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# Examiners' Report
# June 2022

## GCE Biology B 9BI0 03

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## Introduction

It was pleasing to see that the majority of candidates found the paper accessible and were able to attempt most items. This paper covers all areas of the specification and particularly targets the core practicals and synoptic parts of the assessment. To do well, candidates must demonstrate that they can apply their knowledge and understanding of scientific ideas, processes, techniques and procedures (A02) and that they can analyse, interpret and evaluate scientific information, ideas and evidence (A03). In practice, this often means applying their biological knowledge to unfamiliar contexts.

Centres are to be commended for the way that candidates have been prepared for the exam, given the difficult circumstances of the last two years, which have had such an impact on teaching and learning. The general standard of answers was good, but some candidates underestimate the amount of detail which is needed at A level. Overall, candidates did well and this reflects on the hard work they have done to reach this point, after a very challenging two years.

## Question 1 (a)(i)

The majority of candidates gained a mark for the term 'resting potential'.

**1** Nerve impulses are transmitted along neurones.

(a) (i) In the time period between two nerve impulses, the potential difference across the membrane is –70 mV.

State the term given to this potential difference.

**(1)**

resting potential

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Examiner Comments

See above

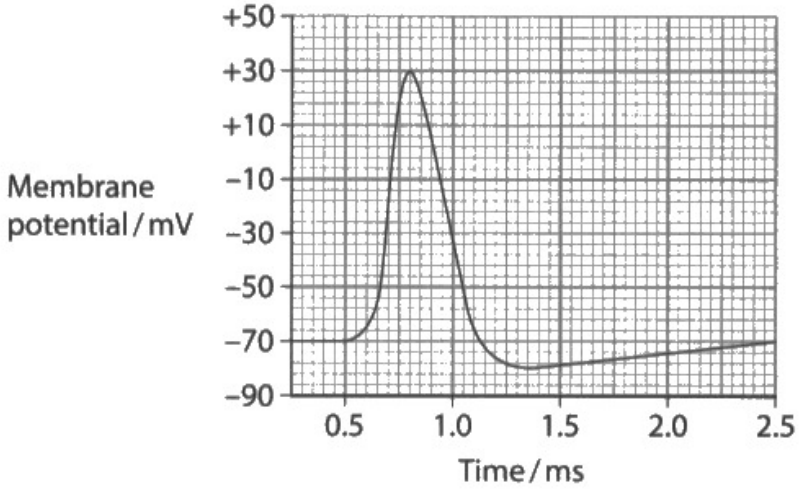
## Question 1 (a)(ii)

Candidates were asked to describe the sequence of events that occurs during an action potential, referring to information given in a graph. There were many strong answers, but not all were complete. Most candidates knew that at 0.55mV sodium channels opened and sodium ions moved, but not all clearly stated that they moved into the axon, rather than into the membrane. Some candidates did not go on to describe what happened at 0.8mV, when sodium channels closed and potassium channels opened.

Credit was not given for stating that the membrane became more permeable to sodium ions, as this information was given in the stem of the question.

(ii) When the neurone is stimulated, an action potential may occur in the axon, due to the change in permeability of the membrane to ions.

The graph shows an action potential.




Describe what happens in the axon membrane to cause the change in potential difference between 0.55 ms and 0.80 ms.

**(4)**

At 0·55 ms, voltage gated sodium ion channels open allowing sodium ions to diffuse down their electrochemical gradient across the membrane into the axon. This makes the inside less negative / more positive causing depolarisation and sodium ions continue to flow into the axon until 30 mv where sodium voltage gated channels close & and the change in potential difference causes potassium ion channels to open. This is an action potential

**ResultsPlus**
**Examiner Comments**

This candidate gained full marks, including correct details of all stages of the process. They covered the events leading to depolarisation (sodium channels opening and sodium ions moving into the axon) as well as the changes taking place at 0.8ms (sodium channels closing and potassium channels opening). The account is clear and follows a logical order, so overall an excellent answer.

**(4)**

At 0·55 s the voltage gated $Na^+$ channels are opened causing an influx of positive $Na^+$ ions this causes the depolarisation of the membrane. When the membrane potential has reached its peak the voltage-gated $Na^+$ channels close and the $K^+$ voltage gated channels open, this causes repolarisation as the potential difference is restored.

**ResultsPlus**
**Examiner Comments**

This candidate gained 2 marks for correctly stating that the voltage gated sodium channels are opened and that this caused depolarisation.

They recognised that later the sodium channels closed and the potassium channels opened, but stated that this was when the membrane potential reached its peak, rather than linking it to a time (0.8ms) or a voltage (30mV).

**ResultsPlus**
**Examiner Tip**

When describing events from information given in a graph, use the values you can read from the graph in your answer.

## Question 1 (b)

This question included a table of data linking a range of stimulus voltages to the response they caused.

Candidates were expected to recognise that there was a threshold stimulus below which an action potential did not occur, and to deduce what that threshold was from the data provided, and many candidates gained at least one mark.

Acceptable answers included a threshold value of more than 45mV and the range 45 – 55mV or 46 – 55mV. Credit was not given to answers which stated that the threshold potential was 55mV, as from the data provided it could have been anywhere above 45mV.

Some candidates described the data in the table in words, saying that from 25 – 45mV there was no action potential and from 55 – 75mV there was an action potential – this did not gain credit.

(b) Scientists investigated the effect of stimulating an axon with different voltages and measured the response.

The table shows the results of this investigation.

| Stimulus voltage / mV | Response |
|---|---|
| 25 | No action potential |
| 35 | No action potential |
| 45 | No action potential |
| 55 | Action potential |
| 65 | Action potential |
| 75 | Action potential |

Analyse the data to describe the conclusions which can be drawn.

**(2)**

Action potential takes place above 45 mV stimulus
- Hyperpolarisation occurs
Below 45 mV, there's no action potential generated.

**ResultsPlus**
**Examiner Comments**

This candidate gained one mark for recognising that an action potential occurred when the stimulus voltage was above 45mV.

- A stimulus voltage (mV) below 55mV does not produce an action potential as voltage is not significant enough and has no affect.
- stimulus voltage of 55mV and above produces an action potential as voltage is significant and produces an excitation

**(Total for Question 1 = 7 marks)**

**ResultsPlus**
**Examiner Comments**

This answer shows one of the most common errors.

The candidate stated that only a voltage of 55mV or above caused an action potential, without realising that a value between 46 and 55 could also result in an action potential.

As they also did not mention the threshold value, they scored zero.

The data shows that an action potential is generated when stimulus is between 45 - 55mV, meaning that a voltage between these values must be the membrane threshold required so that an action potential is generated. ∴ values ∠45 must be below threshold value.

ResultsPlus
Examiner Comments

This was a clear answer which correctly covered both marking points and scored two marks.

The candidate has stated that an action potential is generated when a stimulus is between 45 – 55mV, and that there is a threshold value.

## Question 2 (a)(i)

To answer this question successfully, candidates needed to know which stages of the cell cycle involved actively dividing cells – prophase, metaphase, anaphase and telophase. They also needed to be able to carry out a calculation using the formula given to work out the mitotic index.

The correct number of actively dividing cells was 8 and the total number of cells was 98, giving a mitotic index of 8.2.

While a large number of candidates achieved this, scoring two marks, some had problems with one or both of the parts of the operation.

**2** A student investigated the number of dividing cells in an onion root tip.

The student made a root tip squash and counted the number of cells at each stage of the cell cycle. The table shows the results.

| Number of cells at each stage of the cell cycle | | | | |
|---|---|---|---|---|
| **Prophase** | **Metaphase** | **Anaphase** | **Telophase** | **Interphase** |
| 4 | 2 | 1 | 1 | 90 |

(a) (i) Calculate the mitotic index for these results using the formula

$$\text{Mitotic index} = \frac{\text{number of actively dividing cells}}{\text{total number of cells}} \times 100$$

**(2)**

$\frac{8}{99} \times 100 = 8.08$ (3sf)

Answer .....

**ResultsPlus**
**Examiner Comments**

Here the number of actively dividing cells is correct, so the candidate achieved one mark.

However the total number of cells is wrong (it should be 98), so they did not get the second mark.

4 + 2 + 1 = 7

AO4 $\frac{7}{90} \times 100 = 7.8$ (1 dp)

Answer 7.8

ResultsPlus Examiner Comments

Here the number of actively dividing cells has been calculated wrongly. The total number of cells is also wrong, so this calculation resulted in an incorrect answer which scored zero.

(2)

PMAT

$MI = \frac{4+2+1+1}{90+4+2+1+1} \times 100 = \frac{8}{98} \times 100 = 8.16326\%$

8.2%

Answer 8.2%

ResultsPlus Examiner Comments

This candidate gained both marks. They correctly stated the number of actively dividing cells (8), worked out the total number of cells (98) and used the formula given to get a correct answer (8.2%)

## Question 2 (a)(ii)

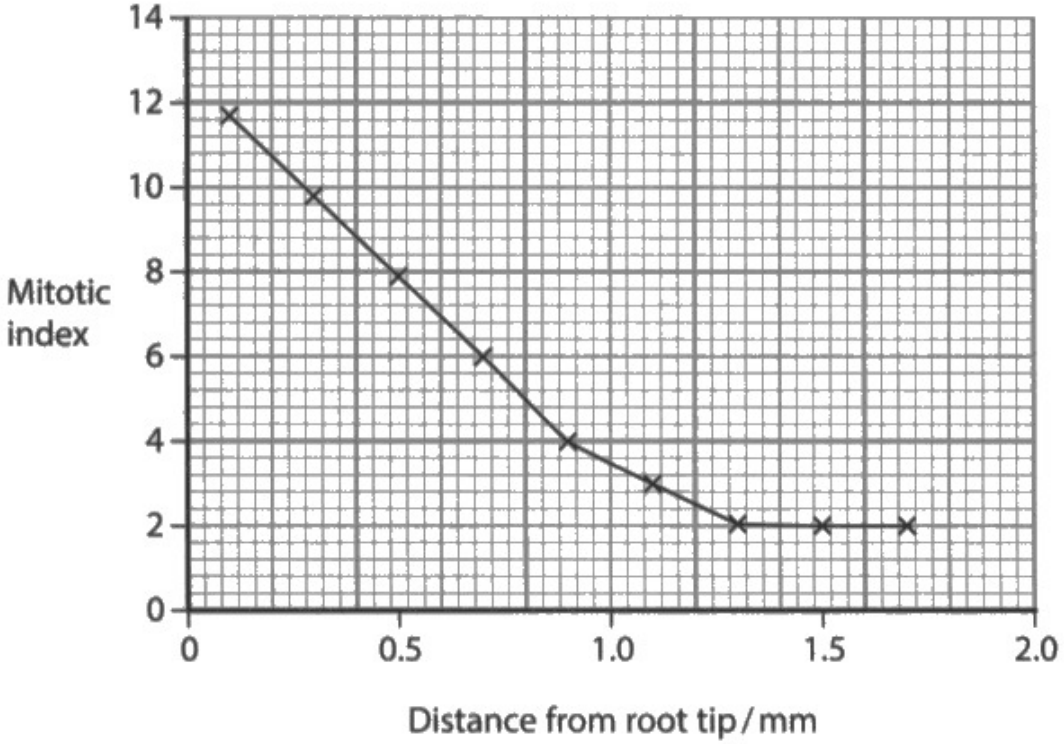
Following on from the calculation of mitotic index in Q02(a)(i), candidates were given a graph of mitotic index and distance from root tip and asked to explain the relationship. The command word 'explain' requires that a reason is given for the relationship.

Almost all candidates scored one mark for describing the relationship. This was done in a variety of ways: as distance increases, mitotic index decreases; there is a negative correlation between mitotic index and distance from the root tip; there is an inverse relationship between mitotic index and distance from the root tip.

Stronger candidates went on to give a reason for this. Some referred to the meristem or stem cells being present at the root tip and some explained how cells further from the root tip are specialised or differentiated. Of the two explanations, the meristem was seen most frequently.

(ii) The mitotic index depends on the distance from the root tip.

The graph shows the relationship between the mitotic index and the distance from the root tip.




Explain the relationship shown in the graph.

**(2)**

The graph shows that the areas closer to the root tip have higher mitotic index. As distance from the root tip increases, the mitotic index decreases. The mitotic index does not drop below 2. This trend is seen because more mitosis is occurring at the root tip, as the root is growing, so more mitosis happens here.

ResultsPlus
Examiner Comments

This candidate correctly described the relationship: as the distance from the root tip increases, the mitotic index decreases.

However, they don't explain it. They simply restate that mitosis is occurring at the tip.

ResultsPlus
Examiner Tip

If you are asked to explain a relationship, make sure that you do not just describe it. Give a reason for the relationship to get full marks.

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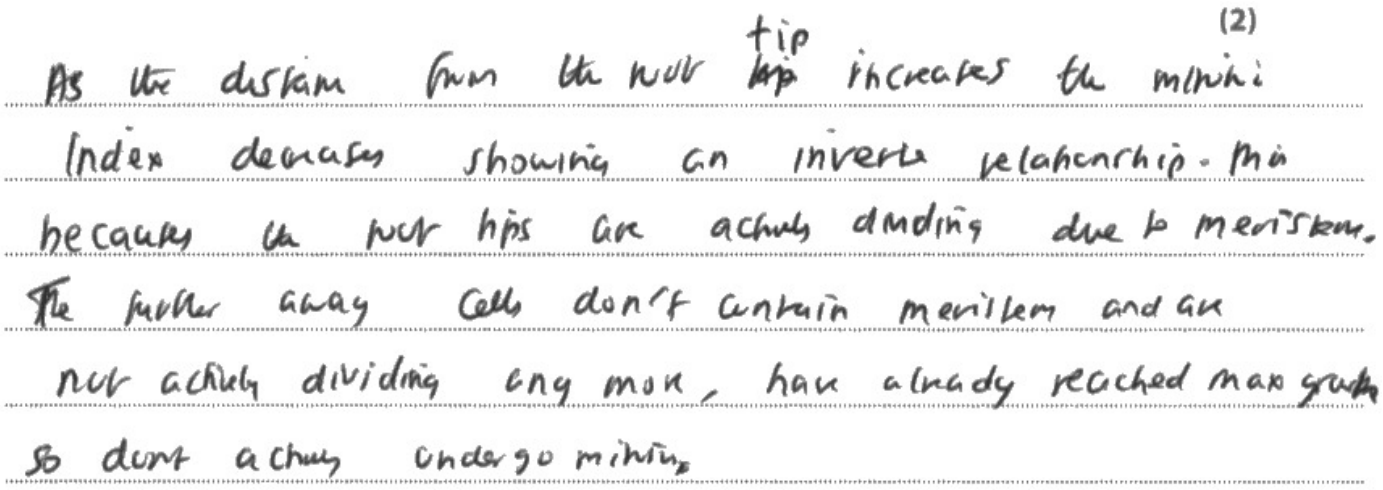

(2)

As the distance from the root tip increases the mitotic index decreases showing an inverse relationship - this because the root tips are actively dividing due to meristem. The further away cells don't contain meristem and are not actively dividing any more, have already reached max growth so don't actively undergo mitosis

**ResultsPlus**
**Examiner Comments**

This candidate gained both marks.

The first mark was for clearly describing the relationship: as the distance from the root tip increases, the mitotic index decreases.

The second mark was for giving the reason: root tips are actively dividing due to meristem. The further away cells don't contain meristem.....

## Question 2 (b)

This question gave the steps of a method that could be followed to make a root tip squash from onion tissue. Candidates were asked to justify two improvements to the method given.

The command word justify requires candidates to make a decision (here about what improvements to the method are necessary) and to give evidence to support that decision (why the changes would improve the method).

Some candidates made suitable suggestions for improvements but did not give any reasons, so were unable to score.

Some candidates made suitable suggestions for improvements and gave reasons, but these were not always correct. A common misconception was that strong acid would break down the cell wall, rather than breaking down the middle lamella, allowing cells to be separated. Many candidates realised that a high power lens was required but did not explain the reason clearly enough, making vague statements about making counting easier. Stronger candidates recognised that without a high power lens, the chromosomes would not be visible and the stages of the cell cycle could not be identified. There was some confusion between resolution and magnification, with several candidates suggesting that a high power lens would increase resolution.

Suitable improvements to the method included

- the use of strong rather than weak acid to break down the middle lamella
- using heat to intensify the effect of the acid or stain
- pressing on the coverslip to form a single layer of cells
- using a high power lens to see the chromosomes

(b) The student used the following method to prepare the root tip squash.

1. Cut a small piece from the tip of a growing onion root and place it in weak acid.
2. Transfer the root tip to a microscope slide.
3. Add a drop of stain.
4. Use a mounted needle to flatten the piece of root and place a coverslip on top.
5. View using low power objective lens of a microscope.
6. Count the cells at each stage of the cell cycle.

Justify two improvements to this method.

**(2)**

Put the small puice of ~~the~~ onion in a strong acid.
View using a higher power objective lens of a microscope.
Add more than a drop of stain.

**ResultsPlus**
**Examiner Comments**

This candidate has suggested two suitable improvements to the method:

- using strong acid rather than weak acid
- using a higher power objective lens

However, they have not given a reason for either of the improvements, so do not score any marks.

**ResultsPlus**
**Examiner Tip**

When the command word is **justify** always give a reason to explain your choice.

· ~~Warm~~ · The sample should be placed in warm acid so the pectins can be broken down. The acid should then be removed by using water. · Furthermore, mounted needle should be used to macerate / tease the piece of root so a thin enough layer is produced and can be observed under microscope.

**(Total for Question 2 = 6 marks)**

· Can view using low power objective lens, then medium and high power so the cell cycles can be more ~~clearly~~ easily recognised.

ResultsPlus
Examiner Comments

This candidate has chosen two suitable improvements to the method and has given a reason for each of these:

- use of warm acid rather than cold, so pectins are broken down
- using a high power lens, so the cell cycles can be more easily recognised.

This allows them to score both marks.

Credit was not given for macerating / teasing with a mounted needle, as this was already described in step 4 of the original method.

## Question 3 (a)(i)

The whole of question 3 was about an investigation into photosynthesis using algae trapped in gel beads. These were placed in a tube of hydrogencarbonate indicator (which changes colour according to the level of carbon dioxide in the tube), and the tubes were placed at various distances from a lamp for 30 minutes. At the end of this time the change in colour of the indicator and position of the gel beads were recorded.

Q03(a)(i) asked candidates to describe two control tubes which could be used. The purpose of the control tubes is to show which components of the original set-up are having an effect: here, the two things required for photosynthesis to take place are the algae and the light, so one of the control tubes should have been without algae and the other without light.

Ideally, the candidates should have explained what was in the tubes (not just what was not), so the best answers stated:

- tube containing indicator, but no gel beads, in the light
- tube containing indicator and gel beads, in the dark

Many candidates were able to score one mark, with stronger candidates achieving both. The most common mistake was to have a tube with no indicator. However this would be pointless as it would not be possible to tell if carbon dioxide levels were changing, since there would be no colour change without indicator.

Some candidates did not understand the term 'control tubes' and instead wrote about controlled variables, suggesting for example, that temperature should be controlled.

(a) (i) Describe two control tubes that should be used in this investigation.

(2)

use the same amounts of algae

make sure they all are left for the same amount of time so none react more than others.

use same amounts of hydrogencarbonate.

**ResultsPlus Examiner Comments**

This candidate has misunderstood the meaning of 'control tubes' and written about controlled variables, so did not score any marks.

Here they have written about the time the tubes are left for, the amount of algae and the amount of indicator. Even if they had been writing about the correct tubes, amount is a very imprecise term. Mass of algae and volume of indicator would be a better way of phrasing it.

one test tube should be experimented without any light, any lamp shine on it

the othe control test should not contain any hydrogen carbonate indicator.

**ResultsPlus Examiner Comments**

This candidate scored one mark for the tube without any light.

There was no credit for the tube without indicator, as this would not tell them whether photosynthesis was occurring.

A test tube with gel beads and indicator in darkness.
A test tube with no gel beads and indicator in the light.

ResultsPlus
Examiner Comments

This candidate has understood what is required and clearly described the two tubes, gaining both marks.

## Question 3 (a)(ii)

Candidates were asked to explain the changes in colour of the hydrogen carbonate indicator in this investigation.

In a complex investigation like this, try to consider the tubes in turn, and what is happening in each of them. The independent variable was the distance from the lamp, so making a comment about the rate of photosynthesis in each tube and linking it to the carbon dioxide levels was a good starting point. However it was important to realise that respiration was taking place in each tube as well as photosynthesis, and that the final colour of the indicator was a result of the net increase or decrease in carbon dioxide.

Most candidates achieved mp1 for explaining the colour of the indicator in the tubes closest to the light, and linking this to a **high** rate of photosynthesis which took in **more** carbon dioxide. Alternatively candidates could get mp1 for talking about a lower rate of photosynthesis in the tubes furthest from the light, resulting in less carbon dioxide being taken in.

Mp2, 3 and 4 all depended on the candidates talking about the balance between respiration and photosynthesis, and the resulting levels of carbon dioxide in the tubes.

Mp3 was for recognising that when the indicator was red, the rate of photosynthesis was **equal** to the rate of respiration.

Mp4 was for a statement that further from the lamp, the rate of photosynthesis was low (due to lack of light), so the rate of respiration was **higher** than the rate of photosynthesis, leading to a net release of carbon dioxide.

Mp3 and 4 were seen more frequently than mp2, perhaps because candidates recognised the compensation point in the tube at 25cm, and this prompted them to write about respiration in the tubes further from the lamp.

The most common misconceptions amongst candidates who did mention respiration were that respiration only starts when photosynthesis stops, or that respiration was slower closer to the lamp.

(ii) Explain the changes in colour of the hydrogencarbonate indicator in this investigation.

**(3)**

The tubes that are closer to the lamp indicate that they have the lowest $CO_2$ concentration after 30 minutes compare to the ones further away.
The ones closer to the lamp use more $CO_2$ due to photosynthesis leading to less being present. And light is a limiting factor that affects the rate of photosynthesis.

**ResultsPlus**
**Examiner Comments**

This candidate recognised that the tubes closer to the lamp have the lowest carbon dioxide concentration, because they were using more carbon dioxide in photosynthesis. This was enough to gain marking point 1

**ResultsPlus**
**Examiner Tip**

When comparing the colour of indicator in tubes at different distances, always use comparative words eg closer / lowest / more in your answer.

(3)

The test tube closest to the lamp (purple) has the highest rate of photosynthesis, as light is not a limiting factor so more $CO_2$ is used in the light independent reaction (calvin cycle) to fix $CO_2$. Therefore it has a lower conc$^n$ of $CO_2$. As the distance from the lamp increases there is a lower rate of photosynthesis and less $CO_2$ is used ~~therefore~~ there is a higher rate of respiration than photosynthesis so more $CO_2$ is released from the krebs cycle increasing $CO_2$ conc$^n$ to higher than atmospheric air to orange (lowest rate of respiration)

**ResultsPlus**
**Examiner Comments**

This was a stronger response, gaining two marks.

mp1 was for the statement that the tubes closest to the lamp had the highest rate of photosynthesis, as light was not a limiting factor, so more carbon dioxide was being used.

mp4 was for explaining that as the distance from the lamp increases there is a lower rate of photosynthesis and less carbon dioxide is used; and that there is a higher rate of respiration than photosynthesis, so more carbon dioxide is released increasing the carbon dioxide concentration in the tube.

They did not get mp2 as although they recognised that both photosynthesis and respiration were occurring in the tube closest to the light, they said that the rate of respiration was lowest. The rate of respiration is the same in all tubes, so this did not gain credit.

-Tubes closer to the lamp are more purple and therefore contain less carbon dioxide.
-This is because there is a higher light intensity, which is needed for photolysis in the light dependent reaction of photosynthesis.
-A higher light intensity increases the rate of photosynthesis therefore more carbon dioxide is taken in to be fixed in the Calvin cycle.
-At 25cm the carbon dioxide is the same as atmospheric so respiration and photosynthesis are at the same rate.
-At 35-45cm the carbon dioxide is higher than atmospheric therefore respiration is producing more carbon dioxide than photosynthesis is taking in.

**ResultsPlus**
**Examiner Comments**

This is a very strong response, gaining three marks.

mp1 for the statement that a higher light intensity increases the rate of photosynthesis so more carbon dioxide is taken in.

mp3 for recognising that at 25cm respiration and photosynthesis are occurring at the same rate

mp4 for a clear statement that at 35-45cm respiration is producing more carbon dioxide than photosynthesis is taking in.

## Question 3 (b)

The question pointed candidates to the idea that the colour of the indicator and the position of the beads can be used to give a quantitative measure of the effect of light intensity.

Many candidates gained two marks for suggesting that a colorimeter was used to give a numerical value (rather than a colour description), and that the position of the beads in the tube was measured rather than described as half way up or at the bottom.

Far fewer candidates realised that standardising conditions was also needed to give valid results. Those who did most frequently suggested controlling temperature, pH or number of algal beads.

The most frequently seen answer that did not gain credit was to repeat the investigation and calculate a mean.

(b) The colour of the indicator and the position of the beads can be used to give a quantitative measure of the effect of light intensity.

Describe how the method could be modified to give valid, quantitative results.

**(3)**

The experiment should be carried ~~out~~ under the same temperature same pH ~~and~~ (controlled using water baths and buffer solution) and the same species of algae to ensure valid results. To make results quantitative, the colour can be measured using a ~~clo~~ colorimeter : the solution can be put into a cuvette and use a colorimeter ~~to~~ to give a numerical value. The position of beads can be measured using a ruler ~~and~~ from the bottom of the ~~ten~~ test tube and be recorded in cm.

**ResultsPlus**
**Examiner Comments**

This is an excellent answer, covering four marking points and scoring a maximum three marks.

Two examples of standardisation are given (temperature and pH) and the candidate goes on to explain how to achieve quantitative results by using a colorimeter and measuring the heights of gel beads in the tube.

**ResultsPlus**
**Examiner Tip**

When suggesting how to achieve valid results, consider controlling variables and what must be kept the same. This candidate has said 'same temperature and same pH to ensure valid results'.

## Question 4 (a)

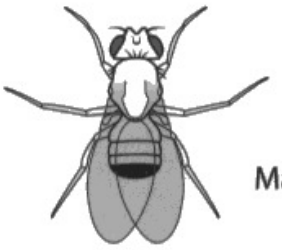
The whole of question 4 was about genetic crosses in *Drosophila melanogaster*, fruit flies.

Q04(a) gave diagrams of a male and female fly and asked candidates to identify one difference between them which was visible in the diagrams, and to state how it differed between them.

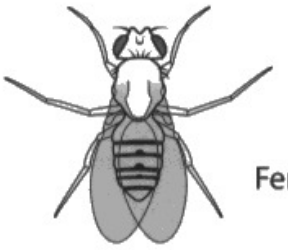
Almost all candidates were able to identify a difference and to describe it, gaining one mark. The most commonly identified differences were abdomen length or shape, or the number or thickness of stripes.

The answer required a statement about male and female flies, eg the male has a rounded abdomen, but the female has a pointed abdomen; or a comparative statement, eg the female has a longer abdomen.

**4** Fruit flies, *Drosophila melanogaster*, are often used in genetics investigations. The diagrams show male and female flies.



Male



Female

Actual size = 3 mm

(a) Give one feature, visible in the diagrams, that you could use to distinguish between male and female flies and state how it differs between them.

**(1)**

Feature

Abdomen

Difference

In males it is short and with less stripes than in females where it is longer and more striped.

**ResultsPlus**
**Examiner Comments**

This candidate clearly described a difference by referring to both the male and female flies. They could have had the mark for either the length of the body or the number of stripes.

**ResultsPlus**
**Examiner Tip**

When you are describing a difference, make sure that you refer to both the male and female flies in your answer

## Question 4 (b)(i)

Candidates were told that a grey bodied fly was crossed with a black bodied fly and all the $F_1$ offspring were grey bodied. This gives two important pieces of information:

- the allele for grey body is dominant to the allele for black body
- all of the $F_1$ flies are heterozygous

Candidates were asked to determine the ratio of phenotypes of the $F_2$ offspring when two of the $F_1$ flies were crossed, using a genetic diagram to support their answer.

This was a straightforward monohybrid cross. Most candidates drew a Punnett square and attempted to give a ratio as required.

Marks were lost where candidates used inappropriate symbols, eg B and G; did not give the ratio of the phenotypes (saying 3: 1, but not what the numbers represented): or gave an incorrect ratio, eg 1:2:1

(b) A scientist investigated the inheritance of several genes in fruit flies.

(i) A grey-bodied fly was crossed with a black-bodied fly.

All the offspring in the $F_1$ generation were grey-bodied.

Two of the grey-bodied flies from the $F_1$ generation were then crossed.

Determine the expected ratio of phenotypes of the offspring in the resulting $F_2$ generation by using a genetic diagram.

**(2)**

| | B | b |
|---|---|---|
| B | BB | Bb |
| b | Bb | bb |

Answer 3 : 1 (grey body : black body)

**ResultsPlus**
**Examiner Comments**

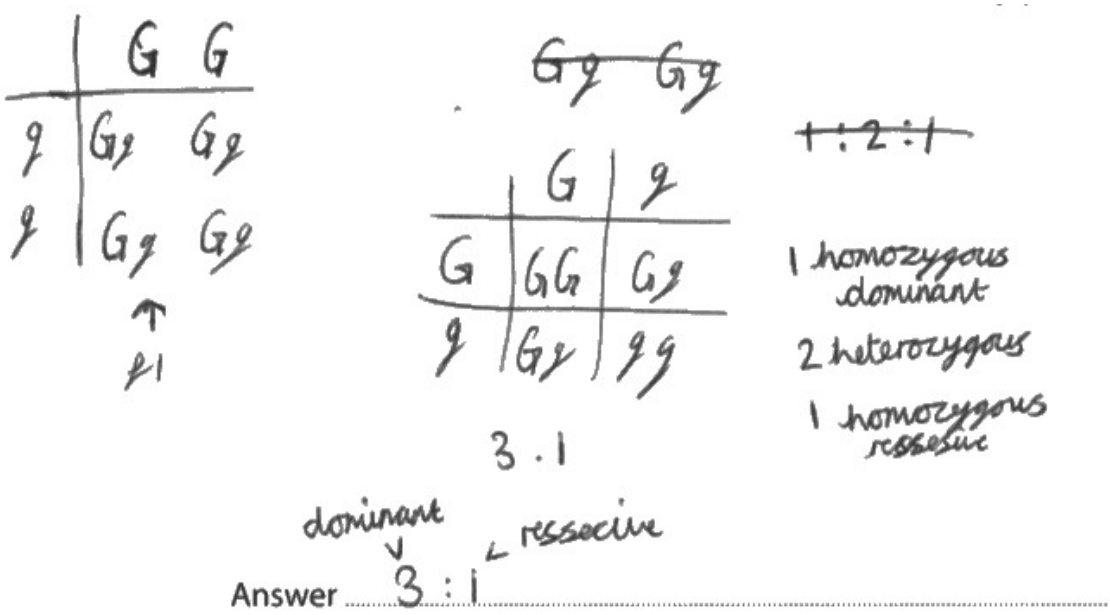
An excellent answer, giving all of the information required for 2 marks.

The Punnett square is clearly laid out, and appropriate symbols have been used for each allele.

The ratio is given as 3:1 and the phenotypes included.

**ResultsPlus**
**Examiner Tip**

If you are not given symbols to use for each allele, choose letters where it is easy to distinguish between upper and lower case, eg B and b, rather than letters that are the same shape, eg S and s




**ResultsPlus**
**Examiner Comments**

This answer scored one mark for the genetic diagram (they also included the $F_1$ cross, but this was not needed).

The ratio was correct (3:1), but the phenotypes (grey body and black body) were not given, so this did not score the second mark.

**ResultsPlus**
**Examiner Tip**

If the ratio of phenotypes is asked for in the question, always include it in the answer.

Here it is body colour and stating the ratio of dominant to recessive is not enough

(2)

| | g | g |
|---|---|---|
| G | Gg | Gg |
| G | Gg | Gg |

$F_1$

| | G | g |
|---|---|---|
| G | GG | Gg |
| g | Gg | gg |

$F_2$

1 GG
2 Gg
1 gg

Answer 1 : 2 : 1 GG : Gg : gg

**ResultsPlus**
**Examiner Comments**

This answer scored one mark for a correct genetic diagram, using appropriate symbols.

It did not achieve the second mark, as the ratio of phenotypes was not correct – they have given a ratio of genotypes.

(2)

gives bodied = G or Gb

black - bodied = bb

| | G | b |
|---|---|---|
| G | GG | Gb |
| b | Gb | bb |

= 3 : 1

Answer 3 : 1

**ResultsPlus**
**Examiner Comments**

Although the genetic diagram was set out correctly, this candidate made two mistakes and therefore scored zero:

- choosing inappropriate symbols (G and b)
- stating the ratio (3:1), but not including the phenotypes (grey body and black body)

**ResultsPlus**
**Examiner Tip**

For a simple monohybrid cross, always use upper and lower case versions of the same letter, eg G and g. Using two different letters eg G and B suggests co-dominance or incomplete dominance is involved.

## Question 4 (b)(ii)

This was a dihybrid cross for 2 unlinked genes.

We know it is a dihybrid cross because we are told in the question stem that two genes are involved – wing length and antenna shape. We know that they are unlinked because one is on chromosome 2 and the other is on chromosome 3.

Candidates were required to

- use the symbols given in the stem of the question (L and l for the alleles for wing length and A and a for the alleles for antenna type) to show the 4 types of gametes produced by each parent
- make a 4 x 4 Punnett square showing the inheritance of these alleles
- give the correct ratio (9:3:3:1) and state what phenotypes these numbers referred to

Many candidates gave excellent answers and scored 3 marks.

The most common error was to give the correct ratio, but not to name the phenotypes corresponding to the numbers.

Some candidates did not realise that the gametes would contain alleles for both wing type and antenna type, so were unable to make an appropriate genetic diagram.

(ii) Normal fruit flies have long wings but some flies have very short wings called vestigial wings.

The allele for long wing (L) is dominant to the allele for vestigial wing (l).

The gene for wing length is located on chromosome 2.

The allele for normal antennae (A) is dominant to the allele for bushy antennae (a).

The gene for antennae shape is located on chromosome 3.

Two flies which are heterozygous for both characteristics are crossed.

Determine the ratio of phenotypes that you would expect in the next generation, using a genetic diagram.

**(3)**

LlAa LlAa

LA La lA la LA La lA la

| | LA | La | lA | la |
|---|---|---|---|---|
| LA | LLAA | LLAa | LlAA | LlAa |
| La | LLAa | LLaa | LlAa | Llaa |
| lA | LlAA | LlAa | llAA | llAa |
| la | LlAa | Llaa | llAa | llaa |

9: long antennae

3: long bushy

3: vestigial normal

1: vestigial bushy

9 : 3 : 3 : 1

9: long winged, normal antannae

3: long winged, bushy antannae

3: vestigial winged, normal antannae

1: vestigial winged bushy antannae

ResultsPlus
Examiner Comments

The candidate has used the symbols given in the question to correctly identify the 4 types of gametes each parent will produce.

They have then used these in an appropriate Punnett square for a dihybrid cross.

They have given the ratio as 9:3:3:1, and given the correct phenotypes for each category, so this answer gains full marks.

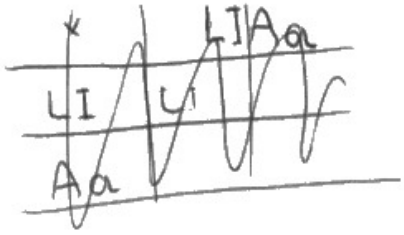
ResultsPlus
Examiner Tip

Take the time to set out the Punnet square carefully, leaving enough space to write all 4 alleles clearly in the boxes. This makes it easier to count up the ratio of phenotypes when you are finished.

Set out the ratio clearly, with a description of each phenotype as done here.

generation, using a genetic diagram. long normal

(3)



| X | L | I |
|---|---|---|
| L | LL | LI |
| I | LI | II ← vestigal |

3:1

| X | A | a |
|---|---|---|
| A | AA | Aa |
| a | Aa | aa |

3:1

Busny.

3:1 ratio of long wings : vestigal wings

3:1 ratio of normal antennae : Busny

SO

6:2 ratio of Long wings : Normal antennae

(3:1)

**ResultsPlus**
**Examiner Comments**

This candidate has not realised that each gamete contains an allele for both wing type and antenna type, and has tried to make 2 separate genetic diagrams. As a result of this, they have an incorrect ratio and have scored zero.

LlAa × LlAa

(LA) (lA) (La) (la) × (LA) (La) (lA) (la)

| | (LA) | (lA) | (La) | (la) |
|---|---|---|---|---|
| (LA) | LLAA long, normal | LlAA long, normal | LLAa long, normal | LlAa long, normal |
| (lA) | LlAA long, normal | llAA vestigal, normal | LlAa long, normal | llAa vestigal, normal |
| (La) | LLAa long, normal | LlAa long, normal | LLaa long, bushy | Llaa long, bushy |
| (la) | LlAa long, normal | llAa vestigal, normal | Llaa long, bushy | llaa vestigal, bushy |

f1 = 9 : 3 : 3 : 1

long normal : vestigal normal, long bushy, vestigal bushy

**ResultsPlus**
**Examiner Comments**

See above

## Question 4 (b)(iii)

In this question, candidates were asked to explain the results of two crosses involving eye colour in fruit flies.

In both crosses we are told the phenotypes of the male and female parent flies and the ratio of phenotypes of the offspring, including whether they are male or female.

Some candidates realised that this meant that the gene for eye colour was sex linked (located on the X chromosome), and that this meant females had two alleles for eye colour, while males had only one.

Cross 1:parents are $X^R X^R$ and $X^r Y$ and offspring are half red-eyed females and half red-eyed males

Cross 2: parents are $X^r X^r$ and $X^R Y$ and offspring are half red-eyed females and half white-eyed males

Some candidates answered entirely through the use of genetic diagrams and were able to score full marks if they understood the principles involved. Some attempted to explain this through a description, although this often proved more difficult.

Some candidates did not realise that sex linkage was involved, and included genetic diagrams showing alleles for eye colour on the Y chromosome eg $Y^R$, which prevented them from scoring most of the marking points.

(iii) The allele for red eyes (R) is dominant to the allele for white eyes (r).

The scientist investigated the inheritance of eye colour.

The crosses used were:

**cross 1** – a red-eyed female fly was crossed with a white-eyed male fly: half of the offspring were red-eyed females and half were red-eyed males

**cross 2** – a white-eyed female fly was crossed with a red-eyed male fly: half of the offspring were red-eyed females and half were white-eyed males.

Explain the results of these crosses.

**(4)**

| | $X^r$ | $Y$ |
|---|---|---|
| $X^R$ | $X^RX^r$ | $X^RY$ |
| $X^R$ | $X^RX^r$ | $X^RY$ |

| | $X^R$ | $Y$ |
|---|---|---|
| $X^r$ | $X^RX^r$ | $X^rY$ |
| $X^r$ | $X^RX^r$ | $X^rY$ |

The red eyed female was homozygous so it would only produce red eyed ~~ff~~ offspring as it is dominant.

A white eyed female will always produce white eyed male offspring as there are no alleles on the Y chromosome

ResultsPlus
Examiner Comments

This answer gained full marks.

The genetic diagrams for cross 1 and cross 2 are clearly set out and show the correct genotypes of parent flies and offspring – this gained marking points 3 and 4.

The candidate has shown in the diagrams that genes for eye colour are only shown on the X chromosome, gaining marking point 1.

The candidate has shown in the diagrams that female flies have two alleles for eye colour and males have only one, gaining marking point 2.

ResultsPlus
Examiner Tip

When setting out a Punnett square with alleles written as superscript letters, eg $X^R$, make sure that you make the diagram big enough to see the letters clearly

(4)

red-R
white-r

1=

| | $X^R$ | $X^R$ |
|---|---|---|
| $X^r$ | $X^R X^r$ | $X^R X^r$ |
| Y | $X^R Y$ | $X^R Y$ |

2=

| | $X^r$ | |
|---|---|---|
| $X^R$ | $X^R X^r$ | |
| Y | $X^r Y$ | |

The allele for eye colour is sex-linked, and is located on the X chromosome. In the first cross, all offspring had red eyes because the females recieve one X chromosome from each parent, in which $X^R$ from the mother is dominant to $X^r$ from the father. The male only recieves one X chromosome and that is from the mother who has only $X^R$. In cross 2, the same thing occurs but with the mother being $X^r X^r$ and father $X^R Y$.

**(Total for Question 4 = 10 marks)**

ResultsPlus
Examiner Comments

See above

## Question 5 (a)

Candidates were given a photograph of a pollen grain as seen through a microscope and asked to calculate the magnification of the photograph. They were told the actual length of the pollen tube in μm.

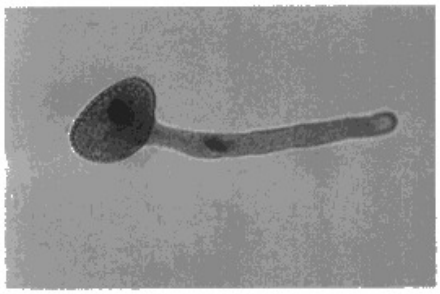
This required them to do several things

- measure the pollen tube correctly
- convert between different units (either cm or mm and μm)
- carry out the calculation
- give their answer with no units

Many candidates managed this process successfully, gaining both marks. As the pollen tube was not completely straight a range of values was accepted for length, and therefore for the final answer.

Some measured incorrectly (the most common error was to include the pollen grain as well as the pollen tube); some converted incorrectly between units; and some were confused about the formula for calculating magnification.

**5** (a) The photograph shows a germinating pollen grain as seen through a light microscope.



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

The actual length of this pollen tube is 136 µm.

Calculate the magnification of this photograph.

**(2)**

136 µm = 0·136 mm = 0·0136 cm

~~ae~~ image length = 32 mm = 3·2 cm

Answer 235x


$$m = \frac{3{\cdot}2}{0{\cdot}0136} = 235\times$$

ResultsPlus
Examiner Comments

This answer scored both marking points.

The candidate correctly measured the pollen tube as 32mm.

They converted this to cm and converted the image length of 136µm to cm.

They correctly divided the image size by the actual size to get a magnification of 235x

(2)

Measured = 3.3cm

~~×10~~ ×10

= 33mm

×100

= 330 nm

×1000

= 330,000 µm

Answer 2426


$M = \frac{I}{A} = \frac{330,000}{136}$

= 2426 (whole number)

**ResultsPlus**
**Examiner Comments**

This answer scored marking point 1 for the correct measurement of the pollen tube.

However the conversion from mm to µm was wrong, so the final answer was a factor of 10 out.

**ResultsPlus**
**Examiner Tip**

Check that you know how to convert between different units of measurement, as this is essential in biology.

Mag = actual / image

136000 / 32 = 4250

136 μm = 136000 mm

actual = 32 mm

Answer × 4250

**ResultsPlus**
**Examiner Comments**

This candidate correctly measured the pollen tube as 32mm, scoring marking point 1.

However they incorrectly calculated the magnification (dividing actual size by image size, rather than image size by actual size), so the final answer was wrong.

(2)

I / AM

42 x 1000 = 42000 µm

42000 / 136 = 308.8

Answer x 309

**ResultsPlus Examiner Comments**

This answer shows one of the most common mistakes.

The candidate has measured the pollen grain as well as the pollen tube, giving a length of 42mm, and an incorrect final answer of 309x.

**ResultsPlus Examiner Tip**

If you are asked to measure from a photograph, check that you are measuring the right thing.

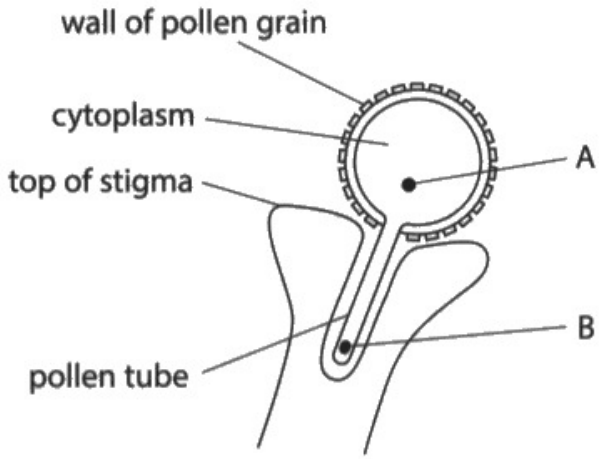
## Question 5 (b)(i)

This question required recall of the names of two structures in a diagram of a germinating pollen grain.

Many candidates were able to identify at least one of these, with tube nucleus being the easiest to remember.

Male nucleus / male gamete were not accepted, as the generative nucleus had not divided in the diagram.

(b) (i) The diagram shows a pollen grain that has begun to germinate after landing on the surface of the stigma of a flower.




Identify the structures labelled A and B.

(2)

A male gamete (undivided)

B pollen tube nucleus

**ResultsPlus**
**Examiner Comments**

This answer scored one mark for pollen tube nucleus. Male gamete was incorrect.

## Question 5 (b)(ii)

There were some excellent answers to this question, which required candidates to describe the process of double fertilisation in flowering plants.

Many were able to describe clearly what happened to each of the male gametes, and to name the initial products of fertilisation which are formed (the diploid zygote and triploid endosperm nucleus).

Some candidates did not recall that the generative nucleus divides to form male gametes, so described the generative nucleus itself fusing with the female gamete or polar nuclei. Some used imprecise terms for the male gametes, such as haploid gamete or sperm cell, and some confused the polar nuclei with polar bodies.

A significant number of candidates referred to triploid endosperm being formed, rather than a triploid endosperm nucleus.

(ii) Describe the process of double fertilisation in flowering plants.

**(3)**

As the pollen tube grows through the style it produces hydrolytic enzymes which digest material of the style. This is used for energy. As the generative nucleus goes down the pollen tube it divides by mitosis to form two identical nuclei (haploid). The pollen tube passes into the micropyle of the ovule. One male nuclei fuses with the female egg cell nucleus to form a diploid zygote. The other male nuclei fuses with 2 polar nuclei to form a triploid endosperm. This is known as double fertilisation.

**ResultsPlus**
**Examiner Comments**

This was a strong answer gaining full marks.

The candidate clearly described the fusion of the male nucleus with the female egg cell nucleus to form a diploid zygote for mp3 and 4. They also described the fusion of the other male nucleus with the polar nuclei for mp1.

(ii) Describe the process of double fertilisation in flowering plants.

(3)

1 Male gamete fuses with the female gamete to create diploid cell which will then divide by mitosis to replicate and grow.

The second male gamete fuses with polar bodies in female (cell) ~~megaspore~~ which creates a cell that is used for nutrients that are used to help the fertilised cell grow.

**ResultsPlus**
**Examiner Comments**

This candidate scored marking point 3 for the male gamete fusing with the female gamete.

However they said that this produces a diploid cell (rather than a diploid zygote), so did not score the fourth marking point here.

They referred to polar bodies, rather than polar nuclei, so did not get the first marking point, and did not name the triploid endosperm nucleus for marking point 2.

## Question 5 (c)

This question generated a wide range of responses to this question, which was a modification of a core practical. Some candidates were able to give a full account of the procedure needed to find the effect of pH on rate of growth of pollen tubes, and scored full marks. It was clear from the level of detail in their answers that many had done this, and remembered the steps of the method well.

Some forgot key aspects of the method, including the addition of sucrose solution, the need to calibrate the eyepiece graticule or how long to leave the pollen grains to germinate.

Many forgot to calculate growth rate (by dividing the change in length of the pollen tube by the time it had been growing), and some recorded percentage germination rather than measuring the pollen tube at all.

There were some good attempts to control variables including using the same plant or anther to provide pollen, using the same concentration of sucrose or using an incubator to control temperature. Most knew that they should repeat the procedure at each pH to calculate the mean or standard deviation.

The most common error was using different concentrations of acid rather than solutions at different pH values.

(c) Devise an investigation to determine the effect of pH on the rate of growth of pollen tubes.

**(5)**

Place ~~five~~ (5) ~~different~~ ~~test tubes~~, ~~containing~~ the
Prepare
~~Make~~ several ~~dilutions~~ of samples of sucrose solution, of the
same concentration and volume, but of varying pH values eg: 4, 5, 6, 7, 8
Place the same volumes of the solution into 5 petri dishes
and place a ~~pea~~ soaked filter paper in each petri dish, which
provides a humid chamber. Using a mounted needle, rub the
same amount of the anther of the same species of the plant
so that they shed the same amount of pollen grains. Do not
the dishes
cover with a coverslips to prevent the conditions from becoming
*Leave the dishes for the same amount of time (in areas with the same light intensity)
acidic. Measure the length of the pollen tube in each dish
to determine the effect of pH on the growth of the pollen
tubes. At lower pH values, ~~the~~ (acidic pH), the pH will
be more optimum for the enzymes in the tube nucleus to digest
the cells of the style so the pollen tube grows more,
(becomes longer).

ResultsPlus
Examiner Comments

A very good start to this answer, with the candidate gaining mp1 (for a range of 5 pH values), mp2 (for including sucrose solution) and mp6 (for stating that the same concentration of sucrose solution is needed) in the first sentence.

(c) Devise an investigation to determine the effect of pH on the rate of growth of pollen tubes.

**(5)**

- independent variable : use a range of pH ~~testing buffer so~~ (e.g pH ~~2~~, 4, 5, 6, 7, 8)
- use pollen grains from ripened anther on the same plant so the age and species ~~of~~ of the pollens are controlled
- use the same ~~conc~~ concentration and volume of the nutrient broth (i.e sucrose and mineral ion concentration)
- put pollens on the slide cavity and in a moistened (~~with~~ using the ~~solution~~ nutrient solution) petri dish to create a humid chamber
- leave to grow for same amount of time under the same temperature e.g 25°C for 2 hours
- view each slide ~~under~~ under the microscope
- calibrate the eye piece using stage micrometer
- measure the length of pollen tube
- repeat the experiment and ~~to~~ calculate the average

safty

avoid contamination

asceptic technique

**(Total for Question 5 = 12 marks)**

ResultsPlus
Examiner Comments

This candidate gained mp1 for using a range of 5 pH values and mp6 for using an anther on the same plant to provide the pollen, so the age and species of pollen was controlled.

(c) Devise an investigation to determine the effect of pH on the rate of growth of pollen tubes.

**(5)**

To investigate the effect of pH on the rate of growth of pollen tubes, we must prepare 5 agar plates at different pH levels, ~~[illegible]~~ a pH of 2, 5, 7, 9, 12. Ensuring we use pollen grains ~~seeds~~ of the same species and same age, place 6 pollen tubes evenly spread in the agar jelly for all 5 pH levels* Placing the agar jellies in an area where light intensity and temperature can be controlled leave them for 2 hours. After returning 2 hours later, take the pollen grains and place them under a microscope. Using a calibrated eyepiece graticule measure the length of each pollen tube in 1 agar and calculate the mean. Do this for the other 4 agar and put the data into a table. ~~Evaluate~~ Ensure you disinfect your desk carefully. Then Compare the data by doing a T-test.

* replacing the lid

**ResultsPlus**
**Examiner Comments**

This candidate gains mp3 for choosing a suitable time for the pollen tubes to grow (2 hours).

They clearly describe the use of a microscope and calibrated eyepiece graticule for mp4.

As they had placed 6 pollen grains at each pH, the description of measuring each pollen tube in one agar and calculating a mean gets mp7.

**ResultsPlus**
**Examiner Tip**

Remember that you cannot measure with an eyepiece graticule unless it has been calibrated.

## Question 6 (a)

There were a wide range of responses to this question, which proved very challenging for many.

Some candidates realised that a random mutation had caused the greyish-brown plants, and that these were better camouflaged, so less likely to be picked; with people collecting them acting as a selection pressure. Those that were not collected would survive and reproduce, passing on the alleles for dull colouration to their offspring, and over time the allele frequency would increase. There were some very strong answers covering these points and scoring high marks. Marking point 2 for referring to the random mutation was least often seen.

The most common errors were

- describing the mutation as taking place **in order** to make the plant better camouflaged, rather than as a random event, so not getting mp2
- recognising that the greyish-brown plants were less likely to be picked, but not explaining that this was because they were harder to see, so not getting mp3
- knowing that the duller plants were more likely to survive and reproduce, but not explaining this in terms of passing alleles on; or describing the trait being passed on (so not getting mp4)
- saying that the allele frequency would change, rather than increase, so not getting mp5

A number of candidates did not realise that natural selection was occurring and explained the greyish-brown colour as a result of mineral deficiency or trampling (both caused by people collecting plants) or said that the plants did not need to be brightly coloured to attract insects and that people would pollinate them as they were collecting them.

A random mutation caused one plant to have greyish brown leaves. The selection pressure was the humans that collect the plants. The mutation with the brown leaves and flowers is an advantageous allele as the plant is able to camouflage against the rocky slope whereas Bright plants would not survive and get picked. The grey/brown plants would survive long enough and reproduce via mitosis only in areas where humans go and bright coloured plants would die out. Natural selection is occuring.

ResultsPlus
Examiner Comments

This was a strong answer, gaining 3 of the possible 4 marks.

The candidate recognised that a random mutation had taken place for mp2.

They described the brown plants as better camouflaged and stated that the brighter plants would be picked, gaining mp3.

They know that the brown plants were more likely to reproduce, but did not explain this in terms of the advantageous allele being passed on, so did not get mp4.

They recognised that natural selection was occurring for mp1.

**6** *Fritillaria delavayi* is a small plant (height 7 cm), that grows on rocky slopes on mountains in China.

The image shows *Fritillaria delavayi*.


For at least 2 000 years, this plant has been collected and used in Chinese medicine. It is not known to be eaten by animals.

In less accessible regions, where few humans go, the plants are bright green with bright yellow flowers.

In locations where bulbs are collected in high numbers, most plants have greyish-brown leaves and flowers.

Scientists believe that the greyish-brown plants are the same species as the brightly-coloured plants.

(a) Explain why most of the plants in areas where bulbs are collected in high numbers have greyish-brown leaves and flowers.

**(4)**

plants in areas of high bulb collection face the selection pressure of being picked by humans, whereas the plants in less accessible regions don't. Plants with duller colours stand out less, and may not look healthy to the humans picking the plants. A random mutation in a plant in this area caused to an allele that its colours to be duller and so it was more likely to survive and reproduce, with its offspring inheriting the advantageous allele. Over many generations the frequency of this allele increased as the phenotype it coded for could better survive the natural selection of humans.

**ResultsPlus**
**Examiner Comments**

This was a very strong answer gaining full marks.

The candidate recognised that plants being collected acted as a selection pressure for mp1.

They referred to a random mutation causing the duller colours for mp2.

They knew that duller coloured plants were more likely to reproduce, passing the advantageous allele to the offspring for mp4.

They clearly stated that the frequency of the allele will increase for mp5.

It is a selective advantage as bulbs which are grey are less likely to be collected me people are a selection pressure. Grey bulbs which

**ResultsPlus**
**Examiner Comments**

This candidate did not explain why the bulbs were less likely to be collected, so did not get mp3, but achieved mp1 for recognising that the people were acting as a selection pressure when they collected the bulbs.

Because most likely the plants in areas where bulbs are collected a lot the brightest plants will be picked and used for medicine until the greyish plants are the only ones left that reproduce meaning over time the plants with the most colour get killed leaving the dull greyest ones left.

**ResultsPlus**
**Examiner Comments**

Although this candidate understood the basics of what was happening, they did not describe it in enough detail to hit any of the marking points.

They did not explain why brightly coloured plants were more likely to be picked for mp3.

They knew that greyish plants were more likely to reproduce, but did not explain this in terms of passing on alleles for mp4.

## Question 6 (b)(i)

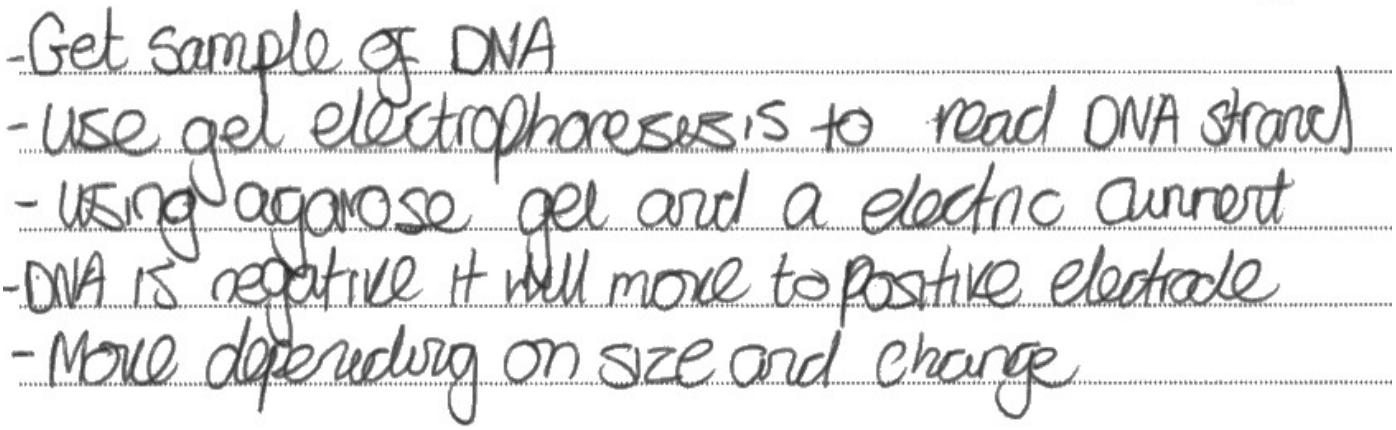
This question asked candidates to describe how gel electrophoresis could be used to show that two similar plants are the same species. There were some excellent answers, showing that candidates understood the process well and could describe it clearly.

Lower scoring candidates often understood the basics of the technique, but did not describe them clearly enough to gain marks.

The most common errors included answers where it was not clear that the DNA had been cut into fragments, or that it was the fragments that were being separated. Even when the rest of the description was good, some answers did not include a reference to comparing the banding patterns, with similarities suggesting they were the same species.

(b) (i) **Describe how scientists can use gel electrophoresis to show that these plants belong to the same species.**

**(4)**




**ResultsPlus**
**Examiner Comments**

This answer gained mp1 for getting a sample of DNA, and mp3 for the brief description of gel electrophoresis.

They did not get mp4 because although they recognised that the DNA would move depending on its size and charge, they did not say that this would separate the fragments.

**ResultsPlus**
**Examiner Tip**

Remember to finish the answer by saying how the results of gel electrophoresis could be used to show that the plants belong to the same species.

↳ DNA placed in gel and in electrical field with one negative end and one positive end

↳ DNA moves ∴ separating genes ∴ can

ResultsPlus Examiner Comments

This answer scored marking point 3 for the description of gel electrophoresis, but not marking point 4 as it is not the genes that are being separated.

- Initially by collecting a sample of the two different plant's DNA, and it is cut up using restriction endonucleases.
- Then ~~amplifying~~ amplifying the DNA to increase the amount of DNA using → PCR.

ResultsPlus Examiner Comments

This answer gains mp1 for collecting the DNA samples and mp2 for amplifying them using PCR.

- Then the DNA moves towards the ~~negat~~ positively charged electrode as it contains a ~~longer positively~~ negatively charged backbone.
- Smaller fragments travel further ~~and~~ as they don't get stuck, thus two patterns are created and they can be compared showing similar DNA fragments under X-ray, showing they are the same species.

ResultsPlus
Examiner Comments

In this part of the answer the same candidate has achieved mp3 for saying that DNA moves to the positive electrode. They got mp4 for stating that smaller fragments travel further.

They achieved marking point 5 by saying that two patterns are created and that they can be compared, showing similar DNA fragments showing they are the same species.

## Question 6 (b)(ii)

Candidates were asked to explain how the features of the brightly coloured plants enabled them to grow successfully in areas where they were not collected by humans.

There were two marks available, for one of two separate explanations, each with 3 marking points:

**Either**

plants contain more chlorophyll / photosynthetic pigments (mp1); so they can absorb more light for photosynthesis (mp2); so more glucose is produced for growth (mp3)

**or**

bright flowers attract more pollinators (mp1); so plants are more likely to reproduce (mp2); to produce seeds / pass the trait on (mp3)

Candidates were not able to move between the two explanations, picking up one mark for talking about photosynthesis and another for reproduction, as this did not allow them to develop the explanation with a reason.

(ii) **Explain why the features of the brightly-coloured plants enable them to grow successfully in the areas where they are not collected by humans.**

**(2)**

The brightly coloured plants have more photosynthetic pigments in their leaves so more light can be captured by leaves for the light dependent stage of photosynthesis. This means that photosynthesis occurs at a higher rate, so more glucose is produced for

**ResultsPlus**
**Examiner Comments**

This answer gained two marks for an excellent description of the effect of having green leaves: that more photosynthetic pigments are present (mp1) so more light is absorbed for photosynthesis (mp2).

(ii) Explain why the features of the brightly-coloured plants enable them to grow successfully in the areas where they are not collected by humans.

**(2)**

The bright colours ~~are~~ attract birds and insects which then carry their pollen to other plants of their same species and fertilise them, allowing them to reproduce.

**ResultsPlus**
**Examiner Comments**

This answer achieved two marks for saying that bright colours attract birds and insects to carry pollen (mp1) and that this allows the plants to reproduce (mp2).

**ResultsPlus**
**Examiner Tip**

Remember to carry on to the end of the explanation, as this answer does, and not stop mid way.

## Question 7 (a)(i)

Candidates were told that plants need mineral ions from soil, and asked to describe how they are taken up by active transport.

There were some excellent answers to this question, but many were incomplete, with candidates covering only one or two of the three marking points.

The most common errors were referring to channel proteins instead of carrier proteins, referring to energy instead of ATP and getting the concentration gradient the wrong way round.

**7** Plants require mineral ions from the soil for healthy growth.

(a) (i) Describe how mineral (inorganic) ions are taken up by active transport.

**(3)**

Mineral ions are taken up by the root hair cells by using up energy to pull in more ions from an ~~area of~~ area of lower concentration to an area of higher concentration through the use of channel proteins

**ResultsPlus**
**Examiner Comments**

This answer gained one mark for ions moving from an area of lower concentration to an area of higher concentration.

They did not achieve mp1 as they stated that channel proteins were used for this.

Energy was not enough for mp3, ATP was required.

**ResultsPlus**
**Examiner Tip**

Make sure you understand the difference between carrier proteins and channel proteins.

This is a process in the root hair cells that requires ATP. The minerals are dissolved in the water, and can take the symplast pathway - through cytoplasm of root hair cells and through plasmodesmata - or the apoplast pathway - through the cell wall space and entering cytoplasm at casparian strip. This whole process requires active pumping of ~~ca~~ and occurs down a concentration gradient from the root hair cell surface to the xylem at the base of the stem.

ResultsPlus
Examiner Comments

This candidate scored one mark for stating that ATP was required. They did not score mp2 as they said this was down a concentration gradient.

ResultsPlus
Examiner Tip

If ATP is used for transport, it is always against a concentration gradient.

ATP produced from respiration allows mineral ions to move against a concentration gradient from ~~soil~~ soil into root hair cells. Carrier proteins in cell membrane of root hair cell ~~to~~ actively ~~from~~ carrier mineral ions from soil into root hair cells.

ResultsPlus
Examiner Comments

See below

ResultsPlus
Examiner Tip

This answer scored all three marks.

They recognised that ATP was used (mp3), that the ions were moving against a concentration gradient (mp2) and that carrier proteins in the membrane moved them into the root hair cell (mp1).

## Question 7 (a)(ii)

Candidates were asked to name a mineral ion vital for growth in plants and to describe its function. It was expected that candidates would name one of the four ions described in the specification, and there were some excellent answers to this question. Nitrate, calcium and magnesium were seen most frequently with clear descriptions of their functions.

Credit was not given for vague descriptions, eg nitrate needed for growth and repair. Some candidates were unable to name a mineral ion, with some giving hydrogen, sucrose or glucose as mineral ions.

(ii) Describe the function of a named mineral ion that is vital for the growth of plants.

**(2)**

Mineral ions

Magnesium ($Mg^{2+}$)

Function

They are required for the production of chlorophyll, a pigment found in leaves which is needed for photosynthesis

ResultsPlus
Examiner Comments

A clear answer, scoring both marks

Mineral ions

Nitrate

Function

for mitosis

ResultsPlus
Examiner Comments

This candidate scored one mark for an appropriate mineral ion (nitrate) but the function was too vague to gain credit at A level.

ResultsPlus
Examiner Tip

Make sure that you know the functions of the four mineral ions stated in the specification.

Mineral ions

Nitrogen

Function

- nitrogen helps increase root growth

ResultsPlus
Examiner Comments

Nitrogen is not an ion, as plants take up nitrate ions, so this candidate did not get mp1.

Their description of the function of nitrate ions is too vague to get credit in mp2.

## Question 7 (b)(i)

This question gave some information about the plant *Galium verum*, and told candidates that a student investigated whether it grows taller in meadows than on sand dunes. They were asked to write a null hypothesis for the investigation for 1 mark.

Around half of students were able to do this. Candidates were expected to include the name of the plant, the dependent variable (height), the independent variable (the two locations, or at least a reference to them) and the type of relationship they were looking for (a difference).

Some who knew the basics of how to write a null hypothesis did not get the mark because they were looking for a correlation or relationship, not a difference.

It was clear that many candidates did not understand the term null hypothesis at all, and wrote a hypothesis in which they suggested where it would grow tallest and why.

(b) The photograph shows *Galium verum* (Lady's bedstraw), a plant that grows in meadows, hedges, road verges and sand dunes.

(Source: © Alfio Scisetti/Alamy Stock Photo)

This plant grows to between 15 cm and 60 cm in height.

A student investigated whether *Galium verum* growing in meadows was taller than *Galium verum* growing on sand dunes.

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

**(1)**

There is no significant difference between the mean height of Galium verum in meadows + Galium verum on sand dunes.

**ResultsPlus**
**Examiner Comments**

This is an excellent answer, scoring the available mark.

There is no correlation between the meadows and sand dunes on growth.

ResultsPlus
Examiner Comments

This candidate scored zero because they referred to a correlation, rather than a difference.

They also did not refer to the height of the plant (they said growth) and did not include its name.

Galium verum will grow best in meadows as it has more reasources to use and is less likely to be bothered.

ResultsPlus
Examiner Comments

This is not a null hypothesis, as the candidate is suggesting that they think it will grow taller in the meadow, so no mark here.

## Question 7 (b)(ii)

Candidates were asked to devise a method to collect valid results to test their hypothesis. Fieldwork sampling is a core practical, and it was expected that candidates would know the basic principles. Credit was given for:

1. use of random sampling using randomly selected numbers as co-ordinates to prevent bias
2. either using a quadrat or selecting the plant closest to the co-ordinates in both areas being compared
3. measuring the height of the named plants
4. measuring a large enough sample; we accepted 10 plants, but would have preferred candidates to use a larger sample of at least 20 in each place, or to use a method like the running mean to determine sample size
5. attempting to control a variable

For marking point 4, some candidates suggesting using a fixed number of quadrats, but there was no indication of how many plants this would provide for measurement.

For marking point 5 (attempting to control a relevant variable) we were looking for long-term factors which would affect the height of the plants such as shading, trampling, grazing or time of year. We did not accept measurement of light intensity or temperature, which would change depending on conditions and throughout the day.

A number of candidates said that the time of day must be controlled, but this would not affect the height of the plants.

There were some excellent answers covering many of the marking points, with mp1, 2 and 3 most commonly seen. Some candidates did not clearly describe sample size, or attempt to control a variable. A few candidates suggested planting *Galium verum* seeds in the two areas, but could still achieve mp3 for measuring the height of the plant.

(ii) Devise a method that can be used to collect valid results to test this null hypothesis.

**(5)**

In each area. Lay out a grid. Use a random number generator to get coordinate. Place a quadrat in each at each coordinate. Use a ruler to measure the height of any Galium verum in that quadrat. Continue doing this until there are at least 10 values for each area. Calculate the mean height of the Galium verum in each area. Calculate standard deviation for each area. Do this at the same time of year at each area.

**ResultsPlus**
**Examiner Comments**

This is a strong answer gaining full marks.

The candidate gets mp1 for a description of how to position the quadrats without bias (using a grid and random number generator to get co-ordinates).

They get mp2 for using a quadrat and carrying out the investigation in the meadow and sand dune (here described as in each area).

They get mp3 for measuring the height of all the *Galium verum* in the quadrat.

They get mp4 for measuring at least 10 plants in each area.

They get mp5 for doing it at the same time of year in each area.

pick area of sand dune and meadow
making sure conditions are the same.
e.g both have access to light.
· random sampling using quadrat
· count abundance of species in each area
· make sure conditions are controlled ~~e.g~~ such as
light intensity, wind, temperature
- measure height of plant for each area

ResultsPlus
Examiner Comments

This answer gained mp2 for sampling with a quadrat in both areas.

They did not get mp1, as although they said random sampling should be carried out, they did not describe how to do this.

They did not get mp3 as they did not make it clear which species of plant they were measuring.

~~Control the time of~~ If the plants measured in the meadows are shaded make sure that the ones on the sand dunes are too. Control the time of year

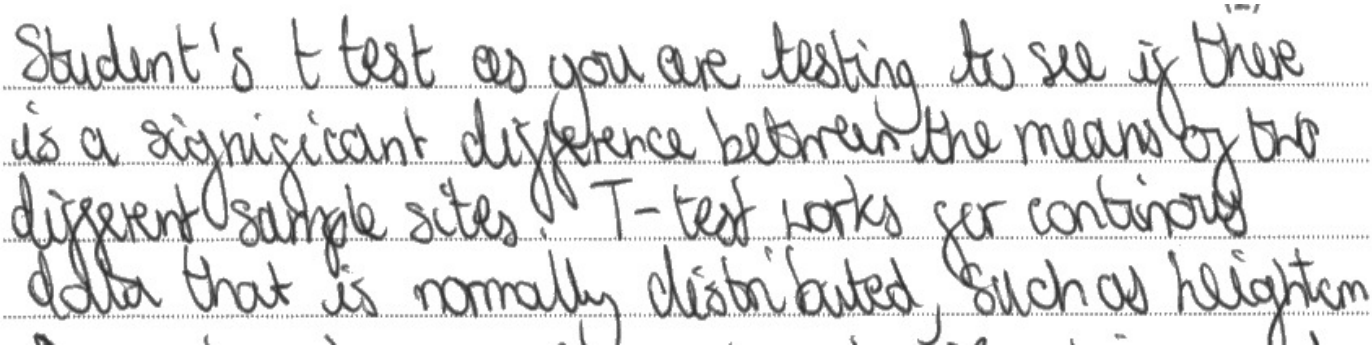
ResultsPlus
Examiner Comments

This shows a good attempt to control variables for mp5 – either shading or time of year were worthy of credit.

## Question 7 (b)(iii)

Candidates were asked to explain which statistical test would be most suitable to test their null hypothesis.

Many candidates correctly suggested a t-test, although relatively few could explain why this was suitable, ie that it tests for the difference between the means of two sets of values.




**ResultsPlus**
**Examiner Comments**

This is a detailed answer scoring both marks.

They have correctly identified an appropriate test (t test) and explained that it is testing for a difference between the means of the different sample sites.

(iii) Explain which statistical test would be most suitable to test this null hypothesis. $\chi^2$

**(2)**

The student's T Test.

The T-test shows if there is significant difference between two sets of data. If the difference between heights is caused by one environment, (ie meadow vs sand dune), the T test will show this.

**ResultsPlus**
**Examiner Comments**

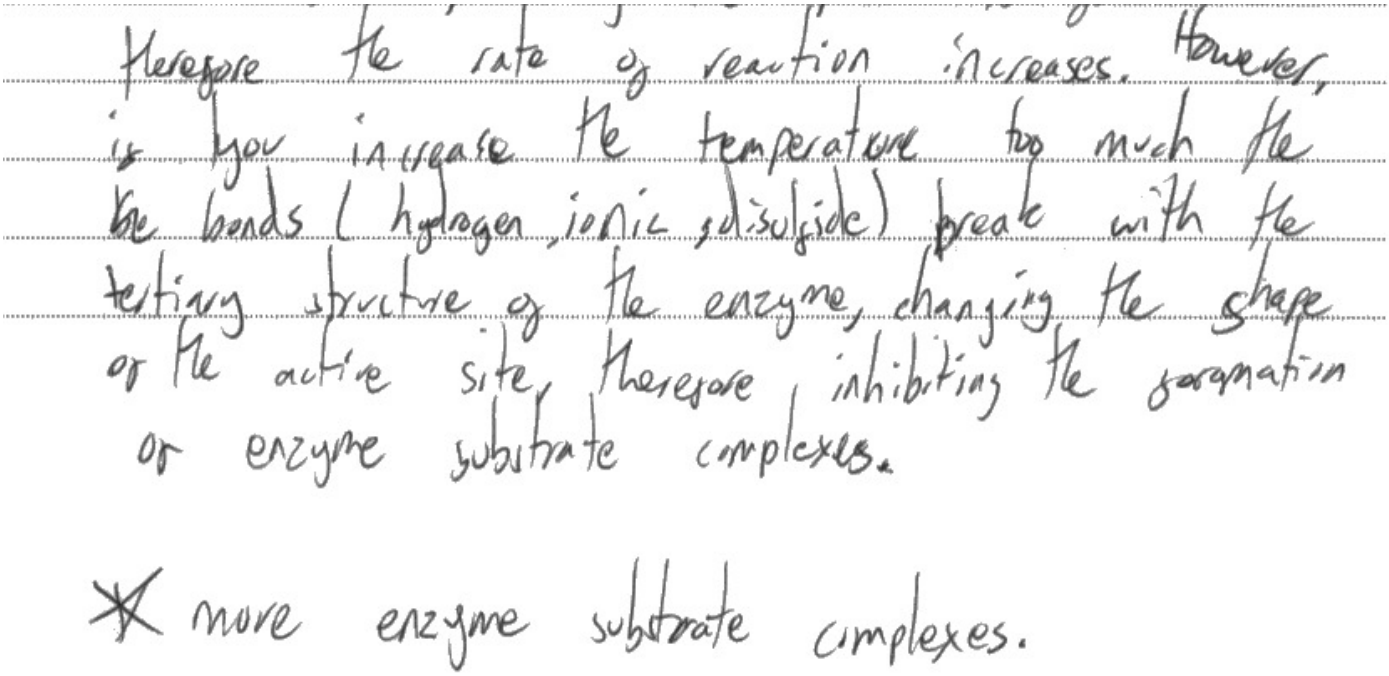
This is a strong answer. The correct test is identified and an appropriate reason given, scoring 2 marks.

## Question 8 (a)

Candidates were asked to explain why increasing the temperature of an enzyme-controlled reaction changes the rate of reaction.The topic of enzymes is very familiar from GCSE, but at A level more detail is needed to explain the changes that occur.

There were a wide range of responses to this question. E grade candidates often explained how increasing temperature increases the rate of reaction by increasing kinetic energy.

Stronger answers went on to explain how further increases in temperature caused denaturation, decreasing the rate of reaction. The best answers explained this in terms of bonds breaking, changing the shape of the active site and preventing substrates from fitting the active site.




ResultsPlus
Examiner Comments

This is a clear statement of mp3: bond changes in the enzyme altering the shape of the active site.

However, if temperature gets too high the tertiary structure of the enzyme is affected and denaturation occurs, meaning these ~~substrate~~ enzyme substrate complexes can't form and rate of reaction will rapidly decrease.

**ResultsPlus**
**Examiner Comments**

This candidate explained that if temperatures were too high the enzyme would denature causing the rate of reaction to decrease (mp2).

They came close to marking point 3 but did not get this; although they said the tertiary structure of the enzyme is affected, they did not describe the effect on the shape of the active site.

The temperature increase provides energy for the enzymes and substrates causing more frequent successful collisions thus increasing the rate of reaction for the enzymesubstrate complexes forming.

**ResultsPlus**
**Examiner Comments**

This candidate came close to marking point 1, but did not explain that it was an increase in **kinetic** energy, so did not gain credit.

Increasing the temperature. Increasing the temperature up to a point increasing the rate of reaction. Substrate and enzymes have more kinetic energy, more frequent collisions, more frequent binding of substrate to active site, more ESCs, faster rate of reaction. Increasing the temperature of an enzyme-controlled reaction past the optimum temperature of the enzyme will decrease the rate of reaction. Heat will cause hydrogen bonds holding the tertiary structure together to break, changing the tertiary structure of the enzyme. This changes the shape of the active site so the substrate can no longer bind to the active site as they are no longer complementary. Fewer/no ESCs, slower rate of reaction. Enzyme becomes denatured.

ResultsPlus
Examiner Comments

See below

ResultsPlus
Examiner Tip

This is an excellent answer, covering all four marking points and scoring full marks.

## Question 8 (b)(i)

Candidates were given a diagram of the apparatus used to investigate the activity of the enzyme catalase in potato. They were asked to describe how two named variables (other than the potato) could be controlled to give valid results.

Credit was given for naming two appropriate variables, eg temperature, pH, volume of hydrogen peroxide or concentration of hydrogen peroxide. A further mark was given for describing how this could be done for each variable, eg use of a thermostatically controlled waterbath, buffer, measuring cylinder or dilution of stock solution.

There were some very strong answers to this question, with many candidates identifying temperature and volume of hydrogen peroxide.

The most common errors seen were

- not identifying appropriate variables; several thought that the volume of water in the beaker must be controlled
- not attempting to explain how to control the variables identified
- describing the method of control in very vague terms, eg use of a waterbath, rather than a thermostatically controlled waterbath; controlling the concentration of hydrogen peroxide by using the same concentration of hydrogen peroxide.

– The temperature can be controlled by using a thermometer, so the enzymes can work at their optimum temperature and not denature, if the temperature gets too high.

– ~~The ## ensure the temp is at~~ The pH can be controlled by using a buffer solution, ensuring the enzymes can work at ~~the~~ their optimum pH.

ResultsPlus
Examiner Comments

This candidate recognised that temperature should be controlled for one mark, but credit was not given for using a thermometer to do this.

They scored two further marks for controlling pH with a buffer.

ResultsPlus
Examiner Tip

When controlling temperature, always use a thermostatically controlled waterbath. Monitoring the temperature with a thermometer is not the same as controlling it.

The concentration and amount of hydrogen peroxide should stay the same to to keep the test fair.

**ResultsPlus**
**Examiner Comments**

This answer gained one mark for keeping the concentration of hydrogen peroxide the same, but they did not go on to explain how this could be done.

No credit was given for keeping the amount of hydrogen peroxide the same.

**ResultsPlus**
**Examiner Tip**

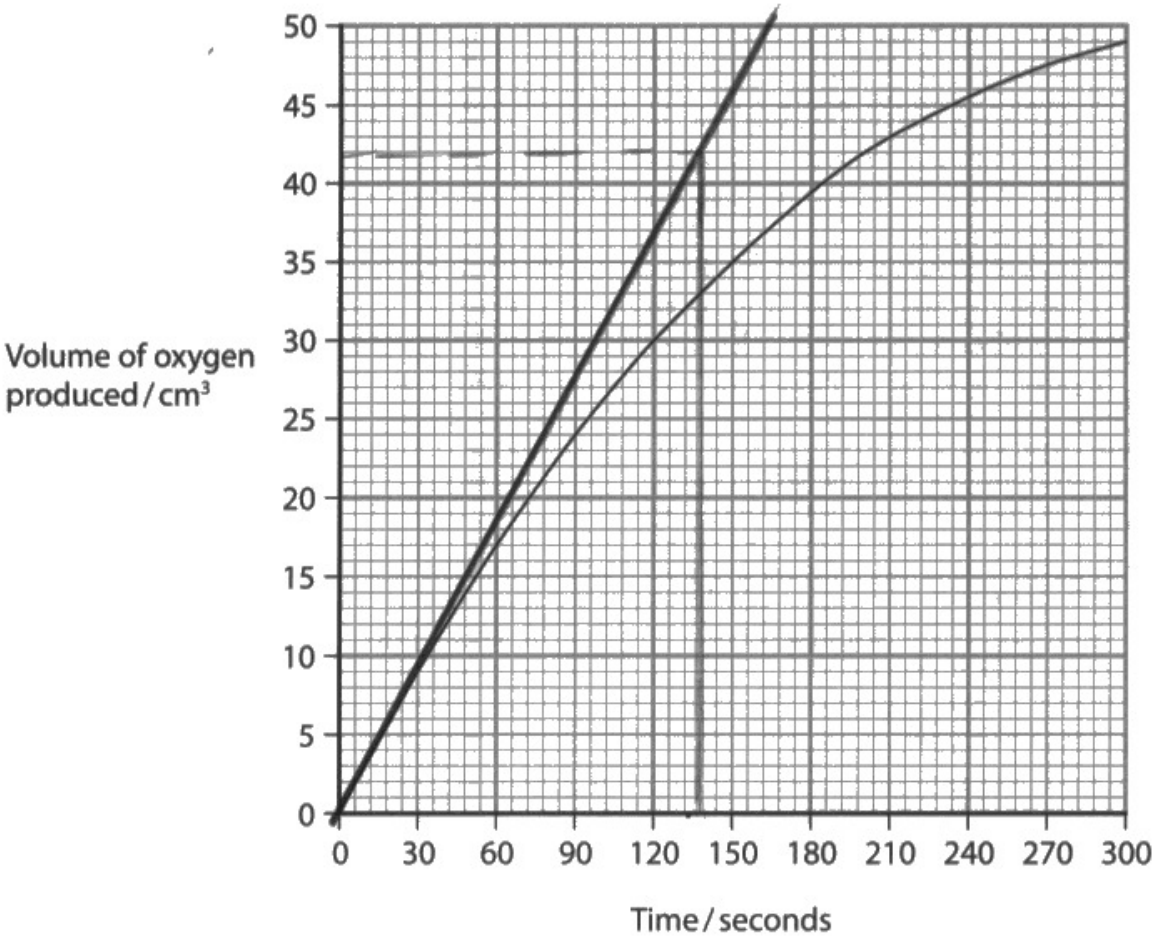
'Amount' is too vague to get a mark. Here they should have said the volume of hydrogen peroxide should stay the same.

## Question 8 (b)(ii)

Candidates were given a graph of rate of reaction (volume of oxygen produced against time) and asked to calculate the initial rate of reaction.

Most knew that they should draw a tangent onto the graph and calculate the gradient. Many completed this successfully, but some did not gain the mark as they did not include units in their answer.

(ii) The graph shows the results of the investigation.




Determine the initial rate of reaction from this graph.

(1)

change in y / change in x = 42 - 0 / 138 - 0

= 1.8947

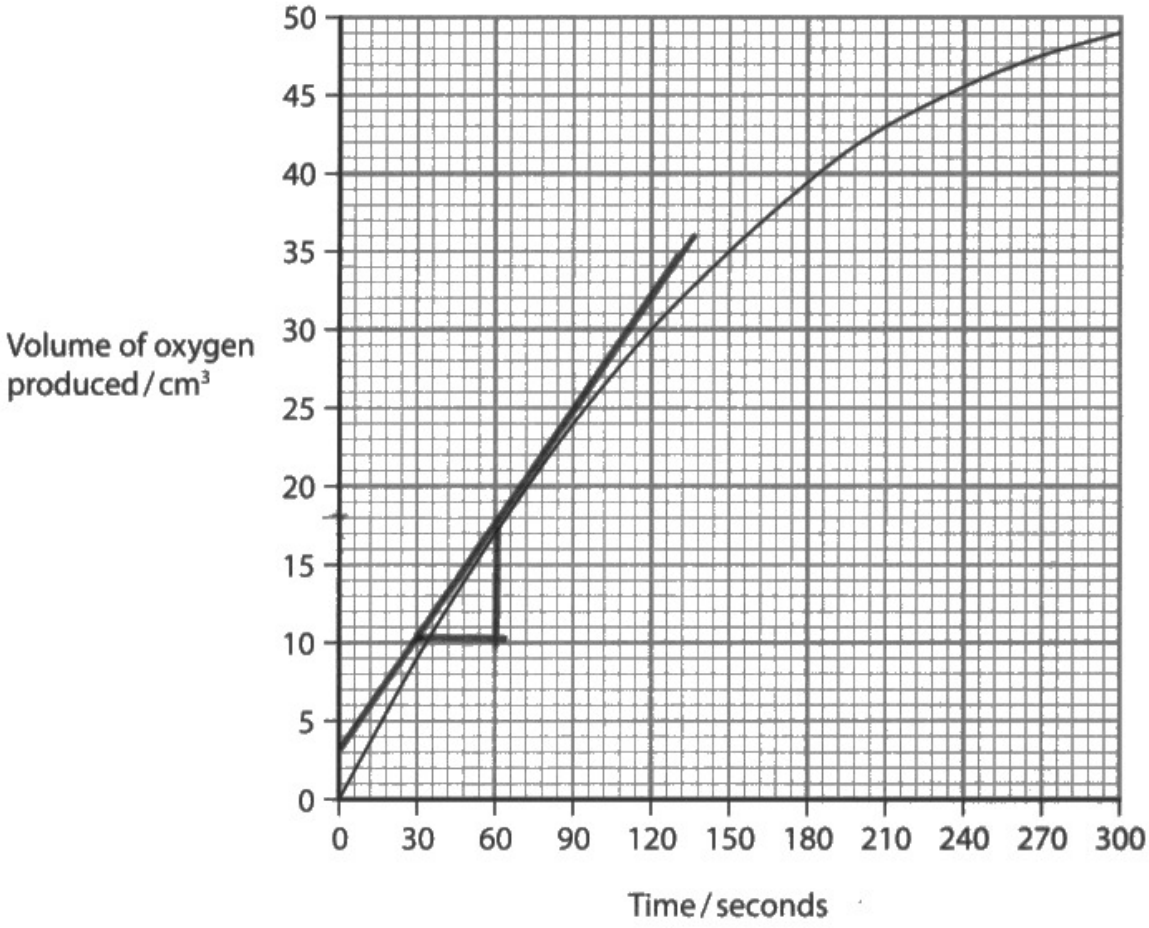
≈ 1.89 cm³ s⁻¹

Answer 1.89 cm³ s-1

ResultsPlus
Examiner Comments

This candidate drew an appropriate tangent, and read the figures off the graph correctly, but the answer was incorrect.

(ii) The graph shows the results of the investigation.




Determine the initial rate of reaction from this graph.

**(1)**

30s, → 60s.

Vol of $O_2$ = 10cm³ → 18cm³

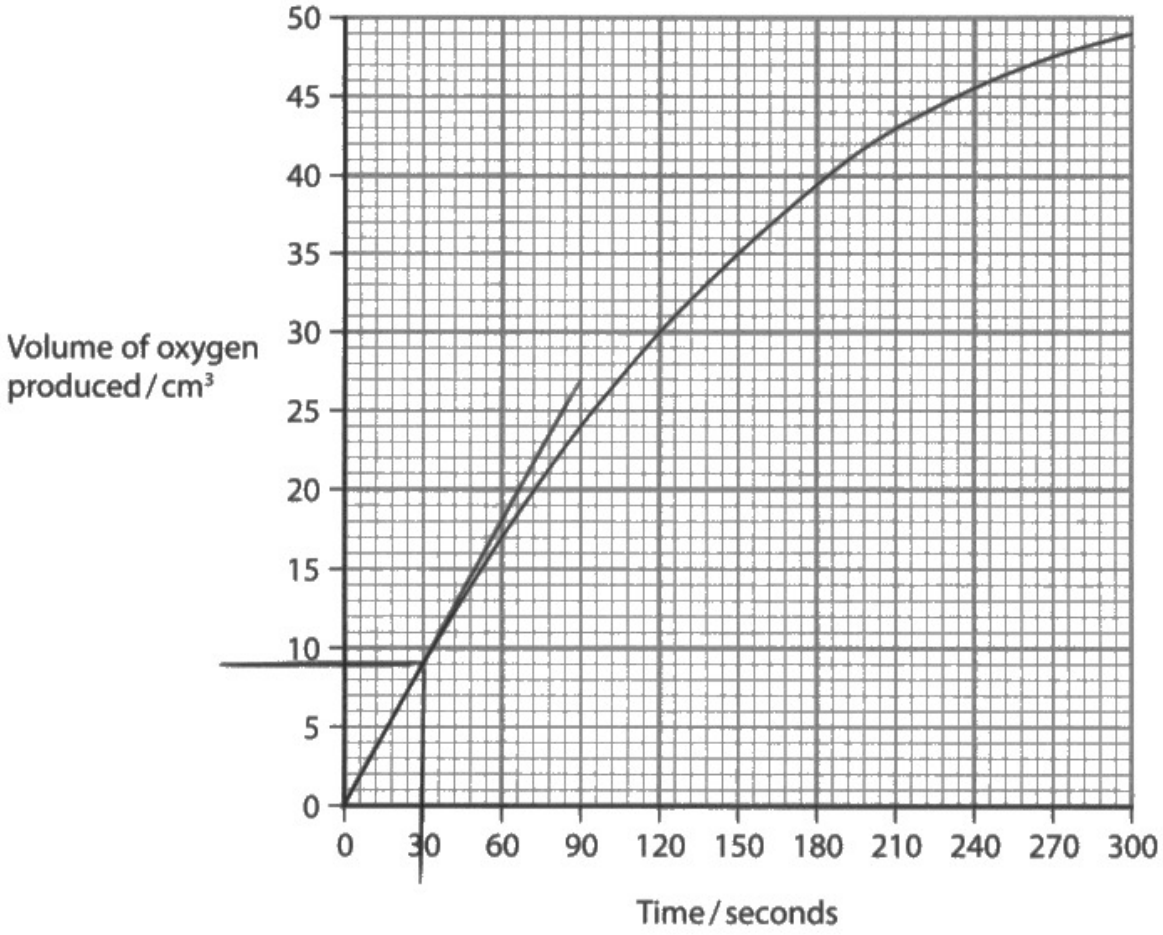
$$\frac{8\text{cm}^3}{30\text{s}} = 0.267\text{cm}^3\text{s}^{-1}$$

Answer 0.267cm³s⁻¹

ResultsPlus
Examiner Comments

To calculate an initial rate, the tangent must follow the start of the curve from zero. This candidate has drawn the tangent in the wrong place, so although the calculation is correct, the answer is not a correct initial rate.

(ii) The graph shows the results of the investigation.




Determine the initial rate of reaction from this graph.

(1)

$\frac{9}{30} = 0.3$

Answer 0·3 cm³ s⁻¹

ResultsPlus
Examiner Comments

This candidate drew an appropriate tangent and carried out the calculation correctly to gain one mark.

## Question 8 (b)(iii)

This question generated a surprisingly mixed quality of answers. Many candidates realised that the hydrogen peroxide was being converted to products, so the concentration of hydrogen peroxide was decreasing and it became a limiting factor. Not all went on to explain how this affected the rate of reaction – that there was less substrate to collide with the enzyme.

However a significant number incorrectly described this in terms of the enzyme being the limiting factor, either because it was used up or denatured as the reaction progressed. Some simply said that either the substrate or the enzyme was the limiting factor and did not gain credit for this.

(iii) Explain why the rate of reaction decreases over time.

**(2)**

Because the ~~substrate concentration~~ ~~enzyme or~~ substrate concentration becomes a limiting factor as more hydrogen peroxide is converted into oxygen. There are fewer substrates for the active sites to bind with so less enzyme substrate complexes form and the rate of reaction begins to level off / decrease.

**ResultsPlus**
**Examiner Comments**

This is a clear answer scoring both marks.

The candidate has stated that substrate concentration becomes a limiting factor and has explained why – hydrogen peroxide being converted to oxygen (and water). This gets marking point 1.

They go on to explain that because there are fewer substrates, less E-S complexes form, getting marking point 2.

As time increases the amount of Enzyme substrate decreases. Without any enzymes available the conversion of hydrogen peroxide to oxygen and water decreases is slower to take place as it acts as a catalyst to make the reaction occur quicker

ResultsPlus
Examiner Comments

This answer scored zero, as the candidate is suggesting that the amount of enzyme is decreasing.

ResultsPlus
Examiner Tip

Remember, enzymes are catalysts which are not used up during the reaction.

The enzymes begin to clenature and so they are unable to convert hydrogen peroxide to oxygen + water.

**ResultsPlus Examiner Comments**

This answer scored zero as the candidate suggests that the enzyme is being denatured. There is no reason to think that this might be happening.

- Less hydrogen peroxide available to be converted to water and oxygen so there will be less collisions as the concentration will decrease over time

**ResultsPlus Examiner Comments**

This answer scored marking point 1 for stating that there is less hydrogen peroxide available to be converted to products.

It did not score marking point 2, as although it referred to less collisions, the candidate did not mention that these were with enzymes.

**ResultsPlus Examiner Tip**

When referring to collisions in questions about enzymes, always make clear that these are between enzyme and substrate.

## Question 8 (c)

Candidates were asked to explain the results they would expect if the investigation was repeated with increasing numbers of cubes of potato. In this investigation the volume of oxygen produced was measured once, 30 seconds after the potato was added.

Generally this was well answered. Many candidates understood that as the number of cubes increased, the amount of enzyme would increase, so there would be an increased rate of reaction. Some went on to say that at a higher number of cubes the enzyme was in excess, and hydrogen peroxide would be the limiting factor, so the rate of reaction would not continue to increase indefinitely.

Relatively few linked the increased surface area to increased levels of enzyme as the number of cubes increased.

(c) The student used this apparatus to investigate the effect of using increasing numbers of potato cubes on the rate of reaction.

The potato was cut into 1 $cm^3$ cubes to be used in five trials.

In the first trial, one cube was added to the flask and the volume of oxygen produced in 30 seconds was measured.

The hydrogen peroxide was then replaced.

This was repeated in the other four trials using 2, 3, 4 and 5 cubes of potato.

Explain the results you would expect from this investigation.

**(3)**

As the number of potato cubes increases, there are more enzymes ^ so the as larger surface area of potato volume of oxygen produced increases rate as more enzyme-substrate collisions so faster initial rate of reaction, more hydrogen peroxide converted to oxygen (and water).

**ResultsPlus**
**Examiner Comments**

This answer gained marking point 1 for the statement that as the number of cubes increases there are more enzymes so the volume of oxygen increases.

It also got marking point 2 for linking the increase in cubes to a larger surface area of potato and an increased volume of oxygen.

**ResultsPlus**
**Examiner Tip**

Although the enzyme is in all the potato cells, only the enzymes at the surface of the cube can catalyse the reaction, so the surface area is important.

As the As the number of potato cubes increases the volume of of oxygen produced would increase to an ~~an~~ it's maximum value, then stays the same as Hydrogen peroxide becomes the limiting factor so no more substrates are available, hence the volume of oxygen produced stays the same.

**ResultsPlus**
**Examiner Comments**

This candidate did not get marking point 1 as they did not link the increased number of cubes to increased enzyme.

They got marking point 3 as they understood that as more cubes were added, the hydrogen peroxide becomes a limiting factor so the volume of oxygen produced would stay the same.

I would expect that increasing the volume of potato cubes would increase the rate of the reaction as there are more enzymes avaliable so more successful collisions will occur. But there will be a point where ~~incre~~ Increasing the volume of potatoes doesn't ~~in~~ increase rate as the amount of hydrogen peroxide avaliable will become a limiting factor so rate would even out.

**ResultsPlus**
**Examiner Comments**

This is a strong answer gaining mp1 and 3. This candidate has understood that with more enzyme present (because there are more cubes) the hydrogen peroxide will become a limiting factor and rate does not increase further.

## Question 9 (a)

This question required candidates to compare and contrast the structure of xylem tissue and phloem tissue. Despite being a commonly-seen command word, this proved very challenging for some candidates, who wrote first about one of the tissue types, then the other, without picking out points of similarity and difference.

To score in compare and contrast questions, candidates should clearly state points of similarity, eg they both have cell walls which contain cellulose, and points of difference, eg xylem has lignin in the walls and phloem does not. To gain full marks, both similarities and differences should be included.

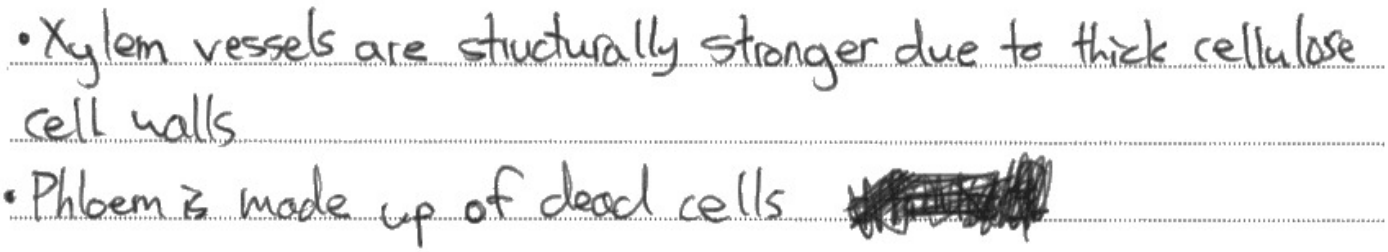
Some candidates wrote about similarities and differences in function, not structure, and did not gain credit for this.

**9** Water moves through xylem vessels in a plant during transpiration.

Phloem tissue is responsible for transport of organic materials such as sucrose.

(a) Compare and contrast the structure of xylem tissue and phloem tissue.

**(3)**




**ResultsPlus**
**Examiner Comments**

This candidate came close to a difference when they said that xylem has thick walls, but did not complete the comparison by referring to phloem, so did not score. Saying that xylem had thicker walls would have got the mark.

**ResultsPlus**
**Examiner Tip**

In a compare and contrast question, make sure you complete the comparison by referring to both of the things you are comparing (here xylem and phloem).

The xylem is a dead tissues which is lignified to be impermeable to water and contains no internal structure. It also has vessels for strength. However, the phloem is a living, non lignified tissue ~~with~~ that is joined and relies on ~~sieve plates~~ companion cells. Additionally it is internally joined by sieve plates in the sieve plates in the membranes.

ResultsPlus
Examiner Comments

This candidate clearly knows a lot about the structure of xylem and phloem tissues.

However they have not arranged their answer as a series of similarities and differences, so have not scored any of the marking points.

ResultsPlus
Examiner Tip

Take the points one at a time, and clearly state the similarities (they both.....) and the differences (xylem has lignin and phloem does not).

Both the xylem tissue and phloem tissue have cellulose, but xylem tissue is made of cellulose. While, phloem tissue only has cellulose in the cell wall. Xylem tissues have pits, while phloem tissue does not. Xylem tissues are not living, while phloem tissues are living. Xylem tissues have lignin, while phloem tissues do not. Both the xylem and phloem are made out of cells.

**ResultsPlus**
**Examiner Comments**

The candidate starts with a valid point of similarity – they both have cellulose.

They then clearly identify two differences (xylem has pits and phloem does not; xylem has lignin and phloem does not), scoring maximum 3 marks.

## Question 9 (b)(i)

Candidates were given a diagram of a potometer and told that it was used to measure the rate of water uptake in a variety of conditions. A table of results was provided and the candidates were asked to calculate the mean rate of water uptake for the root in moving air in the light. They were given the internal diameter of the capillary tubing and a formula to calculate the volume of a cylinder.

This was not a complicated calculation, but it had several distinct steps (which could be carried out in more than one order):

- convert the mean distance given in the table from cm to mm (so it was the same units as the diameter of the tubing)
- put this into the formula to calculate the volume of the cylinder, which was equal to the volume of water taken up
- divide by 5 to find the rate of water uptake in $mm^3$ $minute^{-1}$
- give the final answer to 2 significant figures

Many candidates were able to do this and score the maximum 3 marks. However others made errors at one or more stages of the process. The most commonly seen errors were

- not converting from cm to mm, or converting wrongly, so that the final answer was a factor of 10 out
- using the diameter of the capillary tube in the calculation, instead of the radius
- not dividing the value obtained by 5 to give a rate per minute
- not giving the final answer to 2sf

Although the mean rate was given in the table, some candidates recalculated this and used their own value in the calculation, losing credit for this.

The table shows the results of this investigation.

| Conditions | Distance moved by the bubble in 5 minutes / cm | | | | | |
|---|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Mean |
| Still air, in light | 2.4 | 2.2 | 2.2 | 2.2 | 2.1 | 2.2 |
| Moving air, in light | 6.5 | 6.7 | 6.4 | 6.2 | 6.3 | 6.4 |
| Still air, in dark | 0.9 | 0.4 | 0.0 | 0.0 | 0.0 | 0.3 |
| Moving air, in dark | 1.7 | 0.8 | 0.0 | 0.0 | 0.0 | 0.5 |

(i) The internal diameter of the capillary tubing is 0.3 mm.

The volume of a cylinder is calculated using the formula

$$\pi r^2 h$$

Calculate the mean rate of water uptake for the shoot in moving air, in the light.

Give your answer in $mm^3\ min^{-1}$ to two significant figures.

**(3)**

64 mm

6.4 cm / 5 minutes

$\frac{64}{5} = 12.8$ mm/m

$\pi r (\frac{0.3}{2})$

$\frac{0.3}{2} = 0.15$

$\pi 0.15^2 \times 12.8$

Answer 0.905 $mm^3\ min^{-1}$

$= 0.90477 \ldots\ mm^3/min$

ResultsPlus
Examiner Comments

This candidate converted 6.4cm to 64mm and divided by 5 to find the distance moved by the bubble per minute.

They used this to correctly calculate the volume of water taken up per minute, but did not give their answer to 2sf and therefore scored 2 of the possible 3 marks.

ResultsPlus
Examiner Tip

Always follow the instructions given in the question if it asks for a number of significant figures.

(i) The internal diameter of the capillary tubing is 0.3 mm.

The volume of a cylinder is calculated using the formula

$$\pi r^2 h$$

Calculate the mean rate of water uptake for the shoot in moving air, in the light.

Give your answer in $mm^3\ min^{-1}$ to two significant figures.

**(3)**

6.4 cm = 64 mm

$\pi \times \left(\frac{0.3}{2}\right)^2 \times 64$

$= 4.5\ mm^3\ min^{-1}$

Answer 4.5 $mm^3\ min^{-1}$

**ResultsPlus**
**Examiner Comments**

This candidate converted 6.4cm to 64mm and put this into the formula to calculate the volume of water taken up.

However they did not divide this by 5 to get the rate per minute, so scored 2 of the available 3 marks.

**ResultsPlus**
**Examiner Tip**

Always show your working in a calculation. This allows you to get credit even if the final answer is not correct.

radius = 0.15

(i) The internal diameter of the capillary tubing is 0.3 mm.

The volume of a cylinder is calculated using the formula

$\pi r^2 h$

r = radius
h = height

Calculate the mean rate of water uptake for the shoot in moving air, in the light.

Give your answer in $mm^3\ min^{-1}$ to two significant figures.

**(3)**

Volume Mean distance = 6.4 cm = 64 mm

Volume = $\pi (0.15)^2 (64) = \frac{36\pi}{25} = 4.52\ mm^3$

$\frac{4.52\ mm^3}{5\ min} = 0.90\ mm^3 min^{-1}$

Answer 0.90 $mm^3\ min^{-1}$

**ResultsPlus**
**Examiner Comments**

This answer scored the maximum 3 marks.

The working is clearly set out, so all steps of the process are visible, and the final answer is to 2sf.

## Question 9 (b)(ii)

This question generated a wide variety of responses. Candidates were asked to analyse the data to explain the results of the potometer investigation.

It was important that they linked the movement of the bubble to water uptake or transpiration somewhere in their answer.

Many candidates got marking point 1 for identifying the conditions in which transpiration was fastest (or slowest). The remaining marks were for explaining why this was the case.

Relatively few candidates got mp2 for stating that stomata are closed in the dark. Mp3 was much more commonly seen, and usually well explained in terms of maintaining a concentration gradient or making it steeper.

The most common error was to frame the answer in the context of photosynthesis, with the idea that more water was taken up because it was needed for photosynthesis being very common.

(ii) Analyse the data to explain the results of this investigation.

(3)

distance moved by bubble = water uptake ∝ transpiration. Rate of transpiration is greatest when air is moving and light intensity is great. Increased air movement maintains steep concentration gradient so water vapour diffuses out of the leaf at an increased rate → ↑ rate of transpiration. Even in dark, more transpiration occurs if air moving. Light important as controls rate of photosynthesis so ↑ light ↑ RoP

**ResultsPlus**
**Examiner Comments**

This answer gained marking points 1 and 3.

They have clearly linked the movement of the bubble to water uptake and transpiration at the start.

Mp1 was for the comment that transpiration is greatest in moving air in the light.

Mp3 was for explaining how air movement maintains a steep concentration gradient, leading to a faster rate of transpiration.

(ii) Analyse the data to explain the results of this investigation.

(3)

In the dark
In still air the water uptake is the lowest this is because the stomata are closed due to a lack of light stimuli and the transpiration rate is reduced in still air and the moisture is not moved. The bubble moved the most in moving air and in light as the stomata were open so could release water and the still air/moisture from around the plant is moved.

**ResultsPlus**
**Examiner Comments**

This answer got mp1 for the comment that in still air in the dark transpiration rate is lowest – they also said the converse later (the bubble moved the most in moving air in the light).

They also got mp2 for the comment that the rate was lowest because stomata are closed in the dark.

The statement about moisture being moved from around the plant is not enough for mp3.

**ResultsPlus**
**Examiner Tip**

In an investigation like this, remember to link the movement of the bubble to the process that is causing it – water uptake or transpiration.

can occur and more transpiration occurs when there is a greater concentration gradient by the stomata/leaves so in moving air. In still air in the dark, the plant took in the least amount of water because rate of photosynthesis and transpiration were low. Light intensity effects water intake more than air movement as both highest water intake are in the light

ResultsPlus
Examiner Comments

This answer got 3 marks

mp3 for the statement that more transpiration occurs when there is a greater concentration gradient by the stomata / leaves in moving air

mp1 for the statement that in still air in the dark, the plant took in the least amount of water

mp5 at the end for the comment that light intensity affects water intake more than air movement as both highest water intake are in the light.

(ii) Analyse the data to explain the results of this investigation.

(3)

- During the dark, photosynthesis could hardly take place due to lack of sunlight
- In light but still air had some rates of photosynthesis due to the sunlight carrying it through
- The most photosynthes taken place was moving air and in light. This is because oxygen is needed and sunlight to fully carry out photosynthesis

**ResultsPlus**
**Examiner Comments**

This candidate did not score as the whole answer is written in the context of photosynthesis – water uptake / transpiration were not mentioned at all.

## Question 9 (b)(iii)

Candidates were asked to describe how the investigation could be modified to compare water loss from the upper and lower surfaces of the leaf.

This generated a very wide variety of responses. Some candidates realised that the two surfaces of the leaf had to be tested separately and some could suggest ways to do this.

The importance of external conditions had been raised in Q09(b)(ii) so there was no credit for simply saying that light or air movement should be controlled. Marking point 5 was for suggesting a method of control of one variable, but this was very rarely seen.

The basic technique required was

1. to cover one surface of the leaf in a transparent material eg petroleum jelly / clear tape / cling film
2. to measure the rate of water uptake by measuring the distance moved by the bubble in a set time
3. to remove the covering or use a second shoot with the same surface area
4. to repeat for the other leaf surface
5. to describe how to control a relevant variable, eg light intensity by maintaining a fixed distance from a lamp
6. to repeat and calculate the standard deviation

(iii) Describe how this investigation could be modified to make a valid comparison of water loss from the upper and lower surfaces of the leaves.

**(4)**

One modification would be to have 2 leafy shoots of the same age and size from the same species and for one shoot cover the top of the leaf and for the other cover the bottom of the leaf. Then test using the same conditions and compare the results.

**ResultsPlus**
**Examiner Comments**

This answer scored 1 mark (mp4) for the idea of repeating for the other surface of the leaf and comparing the results.

They did not achieve mp1 as they did not suggest a suitable covering for the leaf surface.

Same size shoot was too vague for mp3.

**ResultsPlus**
**Examiner Tip**

Be specific when you say same size – do you mean same number of leaves, same surface area? Say so.

(iii) Describe how this investigation could be modified to make a valid comparison of water loss from the upper and lower surfaces of the leaves.

**(4)**

- set up two potometers, one with upper surface of leaves covered in vaseline, one with lower surface covered in vaseline
- vaseline is ~~water proof~~ waterproof so prevent $H_2O$ loss from stomata
- only one side of leaf can undergo transpiration
- $O_2$ produced only from one side
- compare average volume of $O_2$ produced after repeating ~~with~~ at least three times

ResultsPlus
Examiner Comments

This answer gained mp1 (for a potometer with one leaf surface covered in vaseline) and mp4 (for a second potometer with the other leaf surface covered in vaseline).

However they did not explain how to collect results or how to control variables, so no further marks.

(iii) Describe how this investigation could be modified to make a valid comparison of water loss from the upper and lower surfaces of the leaves.

**(4)**

-use a control variable with free upper and lower surfaces for validity

- use vaseline/petroleum jelly and seal the upper surface of some leaves and the lower surface of other leaves (5 each)

- place them in the same light and air conditions and measure water uptake using the potometer

- leave for 5 minutes and measure distance moved by air bubble, then repeat with other leaves and find mean. ensure all leaves are similar surface area. (Spearmans rank stats test)

find surface area of leaves using grid paper and counting squares

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

**ResultsPlus**
**Examiner Comments**

This is a strong answer, gaining 4 marks.

They seal the upper surfaces of some leaves and the lower surfaces of others, gaining mp4

They use a suitable covering, so mp1

They measure the distance moved by the bubble in 5 minutes, so mp2

They control the surface area of the leaves, so mp3

## Question 10 (a)

This question proved very difficult for many candidates, who did not have a definition of Gross Primary Productivity to hand.

There were a variety of acceptable ways of expressing this, but all referred to rate and biomass.

Some candidates were able to give correct units for mp2.

**10** Grassland is an important habitat for grazing animals such as cattle.

(a) Fields used for grazing cattle must have a high gross primary productivity.

State what is meant by the term gross primary productivity and include the units in which it is measured.

(2)

The total ~~to~~ mass produced per square metre per year

~~to~~ $kg\ m^{-2}\ y^{-1}$

ResultsPlus Examiner Comments

This answer scored mp2 for the correct units.

There is no reference to producers or photosynthesis for mp1.

The total amount of energy taken in by a producer.

~~3~~ 2 $Jm^{-2}year^{-1}$

ResultsPlus Examiner Comments

This answer scored mp2 for correct units.

There is no reference to biomass or rate for mp1.

→ gross primary productivity is the total amount of biomass produced by a plant / area of plants in a year

& $g/m^2$ $kg\,m^{-2}\,yr^{-1}$ ?

**ResultsPlus**
**Examiner Comments**

An excellent answer, scoring both marks.

**10** Grassland is an important habitat for grazing animals such as cattle.

(a) Fields used for grazing cattle must have a high gross primary productivity.

State what is meant by the term gross primary productivity and include the units in which it is measured. g/m²/year

**(2)**

Gross primary productivity is the rate at which ~~sun~~ energy from the sun catalyses the production of new plant material. It is usually measured in kg/m²/year.

**ResultsPlus**
**Examiner Comments**

Another excellent answer, scoring both marks.

**10** Grassland is an important habitat for grazing animals such as cattle.

(a) Fields used for grazing cattle must have a high gross primary productivity.

State what is meant by the term gross primary productivity and include the units in which it is measured.

**(2)**

Gross primary productivity is the rate at which light is fixed from the sun and converted into biomass. It includes respiration. It is measured in $kJ\ cm^{-3}\ year^{-1}$.

**ResultsPlus**
**Examiner Comments**

Another excellent answer, scoring both marks.

The units kJ **cm**$^{-3}$ year$^{-1}$ were accepted, as this is correct for some habitats eg marine habitat.

## Question 10 (b)

Candidates were asked to describe what happens to the energy in the plants not eaten by cattle. Many candidates found this difficult, with some making vague and contradictory statements.

There was credit for 3 basic ideas:

1. that the plant was eaten by something other than cattle, eg rabbits, insects
2. that the plant was not eaten and the energy remained in the plant (as biomass) or that it died and the energy passed to decomposers
3. that the energy was used in metabolic processes or lost as heat to the surroundings

Some candidates wrote about minerals rather than energy. A number simply said that energy is used in photosynthesis and respiration.

(b) Cattle graze on the plants on grassland.

Describe what happens to the energy in the plants that are not eaten by cattle.

(2)

The plants decompose and return the minerals, such as magnesium and nitrates, back into the soil. This makes the soil richer and gives the energy to the soil for other plants to grow. The ~~grass~~ plants are also eaten by insects which give them energy.

ResultsPlus
Examiner Comments

This answer got mp1 for the plant being eaten by insects.

Credit was not given for the plants decomposing, as this does not describe what happens to the energy.

energy stays in plant, not passed to next trophic level so can be used for metabolic processes / active transport in the cell and to produce organic materials

ResultsPlus
Examiner Comments

This answer gained mp3 for the statement that the energy is used in metabolic processes like active transport.

It also got mp2 for production of organic materials.

Some of the energy is lost by plant respiration and some is lost as heat to the surroundings.

When plants die energy can be transferred to detritivores or

ResultsPlus
Examiner Comments

This candidate scored two marks:

mp3 for energy being lost as heat to the surroundings

mp2 for energy being transferred to detritivores when the plant dies

## Question 10 (c)

Candidates were given information about the role of dung beetles in a farmland ecosystem and asked to discuss the validity of a statement: that farming practices need to change to conserve dung beetles and to maintain biodiversity and the stability of ecosystems.

There were lots of ways to approach this task, and we saw some excellent answers which used the information given and brought in wider knowledge from other areas of biology to support their case. Generally, candidates seemed to find the question accessible and were able to use the source material effectively.

The command word **discuss** requires candidates to explore all aspects of the situation being considered and to investigate it using reasoning. The indicative content was divided into 3 areas:

- T points, which were threats to dung beetles from farming practices
- B points, which were benefits to ecosystems caused by dung beetles
- W points, which were wider points not suggested in the source material, eg that there could be other named causes for the decline of dung beetles; that there is no evidence given that farming practices are to blame; that changing farming practices may be detrimental to farm animals

To achieve level 1, candidates could make points from any of the three areas

To achieve level 2, candidates must make points from a minimum of two areas

To achieve level 3, candidates must have at least two points from each of the the three areas, leading to a more balanced discussion of the problem.

Some scientists have stated that farming practices need to change to conserve the species of dung beetle, and to maintain biodiversity and the stability of ecosystems.

Discuss the validity of this statement.

**(9)**

All of these factors could be things affecting dung ~~beet~~ beetle population. Therefore the statement is valid. However there may be factors out of a farmers control that are also affecting dung beetle population.

**ResultsPlus**
**Examiner Comments**

This candidate missed the opportunity to describe the threats to dung beetles which may cause a decline in population, summarising them as 'all of these factors'.

They later recognise that if dung beetles died, their predators would have less food gaining one B point.

**ResultsPlus**
**Examiner Tip**

Make sure that you describe your ideas fully – don't just refer to them and move on.

Some scientists have stated that farming practices need to change to conserve the species of dung beetle, and to maintain biodiversity and the stability of ecosystems.

Discuss the validity of this statement.

**(9)**

This statement is valid. If dung beetles are lost a food source for amphibians and birds is also lost this could lead to losses of many other species which could affect even more species and so on.
Dung beetles help spread seeds by rolling the faeces to different areas this helps increase biodiversity as it allows plant species to grow and spread to ~~their~~ wider areas.
The loss of the dung beetle would effect the ecosystem as it would affect birds and many other creatures due to losing their food source.
Dung beetles also keep places ~~tidy~~ cleaner this decreases levels of disease and stops bacteria spread as there isn't faeces lying around everywhere this is important as it stops animals and humans becoming ill.

**ResultsPlus**
**Examiner Comments**

This candidate recognised some of the benefits of dung beetles:

- they are food for birds and amphibians (B point)
- that they help to spread seeds to other areas when they are moving faeces around (this was a W point)
- that they stop faeces lying around everywhere which may decrease levels of disease (B point)

They went on to make two other valid points, scoring 5 out of a possible 9 marks.

Some scientists have stated that farming practices need to change to conserve the species of dung beetle, and to maintain biodiversity and the stability of ecosystems.

Discuss the validity of this statement.

**(9)**

This statement is partly valid as the farming practice of constantly treating grazing animals, like cattle, with anti-parasitic drugs is decreasing the population of dung beetles. This is because the drugs enter the cows' faeces and the beetles eat the dung and ingest these anti-parasitic drugs. However the statement is also not valid because it could be argued that the more exposure the dung beetles have to the drugs, the more likely it is that they will become resistant. This is because only the resistant beetles are more likely to survive, reproduce and pass on the advantageous alleles to offspring. This increases the frequency of the resistant allele of the population. The statement is also partly valid

**ResultsPlus**
**Examiner Comments**

This candidate uses the source information to make a valid statement about the use of anti-parasitic drugs, gaining a T point. They go on to develop this by saying that dung beetles might develop resistance to these drugs (which is a W point) and describing how this happens (as the advantageous allele is passed to offspring and the frequency increases in the population) gains a second W point.

This candidate described several more threats to dung beetles, but as they only described one benefit, they were limited to level 2, 6 marks.

Some scientists have stated that farming practices need to change to conserve the species of dung beetle, and to maintain biodiversity and the stability of ecosystems.

Discuss the validity of this statement.

The anti-parasitic drugs are a bad factor upon dung beetle survivability as it kills them, and this may prevent reproduction of beetles, so reduce their population numbers. This may have a damaging effect upon the ecosystem by removing a good source for animals that may eat the beetles, causing a greater selection pressure on such animals, such as forcing them to find other sources of food. As well as effecting soil fertility by causing less dung to be taken underground by beetles, so there will be less nutrients like nitrates below topsoil to replace what is left when plants use up what is in topsoil.

**ResultsPlus**
**Examiner Comments**

This candidate also makes a statement about the use of anti-parasitic drugs, gaining a T point.

They develop this in a different way, by describing what happens if dung beetles die: there will be less food for the predators of dung beetles (B point) and less nitrates in soil for plant growth (B point)

This candidate made 5 other points, including two W points, and achieved level 3, 8 marks.

**ResultsPlus**
**Examiner Tip**

Use the information you were given in the stem of the question to develop an argument – don't just state the information and leave it there.

Some scientists have stated that farming practices need to change to conserve the species of dung beetle, and to maintain biodiversity and the stability of ecosystems.

Discuss the validity of this statement.

(9)

a decrease in dung beetles causes a decrease in biodiversity. Other members of food web depend on dung beetle as a food source so decline in dung beetle may impact population of other members of food web (eg. some species of bird that eat the beetle). By burying dung the dung beetle may be helping in nutrient recycling, including aiding carbon and nitrogen cycle, therefore helping keeping soil fertile and allowing growth of a larger biodiversity of plants. Therefore loss of dung beetle will affect biodiversity and stability of ecosystems,

By keeping cattle in sheds over winter there is reduced food source for dung beetle therefore they reduce in population as there is insufficient food to support the whole population. By keeping at least some cattle outside farmers could help maintain population of dung beetle, however this could negatively impact health and growth of farmers cattle, causing economic implications. Furthermore there is insufficient data to prove causation over correlation, and there may be other factors such as climate change affecting populations of dung beetle.

Isolated populations of dungbeetle cause a ~~gen~~ population bottleneck. Restricted gene flow and reduced ~~gen~~ genetic variation and gene pool increase chance of recessive allele, for ~~and~~ genetic disorder being passed on, reducing the biological fitness of the beetle. A smaller gene pool means the beetle may be less able to adapt to changes in the environment, as there is a reduced chance of the population containing an advantageous allele, therefore less able to adapt by natural selection.
The beetle is more sensitive to environmental changes therefore more at risk.

Building and development minimises habitat for the beetle, potentially reducing its population. To combat this, and geographical isolation, farmers or developers could relocate dung & beetles or set up corridors between fields to enable safe passage of beetles and maintain gene flow which would improve the biological fitness.
Building and development provides economic benefits to farmers and tackles national issues like housing shortage. Therefore a compromise must be reached to help conserve biodiversity whilst maintaining quality of life for those who depend on the land and economic balance.
More data is needed to determine how best to alter farming practices so as to maximise biodiversity whilst maintaining ~~farming~~ farmers incomes and livlihoods.

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

ResultsPlus
Examiner Comments

This is a very strong answer which gained full marks – level 3, 9 marks.

The candidate covers a lot of ground

B points: dung beetles are food for other species; dung beetles improves soil fertility and contribute to the carbon and nitrogen cycles, as well as increasing plant growth

T points: overwintering cattle in sheds causes a lack of food for dung beetles; isolated populations of dung beetles have reduced genetic variation and are more at risk from environmental change; reduced habitat is decreasing dung beetle populations

W points: keeping cattle outside in the winter could impact their health; there is not enough data to prove that farming practices are the cause of the decline; climate change could be the cause of the decline; farmers could set up corridors between fields to prevent reproductive isolation

These are all relevant points and are put together in a logical way to develop the argument. This candidate fully deserves the 9 marks they achieved.

## Question 11 (a)(i)

Candidates were given a graph and asked to calculate the percentage increase in the number of yeast cells between 2 and 6 hours.

This was a straightforward calculation and many scored full marks. Almost all could extract the correct information from the graph.

The most common error was to divide by the number of yeast cells at 6 hours, getting a value of 83%, which was the percentage difference, not the percentage increase.

(a) (i) Calculate the percentage increase in the number of yeast cells from 2 hours to 6 hours.

**(2)**

$2\text{ h} = 4 \times 10^2$

$6\text{h} = 24 \times 10^2$

$$\frac{24 \times 10^2 - 4 \times 10^2}{4 \times 10^2} \times 100 = 500$$

Answer 500 %

**ResultsPlus**
**Examiner Comments**

This answer scores full marks.

The candidate has used the graph to calculate the difference in the number of yeast cells for mp1.

They have divided this by the number of yeast cells at 2 hours and multiplied by 100 to find the percentage increase for mp2.

2h → $5 \times 10^2$

6h → $25 \times 10^2$

$$\frac{(25 \times 10^2) - (5 \times 10^2)}{25 \times 10^2} \times 100 = 80\%$$

Answer 80 %

**ResultsPlus**
**Examiner Comments**

This answer contains two errors and scores 0.

The candidate has read the wrong numbers from the graph: 25 and 5 instead of 24 and 4.

They have divided by the number of cells at 6 hours (instead of the number of cells at 2 hours), so they are not calculating the % increase.

6 hours = 24
2 hours = 4

$\frac{24-4}{4} \times 100 = 50\%$

$\frac{\text{final} - \text{initial}}{\text{initial}} \times 100 = \text{percentage increase}$

(2)

Answer 50 ~~50~~ %

**ResultsPlus**
**Examiner Comments**

This candidate has read the correct numbers from the graph and used these to calculate the difference, so they have scored mp1.

They have divided by the number of yeast cells at 2 hours, but have made an error and their answer is a factor of 10 out.

**ResultsPlus**
**Examiner Tip**

Always show your working in a calculation, so you can get some credit if you make a mistake.

## Question 11 (a)(ii)

Candidates were asked to predict the number of yeast cells per $cm^3$ of culture after 12 hours, using a graph showing the number of cells from 0 to 6 hours (counted at 90 minute intervals).

This proved very challenging for most candidates. There were two ways to do it:

- to attempt to extrapolate the existing growth curve – this was the way that most candidates chose, and most reached a value of around 300 cells
- to read values from the graph at the plotting points to discern a pattern.

The values at the plotting points were 6, 12, 24, 48, 96, 192. The candidates who did this realised that they were doubling every 90 minutes and gave an answer of 384, which was correct.

(ii) Predict the number of cells per $cm^3$ of the culture at 12 hours.

Assume that the culture continues to grow at the same rate.

(1)

192 x 2 = 384

Answer 384 × $10^2$ per $cm^3$

**ResultsPlus**
**Examiner Comments**

This answer got the mark for predicting correctly.

48 x 2 = 96

96 x 192

+ 192 x 2 = 384

Answer ..... × $10^2$ per $cm^3$

ResultsPlus
Examiner Comments

This candidate has shown how they reached their answer of 384.

## Question 11 (b)

Candidates were asked to describe two precautions that could be taken to prevent the yeast culture becoming contaminated with bacteria.

This was very well done, and showed that many candidates have a good grasp of aseptic technique.

A variety of techniques were listed on the mark scheme and all were seen in candidate responses. The most commonly seen were working close to a lit Bunsen burner and sterilising equipment (sometimes by flaming it before use).

The most common errors were

- simply saying use aseptic technique, and not giving examples
- giving two examples of the same technique, eg flaming the neck of a bottle and flaming an inoculation loop
- suggesting that doors and windows were closed, that hands were washed or that lids should not be left off culture vessels – these were too non-specific for credit.

(b) Describe two precautions that would prevent the yeast culture becoming contaminated with bacteria.

(2)

Set up a bunsen burner nearby. Convection currents will draw microbes away from culture.

~~flame metal loop/ neck of~~ the wipe surfaces with antibacterial cleaner.

Close doors + windows to limit air currents.

ResultsPlus
Examiner Comments

This was a clear and concise answer which scored 2 marks: one for the Bunsen burner (providing convection currents) and one for cleaning the surface with anti-bacterial cleaner.

(b) Describe two precautions that would prevent the yeast culture becoming contaminated with bacteria.

**(2)**

use aseptic technique when producing and handling culture. sterilising equipment ✓

**ResultsPlus**
**Examiner Comments**

This answer scored one mark for sterilising equipment.

Use aseptic technique was too vague to gain credit – we wanted to see specific examples of precautions that should be taken.

(b) Describe two precautions that would prevent the yeast culture becoming contaminated with bacteria.

**(2)**

- decontaminating equipment used to grow the culture before and after use
- disinfecting surrounding surfaces
- use a bunsen burner to create a convection current in the air to keep bacteria particles away as the hot air rises

**ResultsPlus**
**Examiner Comments**

This answer scored both available marks.

The first was for disinfecting surrounding surfaces.

The second was for using a Bunsen burner to create a convection current.

Decontaminating equipment before and after use was too vague – the candidate could have said autoclaving or sterilising equipment.

✓ flaming the inoculating loop and neck of culture bottle before and after inoculation of the liquid culture

✓ autoclaving equipment i.e. test tube before use.

ResultsPlus
Examiner Comments

This candidate scored both available marks.

The first was for flaming the inoculating loop (and neck of the culture bottle).

The second mark was for autoclaving equipment before use.

## Question 11 (c)(i)

Candidates were told that the student in the investigation used a haemocytometer to count the yeast cells, and given the method used to do this. They were provided with a photograph showing the counting chamber and told that it contained 0.004mm$^3$ of liquid. They were asked to calculate the number of yeast cells per mm$^3$ and to give the answer in standard form.

This proved very difficult for many candidates. Although they were clearly familiar with the haemocytometer in theory from their answers to Q11(c)(ii), some did not recognise the counting chamber and therefore did not know what to count.

There were three steps to this calculation:

- correctly counting the number of yeast cells
- using this value to calculate the number of cells per mm$^3$
- giving the answer in standard form

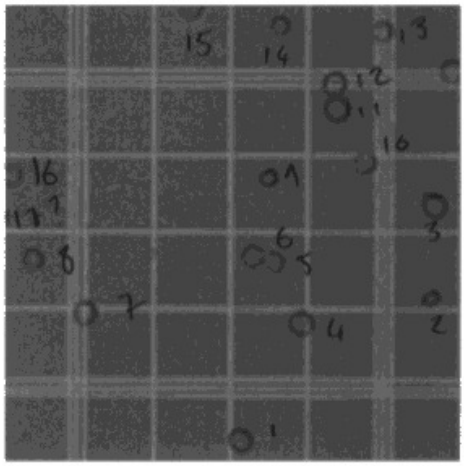
The most common errors were counting all the yeast cells in the photograph, not just those in the counting chamber and giving an answer that was not in standard form.

(c) The student counted the yeast cells using a haemocytometer.

This is a slide with chambers containing a known volume of liquid. The yeast cells are counted when viewed using a light microscope.

Any yeast cells totally within the counting square should be counted, along with those which overlap the top or left-hand side of the square.

(i) The volume of liquid in the counting square shown is 0.004 $mm^3$.



(Source: © Joseph Elsbernd/Flickr)

Calculate the number of yeast cells per $mm^3$.

Give your answer in standard form.

(2)

per 0.004 $mm^3$ . $\times 250 = 1$

=

17 per 0.004 mm .

per 1 =

or 17 + 250? = 4250 cells in 1 $mm^3$

4.25 $\times 10^3$

Answer 4.25 $\times 10^3$ per $mm^3$

**ResultsPlus**
**Examiner Comments**

This candidate used a circling method to count the cells, but unfortunately counted all of the cells in the photograph, not just those inside the counting square (with the boundary of triple hatched lines).

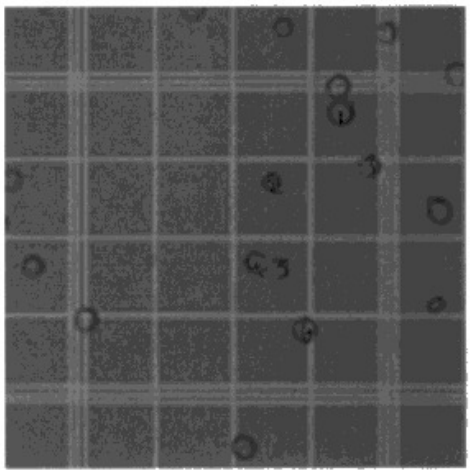
This gave a number of 17 cells, so their final answer was not correct and scored zero.

(c) The student counted the yeast cells using a haemocytometer.

This is a slide with chambers containing a known volume of liquid. The yeast cells are counted when viewed using a light microscope.

Any yeast cells totally within the counting square should be counted, along with those which overlap the top or left-hand side of the square.

(i) The volume of liquid in the counting square shown is 0.004 $mm^3$.



(Source: © Joseph Elsbernd/Flickr)

Calculate the number of yeast cells per $mm^3$.

Give your answer in standard form.

(2)

6 x 250 = 1500

Answer 1500 per $mm^3$

ResultsPlus
Examiner Comments

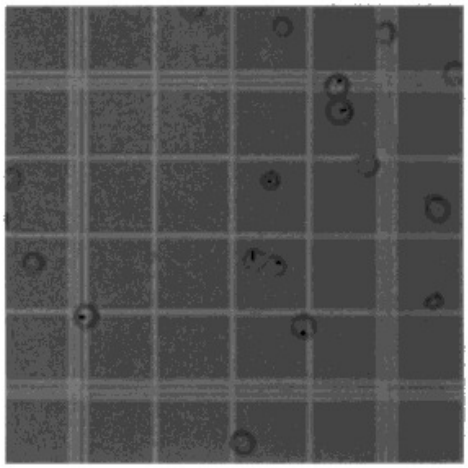
This candidate numbered the cells as they were counting them, but miscounted and recorded only 6, giving an incorrect final answer which scored zero. The answer was also not written in standard form.

(c) The student counted the yeast cells using a haemocytometer.

This is a slide with chambers containing a known volume of liquid. The yeast cells are counted when viewed using a light microscope.

Any yeast cells totally within the counting square should be counted, along with those which overlap the top or left-hand side of the square.

(i) The volume of liquid in the counting square shown is 0.004 $mm^3$.



(Source: © Joseph Elsbernd/Flickr)

Calculate the number of yeast cells per $mm^3$.

Give your answer in standard form.

(2)

0.006

7

7 ÷ 0.004 =

Answer $1.75 \times 10^3$ per $mm^3$

**ResultsPlus**
**Examiner Comments**

This candidate correctly counted the cells, correctly calculated the number per $mm^3$ and gave the answer in standard from. They scored both marks.

## Question 11 (c)(ii)

Candidates were asked to identify two sources of inaccuracy in this method of counting cells (using a haemocytometer).

There were many excellent answers to this question, showing that candidates understood the problems involved. Almost half of candidates suggested difficulties in deciding which cells to count, or the idea that the sample may not be representative, and scored one mark.

Stronger candidates went on to give a second reason, with many knowing that this method does not distinguish between living and dead cells unless a viability stain is used. A small number mentioned that cells undergoing reproduction (budding) would cause inaccuracy, since it is hard to know whether to count them as one or two.

No credit was given for the suggestion that it was too difficult to count them (since the numbers are relatively low) or that human error would cause inaccuracy, unless this was further explained.

(ii) Identify two causes of inaccuracy in this method of counting cells.

**(2)**

Unsure if the cells are dead or alive, some cells can be overlapping each other so the counted cells would be an underestimate

**ResultsPlus**
**Examiner Comments**

This answer scored mp2 (for stating that dead and live cells are counted) and mp1 (for the idea that cells can be overlapping, so the total is wrong).

There is a large scale for human error
The sample used may not be representative
of the culture

ResultsPlus
Examiner Comments

This candidate scored one mark for stating that the sample may not be representative of the culture.

Human error is too vague to gain credit.

ResultsPlus
Examiner Tip

Give an example of the type of mistake that may have been made – human error is a very vague statement.

(ii) Identify two causes of inaccuracy in this method of counting cells.

**(2)**

means double counting, count same cells more than once.

~~human error, miscounting, missing out cells.~~ Not all squares will have same number of cells, density of cells isn't equal / spread of cells throughout solution.

**ResultsPlus**
**Examiner Comments**

This answer scored one mark for the statement that not all squares have the same number of cells.

The idea of double counting (as here) was seen a lot, presumably because the candidate thought that if cells overlapping the top and left hand side were counted in this sample, they might be counted again when the next square was counted. However, this does not happen if all squares are counted following the north-west rule.

This candidate has not understood the method of counting cells which are overlapping two sides and ignoring cells overlapping the other two sides.

If enough squares are counted, this will give a reasonable estimate, so their statement that it is inaccurate is not correct.

As you ignore any of ~~te~~ the yeast cells overlapping the bottom or right hand side of the squares, therefore the number of yeast cells counted is really inaccurate

ResultsPlus
Examiner Comments

See above

- Its done by the eye so not everyone will get the same value. Extremely likey for an error to occur in county

- Causes debate with cells that are along haemocytometer lines. Difficult to visually see whether they are in or out.

**ResultsPlus**
**Examiner Comments**

This answer scored one mark for the statement that it causes debate with cells that are along the haemocytometer lines.

No credit for the idea that it is likely for an error to occur in counting. This may be true if the numbers were much higher, but with numbers like this, it should be possible to count accurately.

**ResultsPlus**
**Examiner Tip**

You are not likely to get credit for suggesting that it is difficult to count accurately when the numbers are so small.

Saying that it is hard to decide which cells are in the square is a better answer.

## Question 11 (d)(i)

Candidates were given a table of data from this investigation, including the mean number of yeast cells at each sampling time, and four of the five standard deviations. They were asked to calculate the remaining standard deviation using the formula given.

Many candidates were familiar with this procedure and scored full marks. Some who were unable to reach a correct final answer scored at least one of the marks for interim steps in the process.

The most common error was to give 2.79 as the answer, but this was not consistent with the other values in the table, so scored 2 of a possible 3 marks.

(d) The table shows the number of cells counted using a haemocytometer.

| Time /hours | Number of cells | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | Mean | Standard deviation (SD) |
| 0.0 | 1 | 2 | 2 | 1 | 2 | 1.6 | 0.5 |
| 1.5 | 2 | 3 | 3 | 3 | 2 | 2.6 | 0.5 |
| 3.0 | 4 | 9 | 9 | 3 | 7 | 6.4 | 2.8 |
| 4.5 | 13 | 10 | 12 | 9 | 16 | 12.0 | 2.7 |
| 6.0 | 43 | 31 | 18 | 14 | 15 | 24.2 | 12.5 |

90min

(i) The student calculated the standard deviations using the following formula.

$$SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n-1}}$$

Calculate the standard deviation for the sample at 3 hours.

**(3)**

$(4-6.4)^2 = 5.76$
$(9-6.4)^2 = 6.76$
$(9-6.4)^2 = 6.76$
$(3-6.4)^2 = 11.56$
$(7-6.4)^2 = 0.36$

$5.76 + 6.76 + 6.76 + 11.56 + 0.36 =$
$= 31.2$

$n = 5$
$5 - 1 = 4$

$\sqrt{\frac{31.2}{4}} = 2.792$
$= 2.8$

Answer 2.8

**ResultsPlus**
**Examiner Comments**

This answer scored full marks, and was clearly set out to show the method used.

The final answer was to one decimal place, matching the other values in the table.

**ResultsPlus**
**Examiner Tip**

If you are not told how many decimal places to use in your answer, make sure that it matches other data if appropriate.

(d) The table shows the number of cells counted using a haemocytometer.

| Time /hours | Number of cells | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | Mean | Standard deviation (SD) |
| 0.0 | 1 | 2 | 2 | 1 | 2 | 1.6 | 0.5 |
| 1.5 | 2 | 3 | 3 | 3 | 2 | 2.6 | 0.5 |
| 3.0 | 4 | 9 | 9 | 3 | 7 | 6.4 | |
| 4.5 | 13 | 10 | 12 | 9 | 16 | 12.0 | 2.7 |
| 6.0 | 43 | 31 | 18 | 14 | 15 | 24.2 | 12.5 |

(i) The student calculated the standard deviations using the following formula.

$$SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

Calculate the standard deviation for the sample at 3 hours.

**(3)**

$(7 - 6.4)^2 + (3 - 6.4)^2 + (9 - 6.4)^2 + (9 - 6.4)^2 + (4 - 6.4)^2$

$= 31.2$

$SD = \sqrt{\frac{31.2}{5 - 1}}$

$= 1.00$

Answer 2.79

**ResultsPlus**
**Examiner Comments**

The calculation in this answer was correct, but the final answer was to a different number of decimal places than the other values in the table, so it scored 2 of a possible 3 marks.

$$\frac{(4-6.4)^2+(9-6.4)^2+(9-6.4)^2+(3-6.4)^2+(7-6.4)^2}{4}$$

$31.2/4 = 7.8$

Answer 7.8

**ResultsPlus**
**Examiner Comments**

This candidate correctly carried out the first steps of the process, gaining marking points 1 and 2 but forgot to take the square root of the value to get a correct final answer.

## Question 11 (d)(ii)

Candidates were told that the student concluded that the population of yeast cells doubled every 90 minutes and asked to comment on the validity of this conclusion.

This proved to be very challenging, with only stronger students gaining any credit at all.

Many candidates rejected the conclusion on the grounds that the mean numbers did not show an exact doubling pattern, even though they had been able to identify sources of error in the method in Q11(c)(ii).

Some candidates recognised that the standard deviations were important, but commented that they were large, rather than looking for an overlap and linking this to a less valid conclusion.

Very few included references to possible sources of error in the method or commented on anomalous data.

(ii) The student concluded that the yeast population doubles every 90 minutes.

Comment on the validity of this conclusion.

(3)

It isn't a complete double every 90 minutes, it can be seen with the 3 hours to 4.5 hours where ~~it jum~~ the mean jumps from 6.4 to 12.60 which is quite close to doubling. From the results, there is very little doubling of yeast cells found. This conclusion isn't completely valid, but the population does increase.

**ResultsPlus**
**Examiner Comments**

This answer is typical of a large number of responses seen, and scored zero.

The candidate recognises that the increase is close to doubling every 90 minutes, but rejects the conclusion as invalid because the values do not show exact doubling.

- Using the mean, every half an hour, the mean does roughly double, at
- 0 hours, mean = 1.6 × 1.625
- 1.5 hours, mean = 2.6 ×2
- 3 hours, mean = 6.4 ×1.875
- 4.5 hours, mean = 12.0

- therefore the number of cells does roughly double however the Standard deviation gives variation around that mean and the Standard deviations overlap for hours 6, and hours 4.5, therefore they aint significantly different and therefore this doesn't go with the conclusion suggested.

ResultsPlus
Examiner Comments

This candidate realised that the mean appeared to double, but that the standard deviations should be taken into account as well. They have scored one mark for recognising that the standard deviation at 6 hours overlaps with the standard deviation at 4.5 hours, and that this does not match the conclusion.

The mean number of cells roughly doubles every 90 minutes. Initially the standard deviations do not overlap and they are small, showing the conclusion is valid Initially, for small numbers of cells. Between 4.5 and 6 hours, the mean doubles, but the standard deviations overlap and the standard deviation is very big for the last group, showing the data is unreliable. Therefore, the conclusion may not be valid for greater numbers of cells.

ResultsPlus
Examiner Comments

This is a strong answer, scoring 2 of a possible 3 marks. The ideas are very clearly expressed.

The candidate gets mp1 for recognising that at low numbers of cells the SD do not overlap, and mp2 for stating that the SD for 4.5 hours and 6 hours overlap.

They summarise this by saying that the conclusion is not valid for greater numbers of cells.

## Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- when doing practical work, always think about why the steps of the method are needed. This will help you to justify procedures and to modify them if necessary
- include detail in your answers when describing practical work. Avoid imprecise terms like amount, and refer to mass or volume. Think about which variables should be controlled and how this can be done
- always consider how the results of investigations can be used to draw a conclusion. Calculating a mean may not be enough – think about the use of standard deviation and stats tests
- make sure you are familiar with the range of mathematical operations and stats tests on the specification. You should know how to choose the most appropriate test and how to carry it out
- when data is given in the form of a graph, be prepared to read values from the graph as well as to spot the general trends
- make sure you are familiar with the range of command words used in this specification, and that you read the question carefully enough to know what is required
- when answering a levels-based question, use the information given in the stem of the question and build on this with your wider knowledge. The key to reaching higher levels is a balance of information from different areas.

## Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

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