be placed randomly.

**(2)**

(ii) The total number of dandelion plants in this area of grassland was 53.

Analyse the data to determine the size of quadrat that gives the most accurate estimate of the number of dandelion plants.

**(4)**

(b) In a different survey, the student wanted to measure the biodiversity of the grassland, using a biodiversity index.

Describe the data that must be collected so that the biodiversity index can be calculated.

**(2)**

(c) (i) State the meaning of the term **species**.

**(1)**

(ii) Describe how scientists can use DNA from two similar looking plants to investigate whether they are closely related.

**(2)**

**(Total for Question 6 = 11 marks)**

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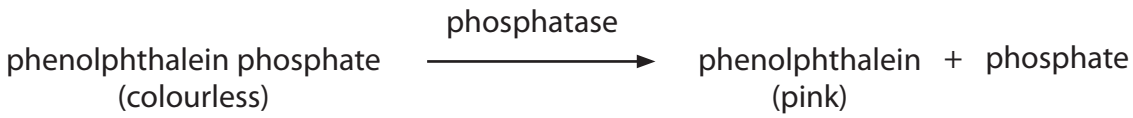
**7** The activity of enzymes is affected by a number of factors.

(a) A class of students investigated the effect of temperature on the activity of the enzyme phosphatase extracted from mung beans.

This enzyme removes phosphate groups from organic phosphate molecules. The diagram shows the reaction between phosphatase and its substrate, phenolphthalein phosphate.




When they are in alkaline solutions, phenolphthalein phosphate is colourless and phenolphthalein is pink.

The students used the following method.

**Step 1** Germinate mung bean seeds, then grind them with water and filter the extract. Use the filtrate as the enzyme extract.

**Step 2** Set up 8 tubes, each containing 1 $cm^3$ of 1% phenolphthalein phosphate, and place in water baths at varying temperatures. Leave for 10 minutes.

**Step 3** Add 1 $cm^3$ of enzyme extract to each tube. Leave in the water baths for 20 minutes.

**Step 4** Add 5 $cm^3$ of 10% sodium carbonate solution (alkaline) to each tube. Place the tubes into an ice bath, which will stop the reaction.

**Step 5** Use a colorimeter to measure the absorbance of light for each tube. As the pink colour increases, the absorbance increases.

(i) Describe how you would ensure that the concentration of the enzyme extract was the same for all students carrying out the investigation.

**(2)**

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(ii) Describe how you would ensure that the colorimeter readings were comparable for each of the students.

**(2)**

(b) The table shows the results obtained in this investigation.

| **Temperature / °C** | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
|---|---|---|---|---|---|---|---|---|
| **Absorbance of light** | 0.25 | 0.33 | 0.39 | 0.46 | 0.53 | 0.55 | 0.50 | 0.33 |

(i) Explain the effect of temperature on the activity of phosphatase.

**(3)**

(ii) For enzyme-controlled reactions at temperatures between 0°C and 40°C, a 10°C rise in temperature will double the rate of reaction.

The data collected in this investigation do not show this pattern, suggesting that there may be errors in the method used.

The students repeated the investigation with these four changes:

- adding buffer solution to the phenolphthalein phosphate
- placing separate tubes containing phenolphthalein phosphate and enzyme extract into water baths for 10 minutes before mixing together
- using smaller temperature intervals than 10°C
- stopping the reaction after 5 minutes instead of 20 minutes.

Justify why the students repeated the investigation with these four changes.

**(4)**

(c) The phosphatase enzyme catalyses the removal of phosphate groups from organic phosphate molecules, releasing phosphate ions.

Give **two** examples of biochemical processes in plant cells requiring phosphate ions.

**(2)**

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**(Total for Question 7 = 13 marks)**

**8** The photograph shows tar spots on a sycamore leaf.

(Source: Nigel Cattlin / Alamy Stock Photo)

Tar spots are caused by a fungus, *Rhytisma acerinum*, growing on the sycamore leaf.

Fungal spores spend the winter in dead leaves on the ground. When new leaves emerge in the spring, they are infected by these spores and tar spots develop.

The fungus is known to be sensitive to sulfur dioxide and oxides of nitrogen in the air.

The fungus grows more slowly when these gases are present.

(a) A student investigated whether there were fewer tar spots on sycamore leaves close to busy roads where air pollution is higher.

This is the method the student used.

**Step 1** Choose one sycamore tree close to a busy road and one sycamore tree in parkland away from busy roads.

**Step 2** Choose 15 leaves from each tree.

**Step 3** Record the number of tar spots on each leaf.

(i) Give a suitable null hypothesis for this investigation.

**(1)**

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(ii) The table shows the data the student recorded.

| Location | Number of tar spots per leaf | | | | | Mean | SD |
|---|---|---|---|---|---|---|---|
| Near road | 8 | 17 | 21 | 4 | 15 | 12.93 | 6.78 |
| | 12 | 5 | 3 | 7 | 13 | | |
| | 18 | 22 | 24 | 16 | 9 | | |
| Parkland | 20 | 17 | 13 | 14 | 24 | 17.07 | 4.06 |
| | 10 | 21 | 16 | 13 | 18 | | |
| | 14 | 23 | 21 | 15 | 17 | | |

The student analysed the data with a *t*-test.

Calculate the value of *t*.

Use the formula $$t = \frac{\left(\bar{x}_A - \bar{x}_B\right)}{\sqrt{\frac{\left(S_A\right)^2}{n_A} + \frac{\left(S_B\right)^2}{n_B}}}$$

where:

$\bar{x}$ is the mean for each set of data

n is the number of samples in each set of data

S is the standard deviation for each set of data

**(3)**

Answer .....

(iii) The table shows the critical values of *t* for different degrees of freedom.

| Degrees of freedom | p = 0.10 | p = 0.05 | p = 0.01 |
|---|---|---|---|
| 14 | 1.76 | 2.14 | 2.98 |
| 15 | 1.75 | 2.13 | 2.95 |
| 16 | 1.75 | 2.12 | 2.92 |
| 17 | 1.74 | 2.11 | 2.90 |
| 18 | 1.73 | 2.10 | 2.88 |
| 19 | 1.73 | 2.09 | 2.86 |
| 20 | 1.72 | 2.09 | 2.85 |
| 21 | 1.72 | 2.08 | 2.83 |
| 22 | 1.72 | 2.07 | 2.82 |
| 23 | 1.71 | 2.07 | 2.81 |
| 24 | 1.71 | 2.06 | 2.80 |
| 25 | 1.71 | 2.06 | 2.79 |
| 26 | 1.71 | 2.06 | 2.78 |
| 27 | 1.70 | 2.05 | 2.77 |
| 28 | 1.70 | 2.05 | 2.76 |
| 29 | 1.70 | 2.05 | 2.76 |
| 30 | 1.70 | 2.04 | 2.75 |

Analyse the data to comment on the results of this investigation.

**(3)**

(b) Justify **two** improvements to the method used by the student.

**(2)**

**(Total for Question 8 = 9 marks)**

**9** Transpiration is the loss of water from the leaves of plants.

(a) Water moves through xylem vessels in a plant during transpiration.

Explain **one** way in which xylem vessels are adapted for their function.

**(2)**

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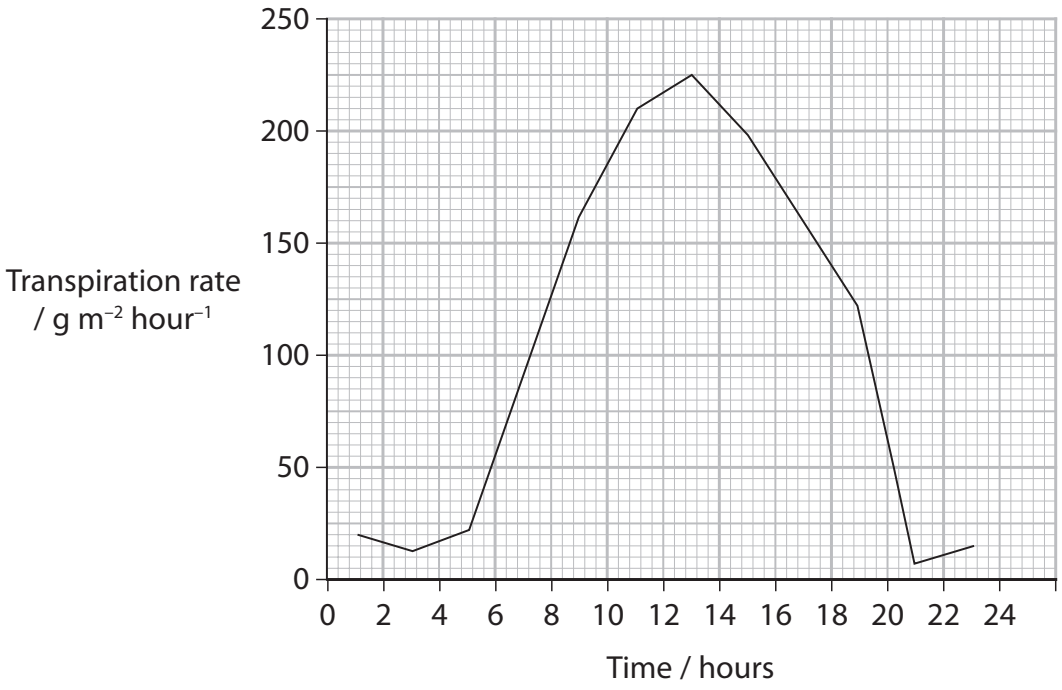
(b) The graph shows the rate of transpiration in oat seedlings during one day.
Windspeed and humidity were controlled.




(i) Calculate the mean rate of change in transpiration from five to thirteen hours.

Give your answer to **one decimal place**.

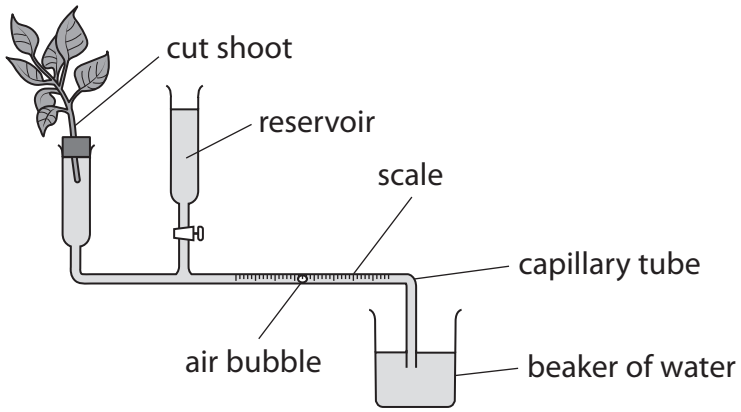
**(1)**

Answer ..... g m$^{-2}$ hour$^{-1}$

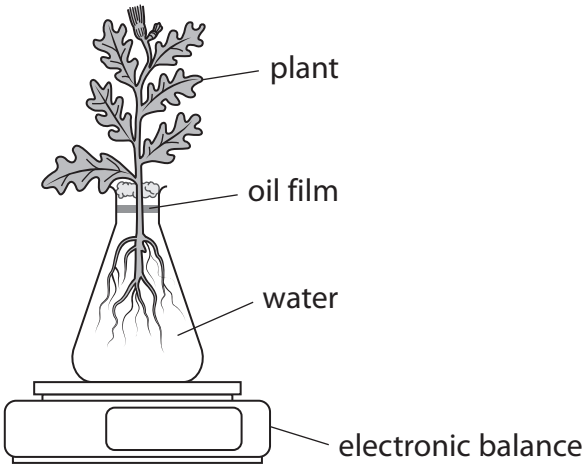
(ii) Explain the shape of the graph over the 22-hour period.

**(3)**

(c) The diagrams show two types of potometer, A and B.




**A**




**B**

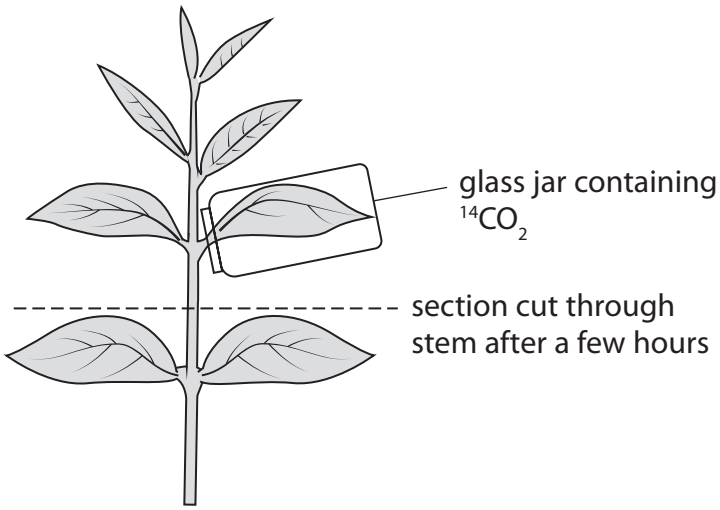
Evaluate which type of potometer would be better to measure the rate of transpiration.

**(5)**

(d) A scientist investigated the movement of sugar from the leaf to the roots of a plant.

One leaf was supplied with carbon dioxide containing the radioisotope $^{14}C$.

The diagram shows part of the apparatus used by the scientist.

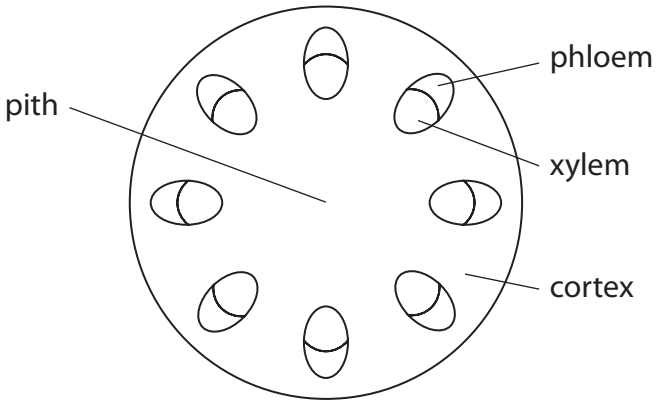



The sugar produced by photosynthesis in this leaf is radioactive.

After a few hours, a section was cut through the plant stem and placed on photographic film.

Structures containing radioactive material will cause darkening of the film.

The diagram shows the structure of the stem when a section is cut.




(i) Shade the areas you would expect to be darker because they are transporting radioactive sugar.

**(1)**

(ii) Name the radioactive sugar causing this darkening on the film.

**(1)**

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**(Total for Question 9 = 13 marks)**

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**10** Oceans cover 71% of the Earth's surface. Marine and coastal habitats are thought to contain about one quarter of all species worldwide.

(a) Some parts of the UK coastline have been designated Marine Conservation Zones (MCZ). These are part of a wider network of sites protected by law, called Marine Protected Areas (MPA).

Large parts of the UK coastline and the sea surrounding it are protected in this way. There are more than 370 protected coastal or marine sites around the UK.

The regulations in these areas protect coastal and marine habitats, and the communities and species which live in them, from damage by humans.

This is an example of in-situ conservation.

Comment on the benefits **and** difficulties of in-situ conservation in coastal and marine sites.

**(4)**

*(b) Seagrasses are flowering plants that live underwater in coastal habitats.

Seagrass meadows are one of the world's most threatened habitats, but only 26% are within Marine Protected Areas.

In the past, seagrass meadows were common worldwide. Over the last 90 years the area covered by seagrass has declined dramatically, with around 7% being lost each year.

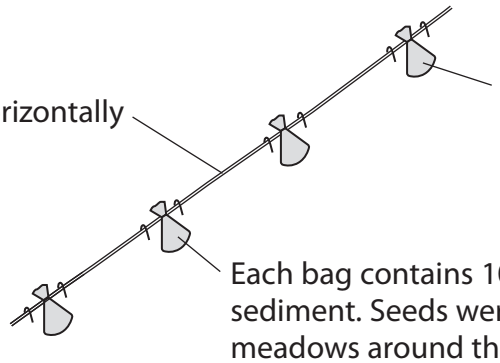
These losses are due to water pollution, damage from fishing, dredging and building ports.

Worldwide, seagrass covers 0.2% of the ocean, but is estimated to be responsible for 10% of its carbon storage. It can store at least 0.5 tonnes of carbon per hectare per year, which is more than a tropical rainforest.

Seagrass meadows protect the coastline from wave erosion. They also provide food and shelter for young fish, including commercially important species like cod.

Around the UK, 90% of seagrass meadows have been lost and only 8 500 hectares remain. A pilot project will plant two hectares of seagrass meadow off the coast of Wales.

Different planting methods have been trialled at different sites. The diagram shows the most successful method, where 4% of seeds germinate after eight months.



Analyse the information to evaluate the importance of seagrass as a habitat, and the importance of this pilot project.

**(9)**

**(Total for Question 10 = 13 marks)**

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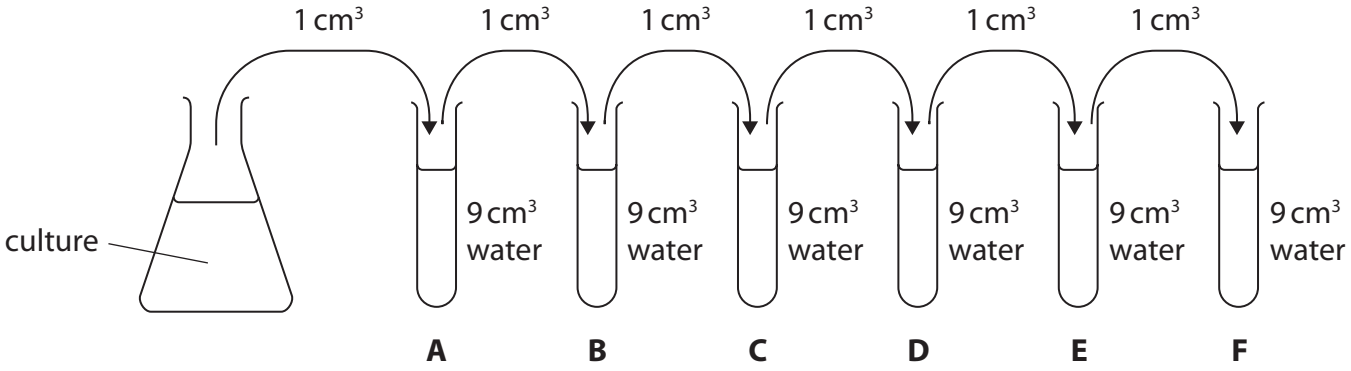
**11** The growth of bacterial populations can be studied if they are grown in liquid culture.

(a) One type of bacteria is grown in nutrient broth under aseptic conditions.

The number of bacteria in the culture at a particular time can be determined using serial dilution and plating.

The diagram shows the dilution series used.




One sample of 0.5 $cm^3$ is taken from each tube (A to F). Each sample is spread onto a separate agar plate using aseptic technique.

The plates are incubated at 25 °C for 48 hours and the number of colonies on each plate is counted.

Each colony represents a single bacterium in the original culture.

The table shows the results obtained.

| **Tube** | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| **Number of colonies on agar plate** | * | * | 126 | 13 | 1 | 0 |
| **Serial dilution factor** | 1 in 10 | | | | | |

* = too many colonies to count

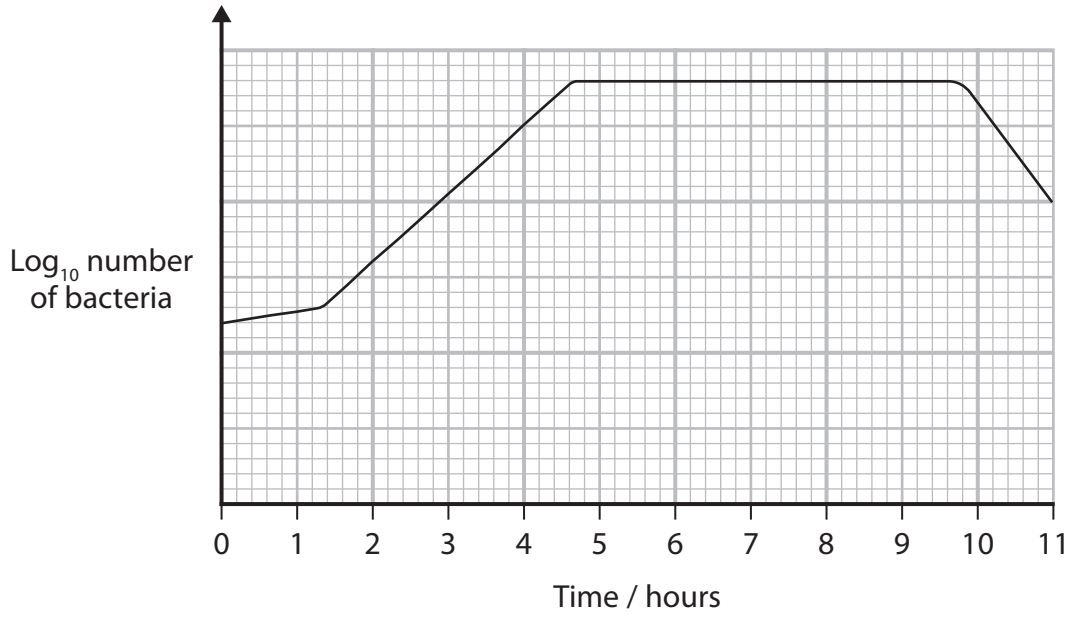
(i) Calculate the number of bacteria per $cm^3$ in the original culture.

Give your answer in **standard form**.

**(2)**

Answer ..... per $cm^3$

(ii) The graph shows the population of bacteria in a culture, as determined using this method.




Explain the shape of this graph.

**(4)**

(iii) Between 1.3 hours and 4.7 hours the number of bacteria is rising very rapidly.

The number of bacteria can be calculated at any time in this period using the exponential growth rate constant, *k*.

The number of bacteria per $cm^3$ at the start of this period was 400 and the number 3.4 hours later was 102 400.

Calculate the value of *k* when the culture has been growing exponentially for 3.4 hours.

Give your answer to **two decimal places**.

Use the formula:

$$k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$$

where $N_t$ = the number of organisms at time $t$
$N_0$ = the number of organisms at time 0
$k$ = the exponential growth rate constant
$t$ = the time the culture has been growing

**(2)**

Answer .....

(iv) Calculate the mean generation time, *g* (time for the population of bacteria to double, in minutes).

Use your value for *k* and the formula $k = \frac{60}{g}$

**(1)**

Answer ..... minutes

(b) An alternative method to dilution plating is to use a colorimeter to measure the turbidity of a culture.

Turbidity is an indicator of the growth of the bacterial population.

Assess the advantages of each of these methods to measure the growth of a bacterial population.

**(4)**

**(Total for Question 11 = 13 marks)**

**TOTAL FOR PAPER = 120 MARKS**