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Examiners' Report
June 2025

GCE Biology B 9BI0 03

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June 2025

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Introduction

This paper covered aspects of AS and Advanced GCE biology, including eight of the sixteen core practicals. A wide variety of indirect practical skills were tested, including commenting on experimental design and evaluating scientific methods, identifying variables, interpreting graphs and processing data.

It was very pleasing to see that so many candidates were able to confidently apply their biological knowledge to new situations, and to write about these using appropriate scientific language. However, some candidates did not provide enough depth in their answers, so they lacked the necessary detail for success at this level. This was particularly true for questions which required candidates to suggest improvements or to justify them.

Many candidates were able to cope well with the mathematical demands of the paper, clearly setting out their working and achieving a correct final answer. Those who did not, sometimes read information incorrectly from graphs, and this is an area which could be improved for some.

Questions requiring extended writing, eg the nine-mark, levels-based question and some four and five mark questions showed that many candidates have the ability to organise their answers logically, setting out the key points and building a narrative or argument. They were able to combine their biological knowledge with their understanding of real world situations to produce some excellent and thoughtful answers.

It is clear that much of the advice given after the 2024 exam series has been followed, and most candidates were able to access all questions. Overall, candidates did well on this paper, and both centres and candidates are to be commended for the hard work they did in preparing for it.

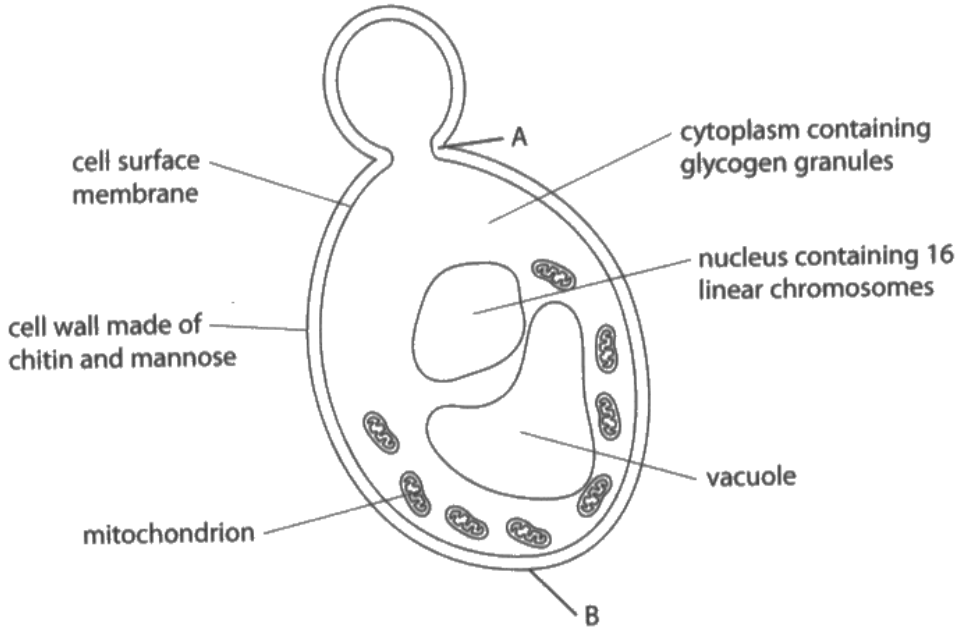
Question 1(a)

Question 1 tested the candidates' ability to use the information given in a diagram to comment on several aspects of yeast cell biology.

Q01(a) required them to calculate the magnification of a diagram when given the actual size of the cell in micrometers. This is part of Core Practical 2: use of the light microscope. While many scored both of the available marks, some candidates were unable to make the conversion between cm or mm and µm.

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

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



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

Calculate the magnification of this yeast cell.

Give your answer to the **nearest whole number**. (2)

A - B = 6.5cm
= 65mm
× 1000
65000µm

$\frac{1}{A \times M} = \frac{65000}{6} = 10833.33$

$M = 10833$

Answer 10833 ×

ResultsPlus
Examiner Comments

This candidate correctly measured the distance between A and B as 6.5 cm and converted this to 65000 µm. This was the image size.

They went on to divide the image size by the actual size (given in the stem of the question), and gave the answer to the nearest whole number, scoring both marks.

ResultsPlus
Examiner Tip

If you are given an instruction, eg **Give your answer to the nearest whole number**, make sure you follow it – you will lose marks if you don't.

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

Calculate the magnification of this yeast cell.

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

(2)

6.5cm $M = \frac{I}{A} = \frac{6500}{6} = 1083.3$

Answer 1083 x

ResultsPlus
Examiner Comments

This candidate correctly measured the distance between A and B as 6.5 cm, but did not correctly convert this to µm, so they did not score mp1.

This meant that the final answer was a factor of 10 out.

ResultsPlus
Examiner Tip

Converting between SI units is an important part of A level biology – make sure you know how to do this.

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

Calculate the magnification of this yeast cell.

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

Image size = 65mm x1000 = 65000µm (2)

Actual size = 6µm

$\frac{I}{A \times M}$ $\frac{65000}{6} = 1083.3\times$

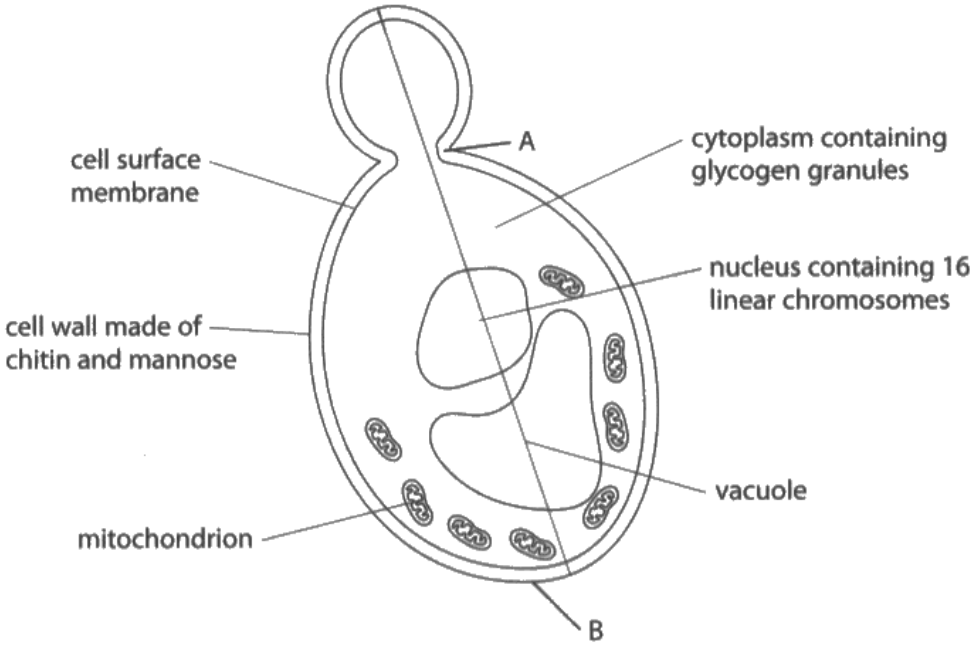
Answer 1083.3×

ResultsPlus
Examiner Comments

This candidate correctly measured between A and B as 65 mm, and correctly converted this to 65,000 µm. This scored mp1.

However the answer written on the line was a factor of 10 out. It was also not written to the nearest whole number.

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



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

Calculate the magnification of this yeast cell.

8.9 cm = 89 mm

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

(2)

mag = area I / A = 89000 / 6

= 14833.3

Answer × 14833

ResultsPlus Examiner Comments

This candidate ignored the instruction to measure between A and B and measured the whole length of the budding cell. They carried out the rest of the process correctly but, not

surprisingly, their final answer was wrong.

Question 1(b)

In Q01(b) candidates were asked to draw the cell as it would appear if viewed with a **light microscope** at high magnification. This is part of Core Practical 2: use of the light microscope including drawing small numbers of cells.

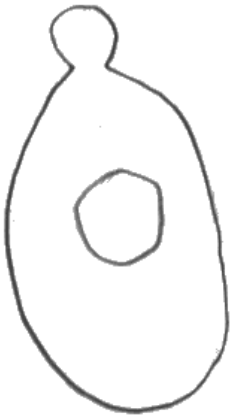
We expected to see the correct shape of cell, drawn with clear lines and no shading or hatching. The nucleus and/or vacuole should have been drawn, but no mitochondria or smaller structures, eg ribosomes, as these would not be visible with a light microscope.

Generally this was done well, but many candidates lost mp2 for including mitochondria.

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

Labels are not required.

(2)



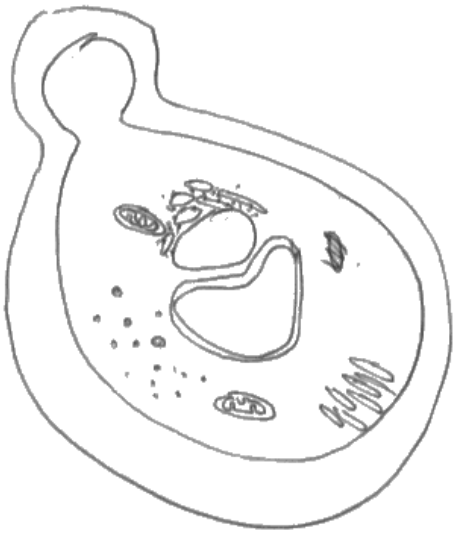
ResultsPlus
Examiner Comments

This was an example of a response scoring both marks. The shape is good enough, and the lines are clear. The nucleus is present and there are no small structures included.

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

Labels are not required.

(2)



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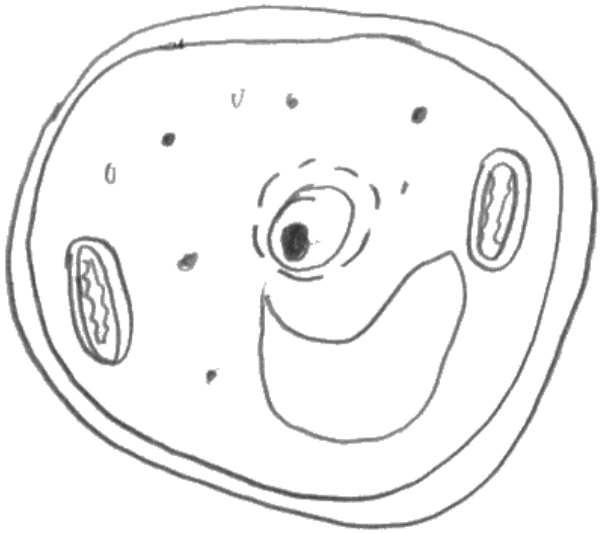
Examiner Comments

This response scored mp1 but not mp2 as mitochondria, Golgi apparatus and ribosomes were included.

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

Labels are not required.

(2)



ResultsPlus
Examiner Comments

This response did not score either mark.

The shape is incorrect, and there is shading, so not mp1.

Ribosomes and mitochondria are included, so not mp2.

Question 1(c)(i)

Q01(c) told candidates **The information in the diagram can be used to classify yeast**. They were asked why yeast is classified as eukaryotic not prokaryotic.

We expected candidates to look at the diagram, read the annotations and use this information to pick out a eukaryotic feature, eg presence of a nucleus, presence of membrane-bound organelles, a cell wall made of chitin and mannose.

Alternatively, candidates could name a prokaryotic feature which it did not have, eg cell wall is not made of peptidoglycan / it has 16 chromosomes, not a looped chromosome.

Where candidates chose to give two features and one was incorrect, eg yeast has a nucleus and a cell wall, no credit was given.

This was well done, with over 90% scoring the available mark.

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

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

(1)

it contains membrane bound organelles, such as the mitochondrion

ResultsPlus Examiner Comments

This is a clear answer for one mark.

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

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

(1)

yeast has a nucleus- prokaryotes don't have a nucleus, eukaryotes do

ResultsPlus Examiner Comments

Another correct answer for one mark.

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

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

(1)

Because it respirates aerobically and anaerobically

ResultsPlus
Examiner Comments

This response scored zero – while it is a biologically correct statement, it does not answer the question. In addition, it does not use information from the diagram.

Question 1(c)(ii)

Q01(c) told candidates **The information in the diagram can be used to classify yeast**. They were asked why yeast is not classified as a plant.

There were several possible correct answers to this:

- yeast has a cell wall made of chitin and mannose (not cellulose)
- yeast has glycogen granules (not starch grains)
- yeast has no chloroplasts
- yeast is single-celled / plants are multicellular or have roots, stems or leaves.

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

(1)

Because it doesn't contain chloroplasts

ResultsPlus
Examiner Comments

A correct answer for one mark.

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

(1)

the cell wall is not made out of cellulose

ResultsPlus
Examiner Comments

Another correct answer for one mark.

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

(1)

it's cell wall is made of chitin and mannose ; not cellulose.

ResultsPlus
Examiner Comments

An alternative correct answer for one mark.

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

(1)

it contains mitochondria so undergoes aerobic respiration rather than photosynthesis

ResultsPlus
Examiner Comments

This answer demonstrates a misconception shared by several candidates: that plants photosynthesise and do not respire. It scored zero.

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

(1)

Yeast contain mitochondria whereas ~~chloroplasts~~ plants contain chloroplasts

ResultsPlus
Examiner Comments

Another variant of the same misconception; that plant cells do not contain mitochondria. Once again, scoring zero.

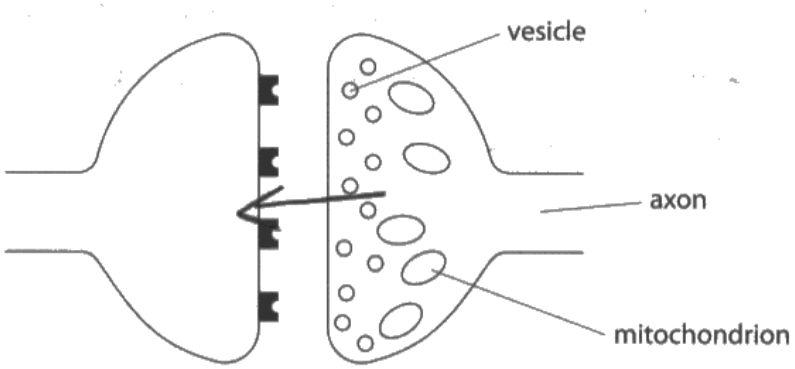
Question 2(a)(i)

Q02 tested candidates' knowledge of nerve transmission.

In Q02(a)(i) they were asked to add an arrow to a diagram of a synapse to show the direction in which the nerve impulse travels. Almost all were able to do this correctly.

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

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



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

(1)

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Examiner Comments

Correct direction for one mark.

Question 2(a)(ii)

Candidates were asked to describe the role of acetylcholine in synaptic transmission. There were four marking points for three available marks:

- (acetylcholine) released from vesicles (into synaptic cleft) / vesicles fuse with pre-synaptic membrane / exocytosis (of neurotransmitter)
- (acetylcholine) diffuses across synaptic cleft
- attaches / binds to receptors (on post synaptic membrane)
- this causes sodium ions to move into (post synaptic) neurone / an action potential / depolarisation (in post synaptic neurone) / opens Na^+ channels.

Most candidates did well on this question, scoring two or three marks. The most common problems were misconceptions about vesicles diffusing across the synapse, or nerve impulses diffusing across the synapse.

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

that ~~causes~~ allows impulses to be transmitted across a synapse (3)

Acetylcholine is a neurotransmitter ✓, when an impulse gets to the end of a neurone (pre synaptic knob) it causes voltage gated Ca^{2+} channels to open & the Ca^{2+} ions stimulate vesicles containing neurotransmitter to fuse with the presynaptic membrane and be released into the synaptic cleft where they diffuse down their concentration gradient to the postsynaptic membrane & bind to receptors that open ligand gated Na^+ channels that cause an EPSP ✓, if these depolarise the neurone enough to reach the threshold ✓ an action potential is initiated. The acetylcholine is then broken down by acetyl cholinesterase & diffuses down its conc grad to the presynaptic knob so it can be reformed.

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Examiner Comments

This candidate scored mp1, 2, 3 and 4 and included further details which were not needed to achieve the marks.

A very clear and comprehensive answer achieving full marks.

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

(3)

acetylcholine is a neurotransmitter which binds to the receptors on the post synaptic neurone and results in the opening of voltage gated Sodium channels.

ResultsPlus
Examiner Comments

This response scored mp3. It came close to mp4 but did not score because it refers to sodium channels, rather than sodium ion channels.

Question 2(a)(iii)

Candidates were asked to state the role of the mitochondria in synaptic transmission. There were two things needed to achieve the mark available:

- the idea of producing ATP
- a named use linked to synaptic transmission, eg synthesis of neurotransmitter / exocytosis / movement of vesicles to membrane.

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

(1)

provides energy & ATP

ResultsPlus
Examiner Comments

This answer is correct but incomplete, because there is no reason for the ATP stated.

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

(1)

mitochondria provides energy in the form of ATP for ~~storage~~ vesicles to move toward the presynaptic membrane

ResultsPlus
Examiner Comments

This answer mentions ATP and gives a suitable use for it, so scores one mark.

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

(1)

- provide ATP for packaging neurotransmitter into vesicles

ResultsPlus
Examiner Comments

This answer also scores a mark.

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

(1)

Used to resynthesise the neurotransmitter after it has been broken down.

ResultsPlus
Examiner Comments

Although this is correct, there is no mention of ATP so this response does not score.

Question 2(b)

Candidates were asked to explain how the myelin sheath speeds up the transmission of nerve impulses.

Almost all were able to score at least one mark, with saltatory conduction being the most commonly seen correct response. Where candidates tried to describe the process (rather than naming it) some showed their lack of understanding, with several thinking that the impulse jumps over the nodes rather than between them.

The other mark was for the idea of myelin being an insulator. Again, some candidates showed a shaky understanding by stating that it was a thermal insulator, which did not get credit.

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

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

(2)

The myelin sheath causes saltatory conduction as ions can only move in and out at the nodes of Ranvier due to the insolating propertries of the Schwann cells. This means the impulse jumps between nodes of Ranvier, speeding up the impulse

(Total for Question 2 = 7 marks)

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Examiner Comments

This strong answer scored both marks.

Mp1 on line 4 for the insulating properties of the Schwann cells.

Mp2 on lines 1-2 for saltatory conduction and again on lines 6-7 for the description of the impulse jumping between nodes of Ranvier.

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

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

(2)

the myelin sheath insulates neuron speeding up impulses with little gaps in the sheath known as the nodes of ranvier which the nerve impulses can jump over speeding up the nerve impulses.

ResultsPlus
Examiner Comments

This answer scored mp1 on line 1.

It did not score mp2 because they have described the impulse jumping **over** the nodes of Ranvier instead of **between** them.

Question 3(a)

Q03 tested candidates' understanding of photosynthesis and included Core Practical 10.

Q03(a) was an unfamiliar context.

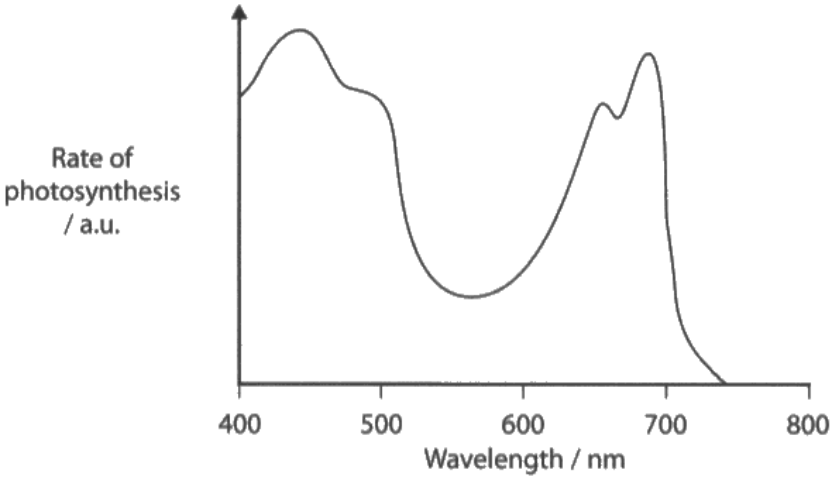
Candidates were given a scenario where a filamentous alga had light of different wavelengths shone along its length, meaning that some areas would photosynthesise better than others. They were given an action spectrum for this alga, showing at which wavelengths the rate of photosynthesis was highest.

They were also told that the alga was surrounded by bacteria which would move to areas of high oxygen concentration.

They were asked to complete a diagram to show the position of the bacteria at the end of the investigation. Around half of candidates scored both marks by drawing two clumps of bacteria, each corresponding to one of the peaks on the action spectrum, where oxygen production would be highest.

3 The wavelength of light affects the rate of photosynthesis.

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



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

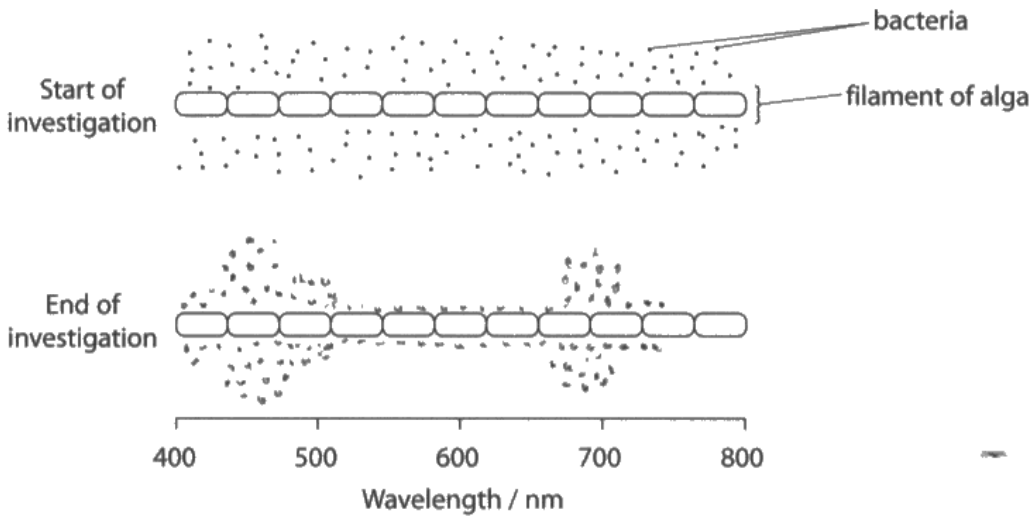
Filaments of the alga were placed on a microscope slide in water containing bacteria that move to areas of high oxygen concentrations. ↑ rate photo → ↑ O_2

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

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

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

(2)



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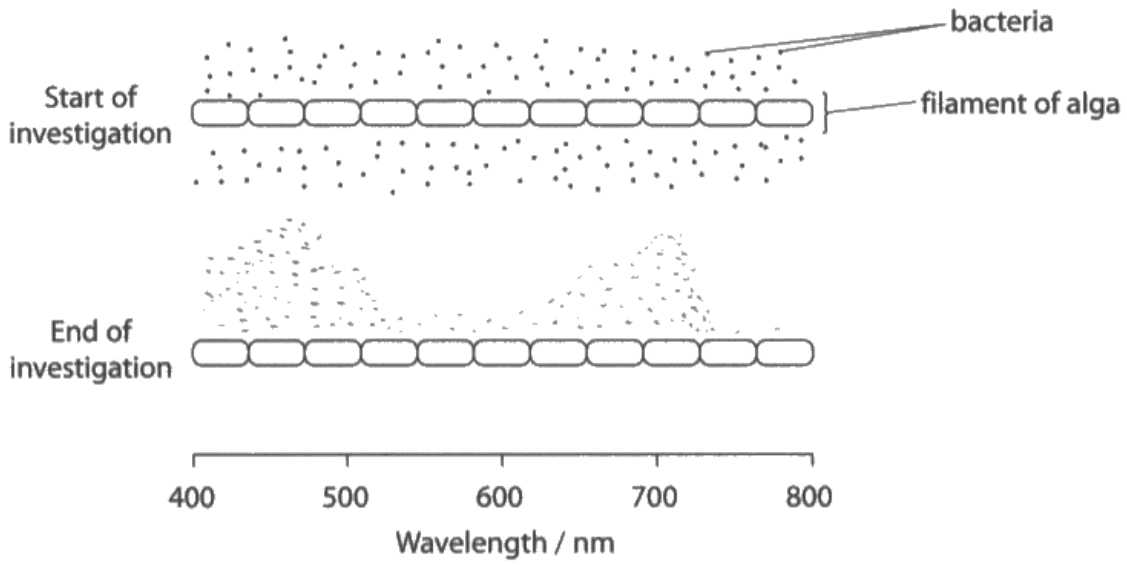
Examiner Comments

This response is what we were hoping to see from candidates.

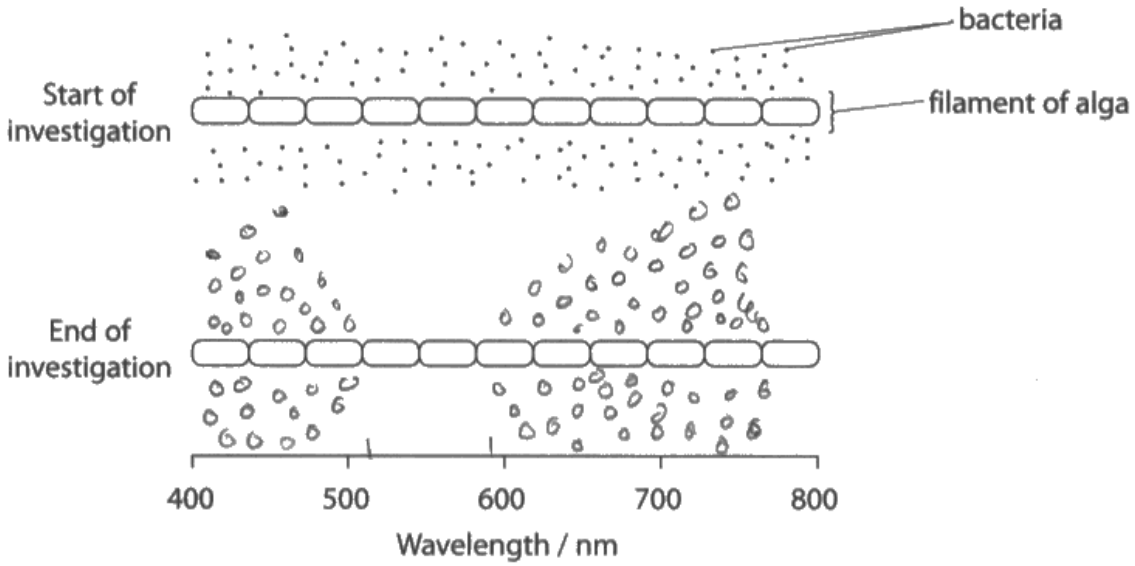
There are two clumps of bacteria:

- one clearly between 400 and 500nm
- one with a peak around 690nm.



ResultsPlus
Examiner Comments

This candidate also scored both marks. We were happy to accept the bacteria drawn both above and below the line, or drawn in one of these areas only, as long as the peaks were in the correct place.



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Examiner Comments

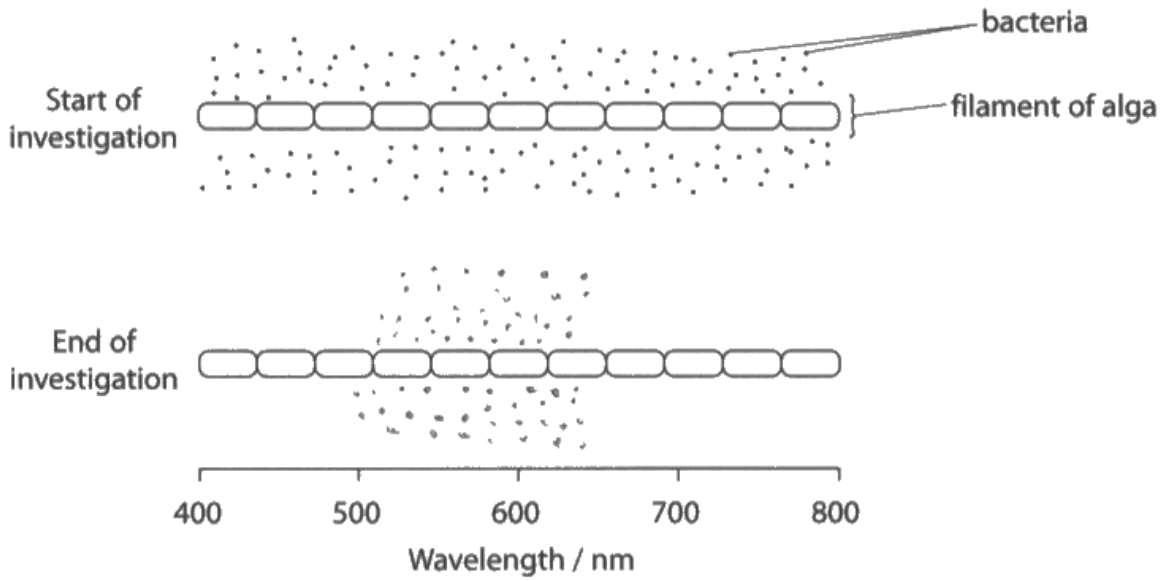
This candidate scored mp1 for the clump of bacterias between 400 and 500nm.

They did not score mp2 as the peak was around 750nm, ie too far to the right.

ResultsPlus
Examiner Tip

This candidate understood the biology of the question, but lost the second mark as their drawing was not precise enough.

Take care when completing diagrams like this and use the scale underneath the alga to position the peaks correctly.



ResultsPlus
Examiner Comments

This response did not score because the clump of bacteria lines up with the lowest rate of photosynthesis on the action spectrum, where the concentration of oxygen would be lowest.

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Examiner Tip

If you are given an unfamiliar context, **use the information in the stem to help you**.

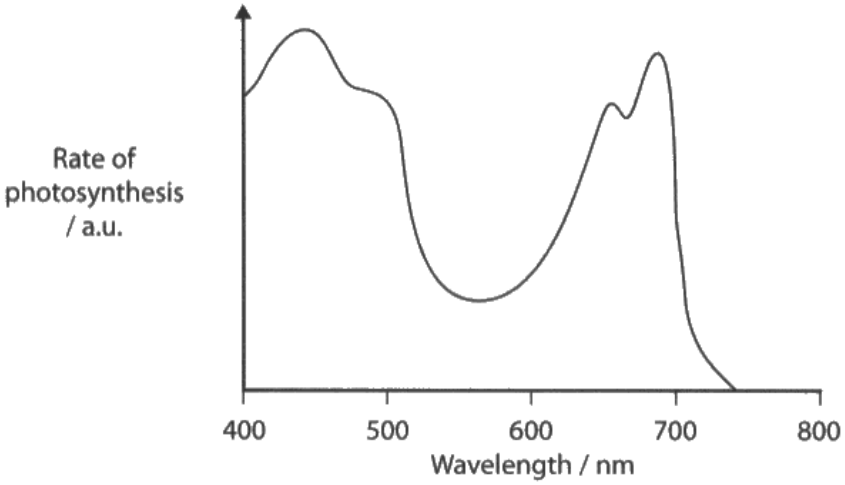
Here candidates were told:

- that this question was about the rate of photosynthesis
- at which wavelengths rate of photosynthesis was highest
- that bacteria would move to areas of high oxygen concentration.

The missing piece of information that linked this together was that most oxygen would be produced in the areas where rate of photosynthesis was highest.

3 The wavelength of light affects the rate of photosynthesis.

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



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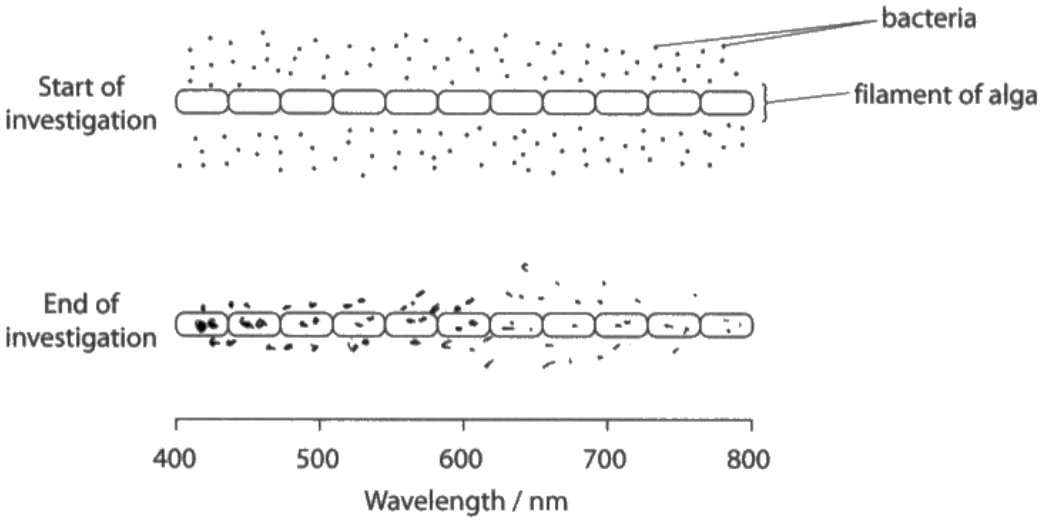
Complete the diagram to show the position of the bacteria you would expect at the end of the investigation.

(2)



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Examiner Comments

Although this candidate understood that the bacteria would cluster around the alga, there was no indication that there would be more around 440nm and 690nm (at the areas where rate of photosynthesis would be highest).

Question 3(b)

Candidates were asked to describe how to modify and use equipment (pondweed under a funnel in a beaker of water) to find the optimum wavelength of light for photosynthesis. This was Core Practical 10: investigate the effects of different wavelengths of light on the rate of photosynthesis.

There were three key things to consider:

- how to change the **independent variable**: here the use of coloured filters was most appropriate
- how to measure the **dependent variable**: the most straightforward way was to collect and measure the volume of oxygen produced in a given time
- how to **control variables** to ensure the investigation was valid: temperature, light intensity, availability of carbon dioxide and mass of pondweed were all important.

Describe how you could modify and use this apparatus to find the optimum wavelength of light for photosynthesis of the pondweed. (5)

You would use different wavelengths of light (using a filter in front of the light source) (independent variable) and compare the volume of O_2 each wavelength of light produced in 20 mins (and allow for equilibration time of 10 mins.) (dependent variable) to see which wavelength produces the highest vol of O_2 as this is the optimum wavelength. You would add a gas syringe so the vol of O_2 can be measured and use the same species of pondweed of the same maturity and same leaf area for repeats. The temperature can be controlled using a thermostatically controlled waterbath and use the same lamp the same distance away so light intensity is controlled. Repeat 5x for every wavelength & do more repeats at smaller increments nearer the optimum wavelength (one which photosynthesis most) to get closer to true optimum. Use a chi squared test to see if vol of O_2 produced (which is directly proportional to rate of photosynthesis) is statistically different from expected (null hypothesis is same rate of photosynthesis for all wavelengths).

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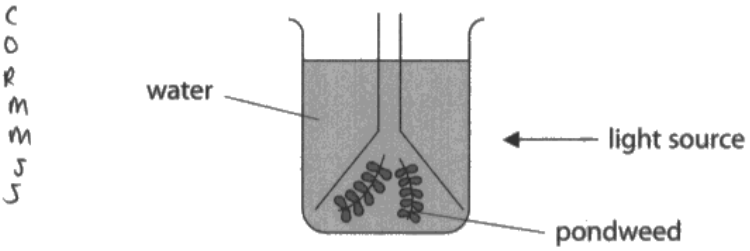
Examiner Comments

This candidate scored full marks:

- mp1 on line 1
- mp6 pieced on lines 2-3 (volume of oxygen produced in 20 minutes) and line 6 (gas syringe)
- mp3 above line 3 for the idea of equilibrating for 10 minutes

- not mp7 for controlling leaf area, as this would be too difficult to do
- mp2 on lines 9-10 for the method of controlling temperature
- mp7 on lines 11-12 for controlling light intensity.

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



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

(5)

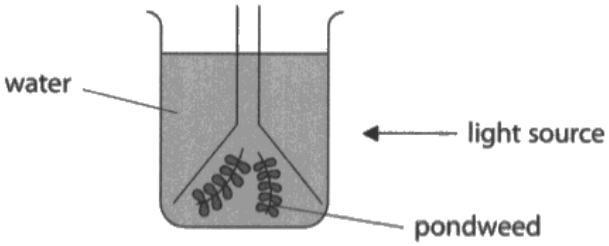
first connect the tube to a delivery tube with a measuring cylinder or a capillary tube with coloured liquid and measure distance moved by liquid in 5 mins upturned in a beaker of water. keep the light source a fixed distance away and completely cover with foil one side of the beaker with pondweed. use 5 different coloured filters in front of the light source to obtain different wavelengths of light. make sure there is a bung attached to the delivery tube so gas doesn't escape. To measure rate of photosynthesis, measure the amount of O_2 produced (water displaced) in 5 minutes. You must add sodium hydrogen carbonate to the pondweed so CO_2 is not limiting. For each coloured filter, do 3 repeats and take a mean ~~an average~~ volume produced and calculate rate by dividing by 5 mins. keep the vol of $NaHCO_3$ the same; keep temp the same by placing in a thermostatically controlled water bath. Make sure the same mass and species of pondweed is used each time. Run a control experiment with no pond weed on the side. Plot a graph of wavelength of light vs rate of photosynthesis. Optimum wavelength is greatest rate of photosynthesis

ResultsPlus
Examiner Comments

Another very strong answer scoring full marks, with six of the seven marking points:

- mp6 on lines 1-2 for dependent variable
- mp4 on lines 3-4 for excluding ambient light
- mp1 on lines 4-5 for filters
- mp3 on line 9 for sodium hydrogen carbonate
- mp2 on lines 12-13 for controlling temperature
- mp7 on lines 13-14 for mass of pondweed.

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



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

(5)

Repeat the experiment using different filters for the light. these being Red, blue, yellow, geen and orangeRepeat 3 times for each wavelength. count the number of bubbles produced in 5 minutes, leaving 5 minutes between applying the filture and measuring to allow the plant to adjust to the wavelength. Measure the radius of one bubble. Use ~~###~~ ~~to~~ the volume of a sphere equation to work out the volume of the bubble Repeat three times and find the mean volume of a bubble. over the 5 minutes, count the number of # bubbles and multiply it by the volume of the bubbles. Divide this by time. Find the mean results. Used Student t-test to compare

ResultsPlus
Examiner Comments

This candidate attempted to describe the independent and dependent variables, but did not consider controlled variables.

They scored mp1 on line 2-3 for using filters to change the wavelength of light.

They did not score mp6 for the description of counting bubbles, measuring the radius of the bubble and calculating the volume from this, as it would not be practically possible.

They scored mp5 on lines 6-9 for the description of acclimatising.

ResultsPlus
Examiner Tip

At A-level, counting bubbles is not a suitable way to measure the rate of photosynthesis. You should collect the oxygen produced and measure the volume.

Question 3(c)

Candidates were asked to explain why plants have a variety of photosynthetic pigments; more than half scored both available marks.

The most commonly seen answers were mp1 for the idea of **absorbing** different wavelengths and mp2 for the idea of **more light being used** in photosynthesis or a **faster rate** of photosynthesis.

Mp3 was very rarely seen.

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

(2)

They are able to absorb a wider range of wavelengths of light, meaning they can maximise rates of photosynthesis.

ResultsPlus
Examiner Comments

This was a typical response scoring mp1 and 2, here for the idea of **maximising rate** of photosynthesis.

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

(2)

To cover as ~~much of~~ many wavelengths of light as possible, more absorbence of ~~of~~ different wavelengths leads to more light available for photosynthesis

ResultsPlus
Examiner Comments

This response also scored mp1 and 2, this time for the idea of **more light available**.

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

(2)

Plants have evolved to possess many photosynthetic pigments in order to allow photosynthesis to occur in a variety of conditions.

ResultsPlus
Examiner Comments

This answer, whilst on the right lines, was too vague to gain credit.

Question 4(a)(i)

Q04 tested candidates' knowledge of genetics, specifically red-green colour-blindness.

Q04(a) related to humans; candidates were given a family tree and asked to deduce the genotypes of four individuals.

In Q04(a)(i) candidates were told that the gene for colour vision was located on the X chromosome and that the allele for red-green vision (X^B) was dominant to the allele for red-green colour blindness (X^b). They were asked to state all the possible genotypes of females.

Almost all candidates were able to achieve this mark. Those who did not showed a variety of misunderstandings.

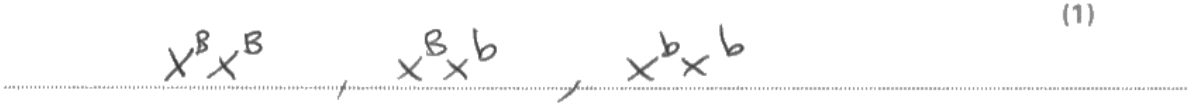
4 Red-green colour blindness is a sex-linked condition.

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

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

(i) State all the possible genotypes of females.

(1)



ResultsPlus
Examiner Comments

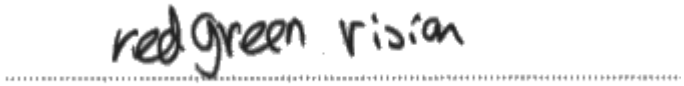
This is what we were expecting to see. The three possible genotypes are clearly stated for one mark.

ResultsPlus
Examiner Comments

This candidate has given the genotypes of males, so did not score.

ResultsPlus
Examiner Comments

This candidate has added two alleles to each X chromosome, so did not score.



ResultsPlus
Examiner Comments

This candidate has given a phenotype rather than a genotype, so did not score.

Question 4(a)(ii)

In Q04(a)(ii) candidates were asked to give all the possible genotypes of males.

Most were able to achieve this mark. Perhaps unsurprisingly the misunderstandings were similar to those in Q04(a)(i).

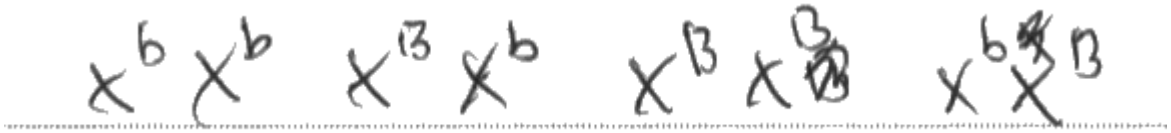
(ii) State all the possible genotypes of males. (1)

ResultsPlus Examiner Tip

This is what we were expecting to see. The two possible genotypes are clearly stated for one mark.

ResultsPlus Examiner Comments

This is correct but incomplete, as there is one genotype missing, so did not score.



ResultsPlus Examiner Comments

This candidate has given the genotypes of females, so did not score.

ResultsPlus
Examiner Comments

This candidate has added two alleles to the X chromosome, so did not score.

Question 4(a)(iii)

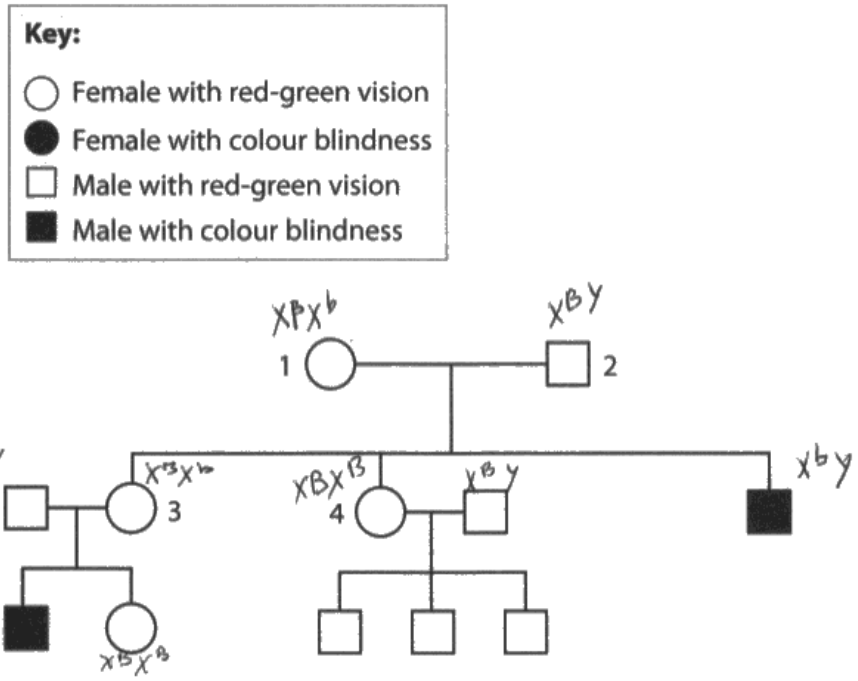
Candidates were asked to deduce the genotypes of four individuals from a family tree.

For individuals 1, 2 and 3 there was only **one** possible genotype. Individual 4 could have been either X^BX^B or X^BX^b, so **both** were required.

Around 60% of candidates gained at least three marks on this question. Common errors were:

- giving more than one genotype for individuals 1, 2 or 3
- only giving one genotype for individual 4
- making the types of mistakes seen in Q04(a)(i) and Q04(a)(ii), although these were rare.

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



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

(4)

1 X^BX^b

2 X^BY

3 X^BX^b

4 X^BX^B or X^BX^b

ResultsPlus
Examiner Comments

This candidate scored all four marks.

They have annotated the family tree, so we can see how they came to their conclusions. Although this annotation was not required, it is the only sensible way to keep track of the information.

ResultsPlus
Examiner Tip

The key to success in a question like this is to start with the individuals whose genotypes you **know** (here this would be males with colour blindness X^bY or red green vision X^BY) and work back from there.

All of the information you need is in the family tree, but you need to work through it carefully and logically.

Question 4(b)(i)

Q04(b) related to squirrel monkeys, where the production of pigments needed for red and green vision is determined by two alleles of a single gene.

In this question candidates were given the phenotypes of the parents (a female with red-green vision and a male able to see only green) and asked to deduce the ratio of phenotypes of the offspring. They were asked to use a genetic diagram to support their answer.

Over half of candidates were able to correctly write the genotypes of the parents X^RX^G and X^GY.

Most were able to produce a suitable genetic diagram showing the offspring. Mp1 was achieved by either correct genotypes of both parents or correct genotypes of offspring in a genetic diagram.

Mp2 was for the correct ratio of phenotypes of the offspring. The most common error was to ignore the sex of the offspring and only give information relating to their colour vision.

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

The photograph shows a squirrel monkey.

(Source: Adrian Hepworth / Alamy Stock Photo)

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

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

This gene is located on the X chromosome.

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

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

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

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

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

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

Use a genetic diagram to support your answer.

(2)

	X^R	X^G
X^G	X^GX^R	X^GX^G
Y	X^RY	X^GY

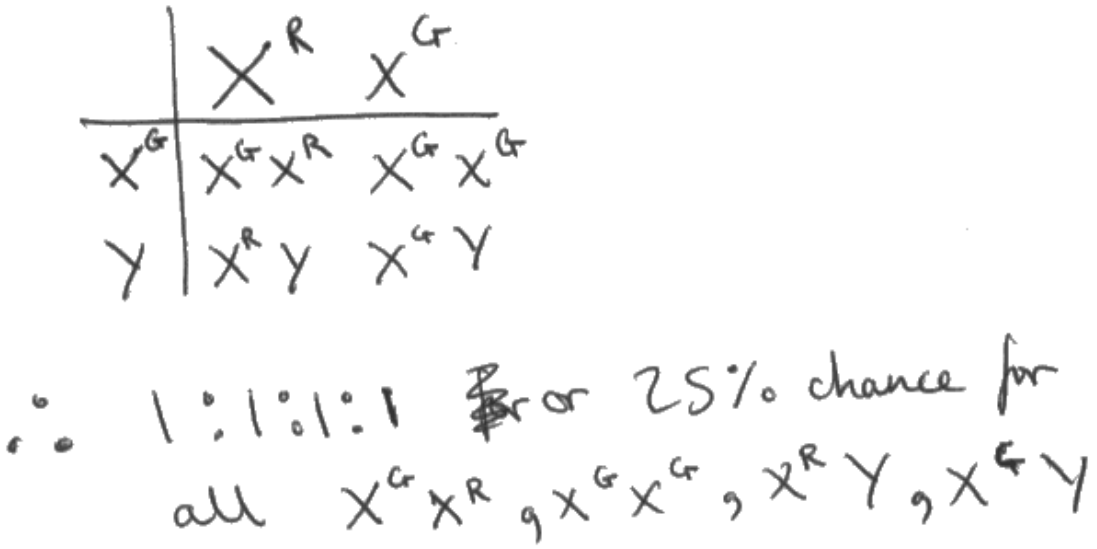
phenotypes: 1 female both red and green
1 female just green
1 male just red
1 male just green

1:1:1:1

ResultsPlus
Examiner Comments

This candidate correctly identified the genotypes of both parents and produced a genetic diagram showing the offspring. Either of these would have achieved mp1.

They went on to give the correct ratio of phenotypes of the offspring, ie 1:1:1:1 of females able to see red and green, females able to see green, males able to see red and males able to see green. This achieved mp2.



ResultsPlus
Examiner Comments

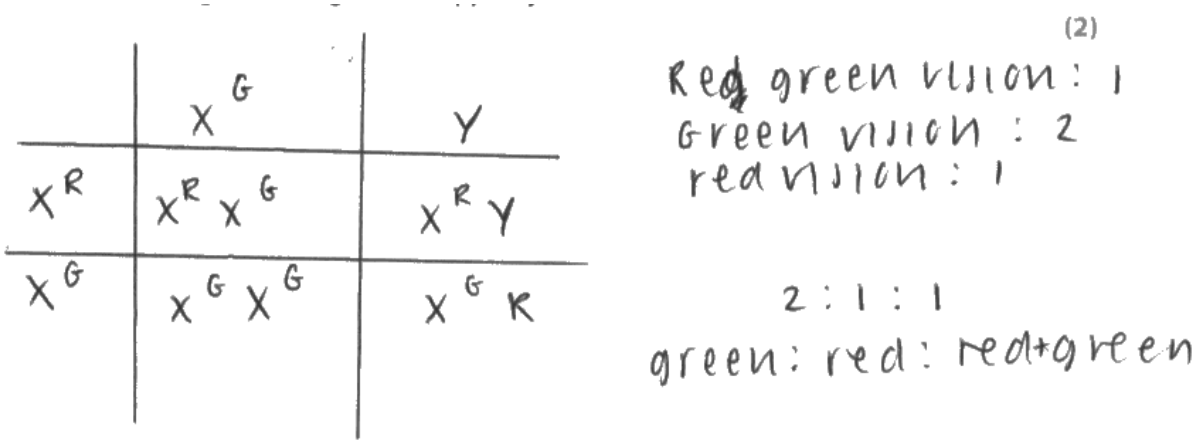
This candidate correctly identified the genotypes of the parents and set out a genetic diagram showing the offspring. Either of these would have achieved mp1.

They correctly identified the ratio as 1:1:1:1, but gave genotypes instead of phenotypes, so did not achieve mp2.

ResultsPlus
Examiner Tip

Look carefully at what you are being asked to do, and follow instructions – here the

candidate understood the genetics but lost a mark for not giving the information that was required.



ResultsPlus
Examiner Comments

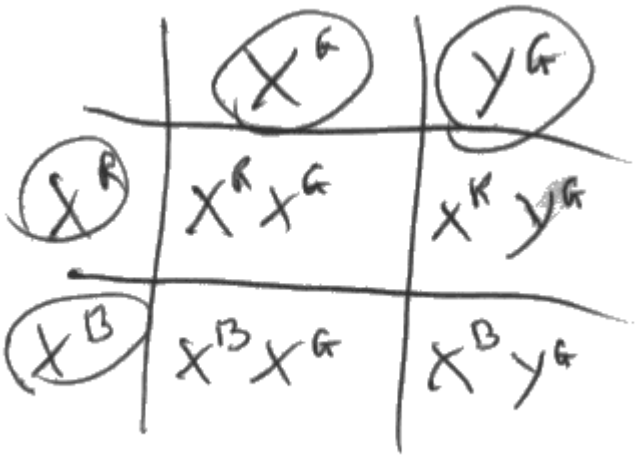
This candidate correctly identified the genotypes of both parents and produced a genetic diagram showing the offspring. Either of these would have achieved mp1.

When they gave the ratio of phenotypes, they only considered colour vision and not the sex of the offspring. This gave a 2:1:1 ratio, rather than the 1:1:1:1 ratio required.

This was the most common error that we saw in this question.

ResultsPlus
Examiner Tip

When a genetics question involves sex linkage, always give the sex of the individual involved, as well as any other features of their phenotype.



ResultsPlus
Examiner Comments

This candidate made three important errors:

- they added an allele to the Y chromosome. In this case only the X chromosome carried an allele for colour vision, so this was incorrect
- they introduced a new allele (X^B) to the mother. Candidates were told in the stem of the question that there are two alleles for colour vision, X^R and X^G
- they made no attempt to give the ratio of phenotypes.

As a result of this neither mark was achieved.

Question 4(b)(ii)

In this question candidates were given the phenotypes of the offspring of a cross and asked to deduce the genotypes of the parents, and to support their answer with a genetic diagram.

Since the offspring were females able to see red and green (X^RX^G) and males able to see red only (X^RY), successful candidates could work backwards to deduce that:

- X^RY males must have received X^R from their mother. Since there were no X^GY males, the **mother must have been homozygous X^RX^R**
- X^RX^G females must have received one of these alleles from the father and one from the mother. As we already know that the mother was homozygous X^RX^R, the X^G must have come from the father, so the **father was X^GY**.

Over 75% of candidates were able to carry out this process and achieve all three marks – this was very pleasing.

The most common errors were to produce a genetic diagram which did not give the correct offspring as set out in the stem of the question; or to have several attempts at working this out with different genetic diagrams (which we expected candidates to do), but then not to make it clear which was their final answer, ie the one we should mark.

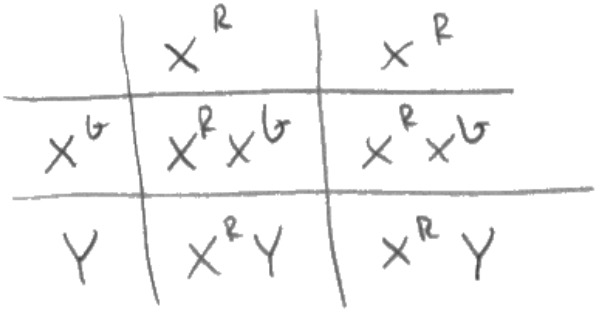
(ii) In separate crosses two monkeys were mated.

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

Determine the genotypes of these parents.

Use a genetic diagram to support your answer.

(3)

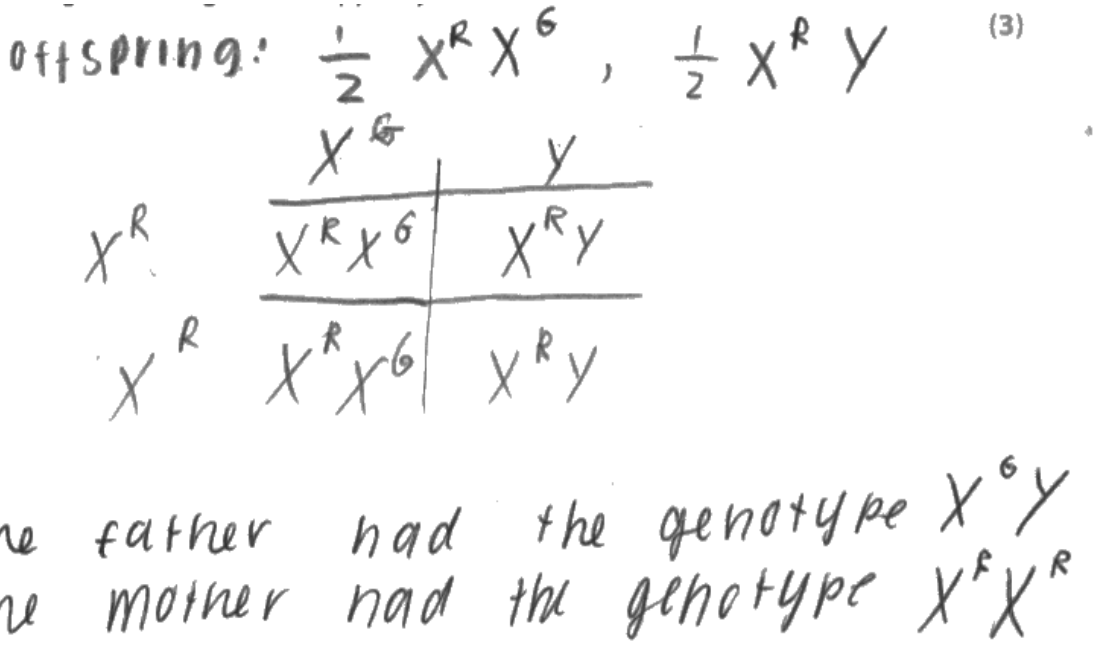


parents must be X^RX^R and X^GY
to produce offspring of females with X^RX^G and males with X^RY

ResultsPlus
Examiner Comments

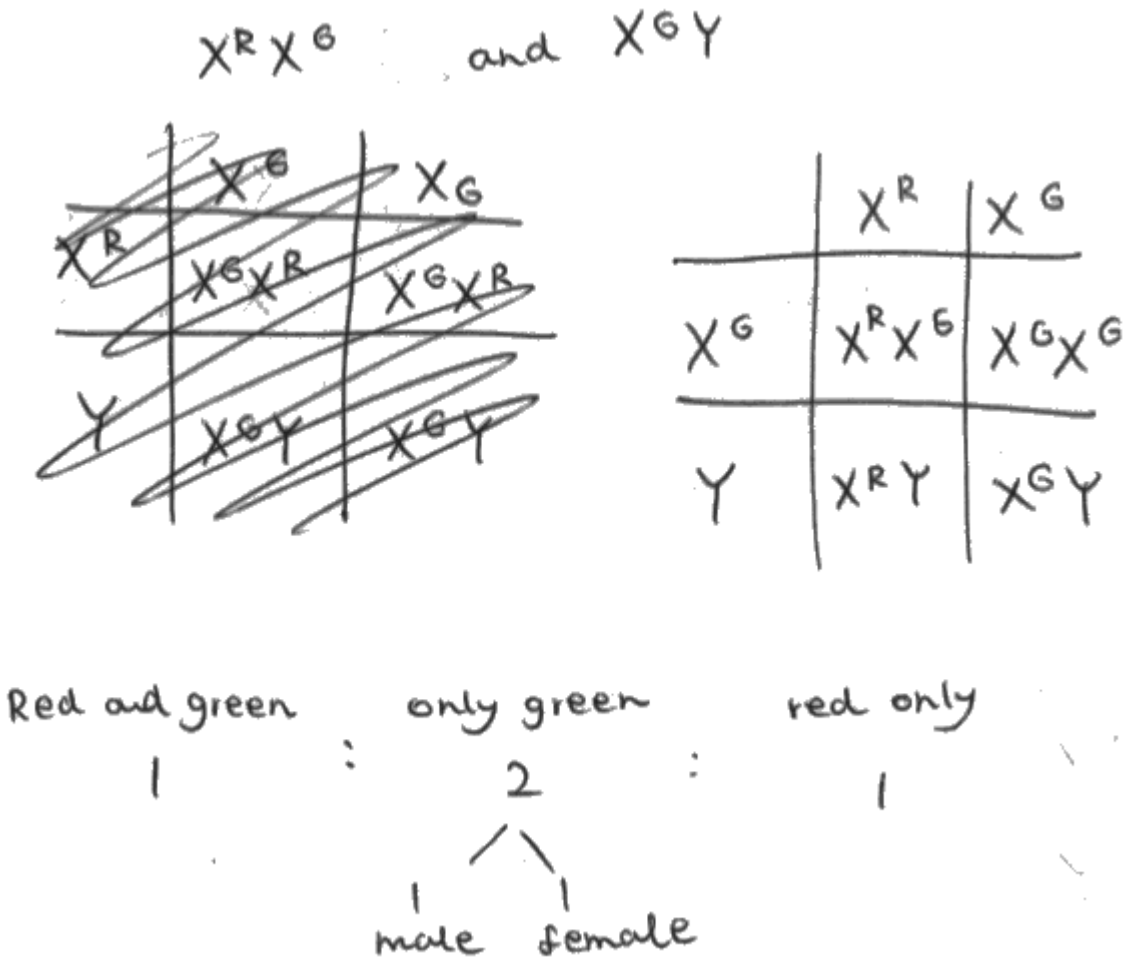
This answer is exactly what we were hoping to see for three marks.

It is clearly set out, showing the parental genotypes, and the genetic diagram shows the offspring of the cross.



ResultsPlus
Examiner Comments

Another strong answer gaining three marks.



ResultsPlus
Examiner Comments

In this response, the genotype of the father is correct scoring mp2, but the genotype of the mother is wrong.

The genetic diagram is therefore incorrect, so this answer achieves only one mark.

Question 4(b)(iii)

Candidates were told at the start of the question that squirrel monkeys have a varied diet including leaves, fruits and insects.

In Q04(b)(iii) they were asked why it would be an advantage for the monkeys to be able to see both red and green. We credited any reasonable answer relating to obtaining suitable food or avoiding predators / poisonous foods.

Almost all candidates were able to achieve this mark.

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

(1)

Advantage as seeing both colours will allow them to more easily spot different foods, such as fruits and insects, as will stand out more against trees / environment. Therefore more likely to survive as can obtain food easier.

ResultsPlus Examiner Comments

This response clearly shows that the candidate recognises the advantages in obtaining food.

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

(1)

They can ~~distinguish~~ recognise both dangers such as poisonous bugs that have red spots & food such as green leaves.

ResultsPlus Examiner Comments

This candidate has focused on the ability to recognise dangers (as well as obtaining food) and scored one mark.

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

(1)

easier to distinguish between two Different objects.

ResultsPlus
Examiner Comments

This was too vague to gain credit.

Question 4(b)(iv)

Candidates were told that scientists had transferred a gene from humans to squirrel monkeys, to enable them to see the colour red. They were asked to describe how this process may have been carried out.

There were four marking points for three available marks:

- the idea of cutting out the gene from human DNA
- the detail of using restriction enzymes to do this
- the idea of using a vector or suitable technique, eg micro-injection, to introduce the gene to the monkey
- the idea of testing the monkey for colour vision.

Most candidates achieved mp1 and 2.

We did not expect them to know the details of mp3 as gene technology in mammals is not specifically required. Many had the idea of using a plasmid, and wrote about using the same restriction enzyme to produce the same sticky ends which could be joined with DNA ligase. As plasmids are only used when transferring genes to bacteria (and then often into plants) this was not relevant, but was not penalised. Similarly, some wrote about using a gene gun to transfer the gene, but this was not a suitable technique to transfer genes into retinal cells.

Mp4 was very rarely seen, although a crucial step in the process to know if it was successful or not.

Around two thirds of candidates gained at least two marks on this question.

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

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

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

(3)

Remove the gene from humans using restriction endonucreases. Amplify the DNA using pcr. Cut open a plasmid using restriction endonucleases (same as one used to cut gene.) Insert tourgett gene into plasmid and use DNA ligase to rejoin sticky ends. Insert into retina of monkeys. Micro injection may be a preferred way to get the plasmid precisely in the retina. observe changes to monkeys visions and report findings to other scientists for peer review.

ResultsPlus
Examiner Comments

This answer achieved all four marking points for full marks.

The idea of using a plasmid was ignored and we credited micro-injection for mp3.

by making the scientists have recombinant DNA, they could done this by using a gene gun. This is when small tungsten pellets are shot into the animal at high speeds, but because its in the eye it would be better to use microinjection which is when a small needle is injected into the animal and gene is inserted.

Plasmid or Splicing could also be used.

ResultsPlus
Examiner Comments

This response achieved mp3 only, for the idea of introducing the gene by micro-injection.

Question 5(a)

Q05 tested candidates' understanding of Core Practical 2: use of the light microscope including using stage and eyepiece micrometers, and Core Practical 4: investigating the effect of sucrose concentration on pollen tube growth.

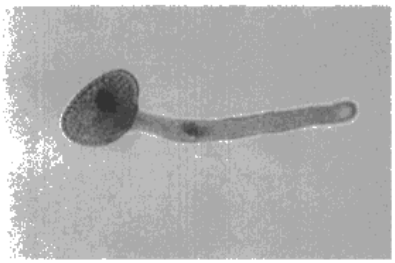
Q05(a) was a relatively straightforward question asking candidates how to use a light microscope to measure the actual length of a pollen tube.

There were two simple steps for two marks:

- calibrating the eyepiece graticule by using the stage micrometer
- using the eyepiece graticule to measure the pollen tube.

This question was not answered well, with only around 30% of candidates achieving both marks and 35% did not score at all. This suggests that they either have not carried out the process themselves, or that their recollection of it is very poor. It would be helpful if centres were able to give candidates more opportunities to practise this skill.

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



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

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

(2)

- Use a stage micrometer to calculate the length of one eye piece unit (using eye piece graticule)
- Observe pollen tube under same magnification, + count how many epu it is
- Multiply up to find length using ratios calculated.

This answer scored both marks.

They describe using the stage micrometer to find the length of one eyepiece unit (which is mp1), then observing the pollen tube and counting how many eyepiece units it is (which is mp2).

Calibrate and eyepiece graticule
lining up the eyepiece graticule with the stage micrometer
and the counting the number of eyepiece divisions in the stage micrometer
division.

This candidate scored mp1 for an excellent description of how to calibrate the eyepiece graticule. However, they did not go on to use it to measure the pollen tube, so not mp2.

- Use a stage micrometer to calibrate the length/division of the eyepiece graticule at a set magnification
- Then use the eyepiece graticule to measure the length by counting the divisions.

Another very clear two-mark answer.

Use eyepiece graticule and line the graticule up with point A → point B = length. Make sure microscope is focused and then measure the length of the pollen grain using your eyes and the graticule.

ResultsPlus
Examiner Comments

This candidate describes calibration, but does not mention the stage micrometer, so not mp1.

They go on to achieve mp2.

Press cover slip to produce single layer of cells

Use Low power objective lens before high power objective lens

Use low power objective lens to locate pollen tube

ResultsPlus
Examiner Comments

This response is typical of those that did not score. They do not mention the stage micrometer or eyepiece graticule at all, but simply describe using low and high power.

Question 5(b)(i)

In Q05(b) candidates were given information about an investigation to find the effect of concentration of calcium ions on the germination and growth of pollen grains. They were given two tables of data:

- one relating to the % germination of pollen grains over a four hour period at different concentrations of calcium ions
- one relating to the mean length of pollen tubes over a four hour period at different concentrations of calcium ions.

In Q05(b)(i) they were asked to calculate the mean rate of growth of the pollen tube in the 500 mg dm^{-3} calcium nitrate solution, and to give their answer to 2dp.

This should have been a very straightforward process:

- select the correct table (mean pollen tube length, not % germination)
- read off the value for the length at 4 hours (which was the last figure given in the table)
- divide this value to 4 to get the mean growth rate per hour
- divide this value by 60 to convert this to mean growth rate per minute.

Candidates made errors at all four stages of the process. The biggest problems were seen with those who:

- did not realise that the lengths given in the table were cumulative, not the length grown since the last reading was taken. This should have been obvious if the two tables were compared, since the percentages given were clearly cumulative - it would not be possible to have 50+60+75+79 = 314% germination
- read off the value at four hours and then subtracted the value at one hour before dividing by either 3 or 4. It is not clear why they did this.

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

The tables show the results from this investigation.

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

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

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

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

(2)

4 hours = 240 minutes

$\frac{547}{240} = 2.28$ (2dp)

Answer 2.28 µm minute^{-1}

ResultsPlus
Examiner Comments

This candidate scored both marks for a correct calculation, with the answer given to 2dp.

Steps 3 and 4 were carried out as a single step, ie divide by 240 rather than by 4 and then

60.

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

The tables show the results from this investigation.

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

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

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

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

(2)

341 + 412 + 455 + 547 = 1755

1755/4 = 438.75 in a hour

438.75/60 = 7.3125

= 7.31

Answer 7.31 µm $minute^{-1}$

ResultsPlus
Examiner Comments

This candidate made the mistake of adding the lengths at each hour together, before dividing by 4 and then 60.

This was the most common single error we saw.

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

The tables show the results from this investigation.

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

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

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

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

(2)

547 − 341 = 206µm

4 × 60 = 240

$\frac{206}{240}$ = 0.86

Answer 0.86 µm minute^{-1}

ResultsPlus
Examiner Comments

This candidate subtracted the length at one hour from the length at 4 hours.

They then divided the value they obtained by 240. This was also a commonly seen error.

Question 5(b)(ii)

Candidates were asked to give three conclusions that could be drawn from the investigation.

There were five marking points for three available marks. The most obvious (and most commonly achieved) were that:

- calcium ions are needed for germination / growth of pollen tubes (mp1)
- as concentration of calcium ions increases, % germination increases (mp2)
- as concentration of calcium ions increases, pollen tube length increases (mp4).

Mp3 and 5 were less commonly seen:

- that above 300 mg dm^{-3} increasing calcium ion concentration makes no difference to initial % germination
- that most germination happens in the first hour / pollen tube growth is fastest in the first hour.

Overall this was very well done, with over 80% of candidates scoring two or three marks.

Where candidates did not score it was often because they did not refer to the concentration of calcium nitrate, eg saying calcium nitrate increases the rate of germination; or because they linked changes to time, rather than calcium nitrate, eg as time increases, % germination increases.

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

(3)

Calcium nitrate must be present for pollen tube growth and germination, as at 0% conc, there is no growth or germination

The initial % germination after 1 hour is not dependent on calcium nitrate conc, as for all concs except 0 there was 50% germination.

As conc of calcium nitrate increases, so does mean pollen tube growth and % of germination after 4 hours.

ResultsPlus
Examiner Comments

This response scores mp1, then 3, then 2 and 4 together at the end, achieving full marks.

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

(3)

Increasing the concentration of calcium nitrate increase the rate ~~of~~ of germination

Increasing the concentration of calcium nitrate increases the ~~rate of~~ mean pollen tube length after each hour.

The more time of pollen grains left in solution the longer the pollen tube length ~~of the~~

pollen grain need calcium ions to germinate

ResultsPlus
Examiner Comments

This candidate scores mp2, then mp4, then mp1 at the end, achieving full marks.

Lines 5-6 are not relevant.

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

(3)

Pollen grains require calcium nitrate to germinate and the higher the concentration of calcium nitrate, the higher the percentage germination of pollen grains after each hour. Pollen tubes require calcium nitrate to increase in length and the higher the concentration of calcium nitrate, the higher the mean pollen tube length. The percentage germination of pollen grains and the mean pollen tube length increase over each hour as these processes take time.

ResultsPlus
Examiner Comments

This response scored mp1, then mp2, then mp4.

Lines 7-9 are not relevant.

Question 5(c)

This question tested understanding of Core Practical 4: investigating the effect of sucrose concentration on pollen tube growth.

Candidates were asked to devise a method that could have been used to collect **valid** data **in this investigation**. To recap, this investigation was finding the effect of concentration of calcium nitrate on germination and pollen tube growth.

There were three key things to consider:

- **how to change the independent variable**: they should use a variety of concentrations of calcium nitrate. The original investigation used 0, 300, 400 and 500 mg dm^{-3}. The proposed method should use at least these four concentrations, but others could be added to improve the investigation;
- **how to measure the dependent variable**: percentage germination and pollen tube length should be measured at least every hour for four hours (as in the original investigation) but more frequent measurements could be made;
- **how to control variables** to ensure the investigation was valid: temperature, concentration of sucrose, pH and species of plant were all important.

An additional marking point was available for repeating multiple times (at least three) and calculating a mean and standard deviation.

Although there were seven alternatives to achieve four marks, candidates did not score as highly as expected on this question. Some ignored the investigation with calcium nitrate entirely, and wrote their own version of an investigation, often changing the concentration of sucrose. Others wrote a detailed account of how to set up the pollen grains in a humid chamber and how to measure the pollen tubes using an eyepiece graticule, ignoring the instruction to collect valid data, ie controlling variables. Some wrote about the wrong core practical altogether (perhaps because they half-recalled using a petri dish as a humid chamber) and wrote about zones of inhibition around seeds on starch agar.

Overall just over half of candidates scored two marks or more.

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

(4)

Collect some pollen grains ~~for~~ from the same plant, so the growth rate can be controlled. Place the at least 5 pollen grains in ~~the same volume of calcium nitrate~~ each conc of calcium nitrate; 0, 300, 400, 500 mg dm^{-3}, in the same volume, ensure the grains are fully submerged in solution. Then, ~~heat up the~~ place each all the beakers of pollen grains in a thermostatically controlled water bath about @ 20°C to keep the temperature constant and controlled. Then let the pollen grains sit for about 30 minutes. Then place ~~the pollen~~ a pollen grain from ~~300 mg/dm~~ 0 mg dm^{-3} under a light microscope and investigate the ~~length~~ growth of the pollen grain by measuring the length of the pollen tube. Repeat at least 5 times for each concentration.

Repeat process for each concentration; 300, 400, 500 mg dm^{-3} and in order to calculate a ~~mean for the~~ each concentration, so standard deviation can be determined the ~~mean~~ significant difference between

ResultsPlus
Examiner Comments

This candidate scored full marks, as follows:

- mp1 on line 1
- mp2a on line 3
- mp4 on lines 5-6
- mp6 on lines 10-12.

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

(4)

- Place sucrose solution, mineral salt solution of same volume and concentration on slide with different concentration of calcium nitrate - 0, 100, 200, 300, 400, 500
- Place each slide in a petridish with moist filter paper.
- Leave pollen tubes to grow for 4 hours. After each hour observe under microscope. Count total ~~cell~~ pollen and number of ~~cell~~ pollen germinated - as well as calculating length of pollen tube using eyepiece graticule.
- Repeat each concentration 5 times and find a mean to remove any anomalies calculating standard deviation. Ensure at least 25 total cells are counted.
- Control temperature of environment as increase temperature may cause faster germination
- Control pH by using buffer
- Use same ~~ca~~ volume of ~~sa~~ calcium nitrate.

(Total for Question 5 = 11 marks)

ResultsPlus
Examiner Comments

This strong answer scored four marks, as follows:

- mp3 on line 1
- mp2a on lines 3-4 / mp2b on lines 7-8

- mp6 on lines 12-14
- mp5 on line 19
- not mp4 as no method of controlling temperature was given.

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

(4)

1) Calcium nitrate dilutions are made up using calcium nitrate and water to produce 3/4 different concentrations in $mgdm^{-3}$ (0, 300, 400, 500).
2) - Add $2cm^3$ of each of these different concentrations of calcium nitrate to separate test tubes.
3) Place an identical pollen tube in each of these test tubes.
- After each hour extract the pollen tube, rinse with distilled water and prepare it on a microscope slide.
- View under the microscope, measuring the pollen tube length using previously calibrated values from an eyepiece graticule and a stage micrometer.
Repeat steps 1-3 for measuring percentage germination. However, instead of viewing under a microscope, place in the centre of an agar plate (separate plates for each pollen grain. Leave for 24-48 hours. Then pour potassium iodide over it and measure the zone of inhibition.
Sodium hypochlorite can be used to sterilise seeds.

ResultsPlus
Examiner Comments

This answer scored only one mark – mp2 on lines 2-3. There was no attempt to control any

variables, and a different core practical was described at the end.

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

(4)

Collect pollen grains from the same plant
measure pollen grain at beginning of experiment using a microscope using a stage micrometer.
Add different concentrations of Calcium nitrate to the pollen tubes.
Measure growth after certain time period e.g. every hour measure the growth.

ResultsPlus
Examiner Comments

This answer scored only one mark – mp1 on line 1. The reference to different concentrations of calcium nitrate was too vague for mp2a; as was the reference to measuring growth every hour for mp2b.

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

(4)

Use a mounted needle to ~~[illegible]~~ put pollen grains

Put, using a pipette, a few drops of a known conc. of sucrose solution & Calcium nitrate into a cavity slide.

Heat mounted needle until orange with bunsen flame, allow to cool, & use it to knock some pollen grains from an anther into the cavity slide. Leave for 15 minutes.

Put cavity slide under a light microscope at low power, find pollen grains then put it at high power. Use a callibrated eye piece graticle to measure length of pollen tube of multiple pollen grains & take a mean /sn. Count n^{o} of pollen grains with a tube & take as a % of total pollen grains. Do this every hour for 4 hours.

Repeat using different conc. of Calcium nitrate.

Control: conc. of sucrose solution, species of pollen. Duration left to grow.

(Total for Question 5 = 11 marks)

ResultsPlus
Examiner Comments

Another answer achieving full marks, as follows:

- mp3 on line 4
- mp6 on lines 12-13
- mp2b on lines 15-16

- mp1 on line 18.

Question 6(a)(i)

Q06 tested candidates' understanding of aspects of classification, and Core Practical 15: investigate the effects of different sampling methods on estimates of the size of a population.

Q06(a)(i) asked candidates to describe how to place quadrats randomly in an area 5m x 10m. There were three marking points for two available marks:

- set up a grid (5m x 10m) / use tapes at right angles to each other as axes
- use random numbers as co-ordinates
- a method to place the quadrat at the co-ordinates without bias, eg bottom LH corner at co-ordinate point.

Candidates generally did well on this, with around 40% scoring both marks. A further 40% scored one mark, usually mp2. However, a number are still describing throwing quadrats, or a complex method involving closed eyes and spinning around – neither of these were given credit.

The table shows the results obtained. $\frac{N(N-1)}{n(n-1)}$

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

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

(2)

Lay two tape measures perpendicular to each other. Randomly generate co-ordinates using random number generator. Place bottom left corner each time of quadrat at those coordinates on the tape measures.

ResultsPlus
Examiner Comments

This response covered all three marking points, scoring full marks.

The table shows the results obtained.

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

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

(2)

Using a line transect and a random number generator. eg. generates the number 20 so place quadrat at 20 metres along the transect.

ResultsPlus
Examiner Comments

This candidate knew that random numbers were important. They explained how to obtain them (which was not required) but did not use them as co-ordinates, so did not achieve mp2. The use of a transect negated mp1.

This was not a suitable method to randomly sample an area 5m x 10m.

The table shows the results obtained.

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

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

(2)

randomly place the quadrat record the what is seen then walk 20 steps and place the quadrat, repeat this walking in different direction.

ResultsPlus
Examiner Comments

This answer does not achieve any credit.

There is no indication how to place the first quadrat randomly. The placement of the second quadrat depends on the placement of the first, so this method overall is not random.

The table shows the results obtained.

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

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

(2)

throw quadrats in area so they land randomly preventing selective bias where more dandelions or less may be

ResultsPlus
Examiner Comments

Throwing quadrats is never a suitable method to place them randomly.

Question 6(a)(ii)

Q06(a)(ii) tests candidates' understanding of Core Practical 15: investigate the effects of different sampling methods on estimates of the size of a population. Candidates were given the context of a pilot study to find the best quadrat size to estimate the population of dandelion plants in an area 5m x 10m.

They were given three possible quadrat sizes (1m x 1m, 0.5m x 0.5m, 0.1m x 0.1m), told there were 53 dandelions in the area and given a table of results showing how many were recorded when each quadrat was used.

Some candidates realised that each quadrat was used to sample the same area ($5m^2$), so this was a valid sampling comparison; some thought that it was unfair because the small quadrat was used a lot more than the others.

Some candidates used the information to calculate a comparable estimate for each quadrat size. There were three ways to do this:

- recognise that $5m^2$ was a tenth of the total area being sampled, and multiply the number of plants found by 10 to estimate the number in the whole area. This gives a value of 10 for the $1m^2$ quadrat, 30 for the $0.25m^2$ quadrat and 60 for the $0.01m^2$ quadrat;
- calculate the number of dandelions per $1m^2$ of the whole area (53 divided by 50 = 1.06), and the number per $1m^2$ of the sampled area; this gives a value of 0.2 for the $1m^2$ quadrat, 0.6 for the $0.25m^2$ quadrat and 1.2 for the $0.01m^2$ quadrat;
- use the known value of 53 dandelions in the whole area to find the number in $5m^2$ ie 53 divided by 10 = 5.3, and compare this to the numbers in the table, which are the number found in $5m^2$ with each size of quadrat.

Whichever method was used, the candidates should then compare the values for each quadrat size to the actual value to find which gave the best estimate (it was the $0.01m^2$ quadrat), and explain their reasoning. Candidates should note that the command word for this question was **determine,** which always requires a quantitative element to the answer from the stimulus material provided.

Some candidates realised that the $0.01m^2$ quadrat was the most representative because it sampled the widest area (not the larget area, as all sampled $5m^2$).

This question required logical thought and reasoning, and it was pleasing to see that almost 30% of candidates scored either three or four marks (usually mp2, 3 and 4). The least commonly seen marking point was mp5, for the idea of being most representative.

There were some excellent and well articulated answers, showing real understanding of the principles behind sampling.

Around a third of candidates did not achieve any marks on this question. The majority of these ignored the numbers altogether and went with the idea of the size they thought was most sensible. This could be summed up as the Goldilocks theory: the biggest one was too big, the smallest one was too small and the middle one was just right. Some wrote about the time it

would take, or the damage that would be done by trampling dandelions, neither of which was relevant when they were asked for the size that gave the best estimate. Frustratingly some started to do the calculations then decided to abandon them because the small quadrat would take too much time, so they randomly chose one of the others as their answer. Some tried to do the calculations but an error sent them down the wrong track. The most commonly seen of these was multiplying the number of dandelions by the number of quadrats, and reaching an estimate of 5 for the $1m^2$ quadrat, 60 for the $0.25m^2$ quadrat and 3000 for the $0.01m^2$ quadrat, leading them to a wrong conclusion that the $0.25m^2$ quadrat gave the best estimate.

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

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

numerical

(4)

The field is $50 m^2$. For quadrat size $1m^2$, in a total area of $5m^2$ sampled there was 1 plant, implying in $50 m^2$ there was 10 plants. For size $0.25 m^2$, a total area of $5m^2$ sampled showed 3 plants implying in $50m^2$ there are 30 plants. For $0.01 m^2$, for $5 m^2$ total sampled there were 6 plants so in $50 m^2$ there were 60 plants. 60 is the closest to 53. so the 10 cm x 10 cm ($0.01 m^2$) quadrat is the best to use.

ResultsPlus
Examiner Comments

This candidate scored four marks for a well-reasoned answer.

They scored mp2 for the number estimated in each size of quadrat (10, 30, 60); mp3 for identifying that the $0.01m^2$ quadrat gave the best estimate; and mp4 for explaining that 60 was closest to 53.

During the answer they stated that each of the sampling areas was $5m^2$, so they also scored mp1.

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

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

(4)

0.01 m^2 gives the most accurate, but it is still far from accurate as 6 is a huge underestimate. 0.25 ^{2} is the next most accurate but still a huge underestimate. 1 m^2 is the least accurate. 0.01 used about 500 x 9 more times would give more accuracy, or using an axis + random number generator.

ResultsPlus
Examiner Comments

This candidate scored mp3 only, for identifying 0.01m^2 as the quadrat size that gave the best estimate. Unfortunately it was for completely the wrong reason, as they were comparing the figures in the table without any further conversion, ie 6 is closest to 53. This error was seen several times.

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

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

(4)

total area = $50m^2$

$1m^2$ in $5m^2 = 1$ ∴ $50m^2 = 10$ dandelion

$0.25m^2$ in $5m^2 = 3$ ∴ $50m^2 = 30$

$0.01m^2$ in $5m^2 = 6$ ∴ $50m^2 = 60$

60 is closest to 53 so, the $0.01\ m^2$ quadrats were the most accurate.

ResultsPlus
Examiner Comments

This minimal answer scored full marks:

- mp1 in the calculations (for each sampling area being $5m^2$)
- mp2 for 10, 30, 60
- mp3 for the identification of the $0.01m^2$ quadrat
- mp4 for the explanation that 60 is closest to 53.

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

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

(4)

① = 5. estimate the 0.01 m quadrats was

② = 120 estimate the most accurate number

③ = 6000 estimate. of dandelion plants at

10 dandelions were the 0.01 quadrats estimated. was 6000 dandelions, this means that there must have been outliers on the $0.01 m^2$ data as it was so far off.

ResultsPlus
Examiner Comments

This candidate attempted to work out the answer but their maths was flawed.

To get the numbers on the left they multiplied the number found in the $1m^2$ quadrat by 5 (but later changed this to 10); the number found in the $0.25m^2$ quadrat by 40 and the number in the $0.01m^2$ quadrat by 1000.

This is one of several examples of candidates following a flawed method and coming up with the wrong answer. It scored zero.

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

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

(4)

- 53 in $50m^2$ field
- Large 1 per $5m^2$ So 10 per $50m^2$
- Medium 3 per $5m^2$ So 30 per $50m^2$
- Small 6 per $5m^2$ So 60 per $50m^2$
- AS evidenced the $0.01m^2$ quadrat gives the most accurate estimate of the number of dandelion plants as only 7 above for entire field.
- Greater abundance of smaller quadrats allow for wider spread of data collection
- All quadrats cover equal area but more diverse spread allows for more accurate results.

ResultsPlus
Examiner Comments

This strong answer achieved all five marking points, scoring full marks.

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

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

(4)

First of all, different numbers of quadrats were used for $1m^2$, $0.25m^2$ and $0.01m^2$, 5 is too small and 500 is too big. So if 20 quadrates were used for all the sizes of quadrates, like For $0.25m^2$, it makes it more valid. This would mean X4 $1m^2$ quadrates need to be used, roughly suggest X4 dandelion would be recorded, making it around 4. These would still be 3 dandelions for $0.25m^2$, but $500 \div 20 = 25$, So $6 \div 25 = 0.24$, dandelions in x20 $0.01m^2$ quadrat. From this it can be concluded that none of them gave a number close to 53 however $1m^2$ gives a slightly higher number than $0.25m^2$, so this is the most accurate.

ResultsPlus
Examiner Comments

This candidate decided to redesign the investigation instead of focusing on the results obtained from the actual investigation, and scored zero.

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

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

(4)

$5 \times 10 = 50m^2$ total.

$1m^2$ quadrat: $5 \times 1 = 5m^2$ analysed $50 \div 5 = 10$ $1 \times 10 = 10$ dandelions estimated

$0.25m^2$: $0.25 \times 20 = 5m^2$ analysed $50 \div 5 = 10$ $3 \times 10 = 30$ dandelions estimated

$0.01m^2$: $0.01 \times 500 = 5m^2$ analysed $50 \div 5 = 10$ $6 \times 10 = 60$ dandelions estimated.

The $0.01m^2$ quadrat gave the most accurate estimate of number of dandelions. Every quadrat analysed a total $5m^2$ of the $50m^2$, so the estimated number will be $\times 10$ the number recorded. For the $0.01m^2$ quadrat, the estimate is 60 dandelions, which is only 7 off from the accurate value. Its most accurate because it allows more seperate areas within the field to be analysed.

ResultsPlus
Examiner Comments

Another four-mark answer covering all five marking points.

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

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

(4)

From the data, 0.25m² sized quadrat gives the most accurate estimate. ~~Because~~ Despite 0.01m² recorded the highest number of ~~dense~~ dandelion but it used 500 quadrats to only find 6 dandelion because the quadrat is too small and the many of the times, the quadrat does not fall at the area where dandelion is found. Since the area is too specific. Whereas in 1m² quadrat, the area is too big, not a ~~ton~~ lot of quadrats can be placed in the given area, there will be a lot of overlapping. So some dandelions might be counted twice accidentally. Whereas in 0.25m², the quadrat is decently sized, it can ~~cover~~ cover a decent area to count the number of dandelion ~~Without having to worry the~~ and the chance of overlapping is smaller. ~~However, the data shows that different sizes of quadrats, they're used different number of quadrats, it~~

ResultsPlus
Examiner Comments

This is the Goldilocks theory in action: the small quadrat is too small, it will miss the dandelions; the big quadrat is too big, there will be overlapping and dandelions will be counted twice; the middle sized quadrat is a decent size and it can cover a decent area.

All of the data in the table was ignored, and this response scored zero.

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

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

(4)

total area of selected region = 50m²

- 1m² = 1 dandelion, ~~so~~ there where 53 dandelions so 53/50 = 1.06 dandelions every m², 1m² quadrat found 1 in 5m², fairly inaccurate, 0.2 every m², ~~so ≈ 1 every m², so 1m² quadrat has been fairly accurate~~
- 0.25m² = 3 dandelions, in 5m², 3/5 = 0.6 every m² so still quite inaccurate
- 0.01m² = 6 dandelions in 5m² area, 6/5 = 1.2 dandelion per m². This is closest to true number per m² which is 1.06.
- therefore 0.01m² quadrats provide most accurate reading for ~~distance~~ estimated number of dandelions

ResultsPlus
Examiner Comments

This candidate achieved mp1, 2, 3 and 4 with a lesser seen alternative marking point 2.

Question 6(b)

Candidates were asked to describe the data that must be collected so a biodiversity index could be calculated for a grassland. This was:

- number of species present
- number of individuals of each species.

Candidates found this surprisingly difficult, with just over 40% achieving both marks. The most common error was to think that the total number of individuals of all species should be recorded.

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

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

(2)

The total number of all the species in the grassland. Also, within each species the number of organisms present

ResultsPlus Examiner Comments

This candidate scored both marks.

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

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

(2)

- The total number of each species present in the area

- The total number of organisms present in the area.

ResultsPlus Examiner Comments

This response illustrates the most common error we saw. The candidate achieved mp1 but

not mp2.

Question 6(c)(i)

Candidates were asked to state the meaning of the term **species.**

Almost three-quarters were able to do this. The most common errors were:

- referring to animals, rather than organisms or individuals
- referring to mating, rather than interbreeding
- not referring to reproduction at all, eg organisms that can produce fertile offspring.

Candidates should be encouraged to learn key definitions, rather than trying to develop them in an exam situation.

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

(1)

~~An organism~~ A group of organisms which can interbreed to produce fertile offspring.

ResultsPlus
Examiner Comments

This definition scored one mark.

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

(1)

two animals belong to the same species if when they mate they produce offspring, which themselves can reproduce.

ResultsPlus
Examiner Comments

This definition was not acceptable, because it referred to animals and to mating.

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

(1)

Species ~~are~~ have similar morphology and

ResultsPlus
Examiner Comments

Similar morphology was not enough, we needed a reference to interbreeding and fertile offspring.

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

(1)

type of animal that has the same niche

& can interbreed with each other

ResultsPlus
Examiner Comments

This response did not score for two reasons: it referred only to animals, and the last part of the definition (about fertile offspring) was missing.

Question 6(c)(ii)

Candidates were asked how scientists could use DNA from two similar looking plants to investigate whether they were closely related.

They could choose to go down one of two routes, both with three marking points for two available marks:

- gel electrophoresis, with a detail of the technique given and the way to obtain results, ie to compare the two banding patterns
- DNA sequencing, with a detail of the technique given and the way to obtain results, ie to compare the two base sequences.

Most candidates chose to write about gel electrophoresis and over 60% achieved both marks. Occasionally candidates gave information about both methods, ie changed from one to the other half way through – in this case only their highest scoring route was used in marking.

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

(2)

carry out gel electrophoresis. take DNA samples from both plants, cut each using restriction endonuclease enzymes. add to agrose jell + apply current. DNA ~~band~~ fragments will seperate. compare the banding patterns. more matches means more closely related.

(Total for Question 6 = 11 marks)

ResultsPlus
Examiner Comments

This response achieved all three marking points, for two marks.

The detail of adding to agarose gel and applying a current was enough for mp2.

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

(2)

Gel electrophoresis, compare DNA to see how similar the DNA is and compare relationship.

ResultsPlus
Examiner Comments

This response scored mp1 for gel electrophoresis, but no details were given for mp2 and comparing the DNA was not enough for mp3.

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

(2)

They can use DNA sequencing to find the base sequence of both plants and look for amount of differences, the more closely related the 2 plants are, the less genetic differences between them.

ResultsPlus
Examiner Comments

This answer scored two marks for the DNA sequencing route; mp1 for DNA sequencing and mp3 for the idea of finding the amount of differences in the base sequence of both plants.

Question 7(a)(i)

Q07 tested candidates' understanding of Core Practical 1: investigate a factor affecting the inital rate of an enzyme controlled reaction.

The context was an investigation involving the enzyme phosphatase from mung beans, which catalyses the conversion of (colourless) phenolphthalein phosphate to (pink) phenolphthalein + phosphate.

The activity of the enzyme was measured by using a colorimeter to determine the absorbance; as the concentration of product increased, the solution became more pink and the absorbance decreased. The effect of temperature on enzyme activity was being investigated, and candidates were given a detailed method which the students followed.

Q07(a)(i) asked them to describe how to ensure that the concentration of enzyme extract was the same for all students carrying out the investigation.

There were three marking points for two available marks:

- use the same mass of mung beans
- use the same volume of water
- use the same germination conditions / a named example of a condition which should be controlled, eg temperature, time after germination starts.

This proved more challenging for candidates than we expected, with almost half not scoring at all, and only 14% scoring both marks. This may reflect the fact that candidates do not usually prepare their own enzyme extract during investigations, but it was reasonable to expect them to understand the principles of this. Errors included:

- using the same number of beans, rather than mass
- imprecise terminology, eg amount of beans, amount of water
- candidates who wrote about ensuring the volume (rather than the concentration) was the same, eg by using a measuring cylinder or syringe. This was a surprisingly common error.

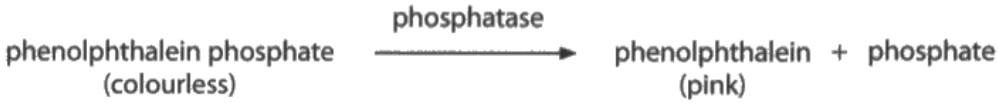
Mark point 3 was very rarely attempted.

Quite a lot of candidates suggested using a stock solution, ie a single batch which was shared by all students, and this achieved one mark.

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

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

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



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

The students used the following method.

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

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

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

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

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

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

(2)

Use the same volume of water and the same mass of mung bean seeds. Use same specie and age of mung beans.

ResultsPlus
Examiner Comments

A clear answer, scoring mp1 and 2.

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

(2)

germinate the ~~bot~~ mung bean seeds all for the same amount of time and only one person grinds all the mung bean seeds with water ~~to~~ and filter the extract.

ResultsPlus
Examiner Comments

A rare example of mp3 for germinating the mung bean seeds for the same time, but mp1 and 2 are not attempted.

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

(2)

Ensure th mung beans were th same mass.
When grinding th mung beans, use th same amount of water to prevent different [redacted] dilutions.
Ensure th mung beans came from th same plant.

ResultsPlus
Examiner Comments

This candidate achieved mp1 (same mass of beans) but not mp2 as they stated same amount of water.

ResultsPlus
Examiner Tip

"Amount" is **never** the best word to use in biology – think about what you actually mean! It could be number (eg number of beans), mass, volume, concentration etc.

Using a precise word like this is likely to get you the mark, using amount is not going to get the mark.

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

(2)

Use the same stock solution for all students.

ResultsPlus
Examiner Comments

This candidate achieved one mark for the idea of a stock solution which is shared by all of the students.

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

(2)

use a measuring pipette to increase the accuracy of the measurment. use the same pippet in every repeat, ensures any differenies that may occur are minimised. could also use a mechanical pipette which removes humanerror.

ResultsPlus
Examiner Comments

This candidate has written an answer about how to ensure all of the students got the same volume of enzyme extract, rather than the same concentration. It scored zero.

Question 7(a)(ii)

Candidates were asked to describe how they would ensure the colorimeter readings were comparable for each of the students.

There were three marking points available for two marks:

- zeroing the colorimeter with water or other suitable colourless liquid
- using an appropriate filter
- ensuring that the cuvette was not scratched or had no fingerprints.

This was done better than Q07(a)(i), perhaps because candidates could remember using a colorimeter themselves. Almost two thirds got at least one mark, usually for zeroing the colorimeter with water.

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

(2)

use a cuvette with only phenolphthalein phosphate to zero the colorimeters and make this the control. make sure all colorimeters set to absorbance and using the same filter.

ResultsPlus
Examiner Comments

This response gained mp1 for zeroing the colorimeter with phenolphthalein phosphate and mp2 for the same filter.

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

(2)

Each student could use the same colorimeter so there is no difference in equipment and ensure the colorimeters have been zeroed using a control cuvette with distilled water in it and that the ~~colorimeters~~ cuvettes aren't scratched. Ensure each student using the blue filter on the colorimeter.

ResultsPlus
Examiner Comments

This strong answer gained all three marking points for full marks.

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

(2)

Add the same volume of solution into the viles / colorimeter tubes. Add a control tube with just water.

ResultsPlus
Examiner Comments

This response did not score. The idea of using the same volume was seen a lot, but is not creditworthy.

It came close to mp1, but using water as a control is not the same as using it to zero the colorimeter.

Question 7(b)(i)

Candidates were given a table showing the absorbance at eight temperatures between 10 and 80°C, and asked to explain the effect of temperature on the activity of phosphatase.

There were five marking points for three available marks; these can be summarised as:

1. as temperature increases the activity of phosphatase increases
2. because molecules have more kinetic energy
3. so there are more frequent collisions between enzymes and substrates
4. the optimum temperature was between 51 and 69°C
5. above optimum temperature the activity of phosphatase decreases because it is denatured.

This question was generally well done, with 58% of candidates scoring two or three marks. However all marking points showed misconceptions from some candidates, which it may be helpful to address here:

- this was sometimes lost because candidates were simply referring to the change in absorbance in the results table, rather than the enzyme activity
- this was sometimes lost as the kinetic energy was not associated with a molecule / particle / enzyme / substrate
- this was sometimes lost because candidates expressed it as **more** collisions or more E-S complexes forming, rather than **more frequent**/ **more likely** / **more per unit time**. However, this was less of a problem than in previous years, and centres are to be commended for the improvement on this point
- whilst almost all candidates named an optimum temperature (usually 60°C), this value could not be assumed from the data given. From the limited range of temperatures tested, the highest activity was at 60°C, but the optimum could have been anywhere between 51 and 69°C. This was not understood by candidates, even though many of them stated in Q07(b)(ii) that using smaller intervals would allow the optimum temperature to be more precisely identified
- this was sometimes lost because candidates were simply referring to the change in absorbance in the results table, rather than the enzyme activity.

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

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

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

(3)

• as the temperature increased from 10°C to 60°C the absorbance of light increased, this was because the activity of phosphatase was increasing

• as the temperature increases the phosphatase enzyme has more kinetic energy so it ~~moves~~ moves around faster, this causes the frequency of successful collisions between the phosphatase and phenolphthalein phosphate to increase (more enzyme substrate complexes form)

• however after 60°C, the activity of phosphatase decreased this is because the enzyme denatured after this temperature

• as the enzyme denatures the shape of the active site changes so enzyme – substrate complexes can no longer form

• 60°C is the optimum temperature for the activity of phosphatase

ResultsPlus
Examiner Comments

This answer scored mp1 in the first 3 lines; mp2 in lines 4-5; mp3 in lines 6-8; mp5 in lines 9-12. It was a very strong and clearly written response.

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

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

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

(3)

Increasing temperature upto to 60°C increases activity of phosphatase because substrate and enzymes have more kinetic energy so there are more successful collisions. and more enzyme-substrate complexes form. Increasing the temperature above 60°C reduces the activity of phosphatase because the enzyme is denatured dene to disruption of tertiary structure. the active site no longer fits the substrate

ResultsPlus
Examiner Comments

This response also scored full marks: mp1 on lines 1-2; mp2 on line 3; mp5 on lines 5-9.

Not mp3 as they say that there are more successful collisions and more E-S complexes form, rather than saying more per unit time.

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

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

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

(3)

- As temperature increases absorbance decreases
- This is because the enzymes are breaking down phenolphthalein phosphate so, absorbance decreases.
- Increasing temperature increases the rate of reaction of phosphatase.
- This is because the Temperature increases the Ke of the substrate and phosphatase therefore, increasing collision with the active site.
- As a result more phenol phosphate broken down.

ResultsPlus
Examiner Comments

This answer is confused in places, but scored two marks.

Lines 1-3 are about absorbance and are incorrect because as temperature increases, absorbance increases.

Mp1 on line 4 mp2 on lines 5-6. Not mp3 as it says increasing collisions with active site, rather than increasing the **frequency** of collisions.

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

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

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

(3)

• temperature increased as • absorbance increased as temperature increased as it is an enzyme reaction, so enzymes gained more kinetic energy, more phenolphthalein was produced as an enzyme substrate complex

• enzymes (phosphatase) reached its optimum at 60°C where the most enzyme substrate complexes were formed and absorbance was highest at 0.55

• ~~at~~ phosphatase denatured after 60°C and absorbance decreased as less enzyme substrate complexes were formed.

ResultsPlus
Examiner Comments

This candidate scored only one mark; this was mp2 on line 3.

Not mp1 and 5 because they were writing about absorbance, not enzyme activity.

Question 7(b)(ii)

Candidates were told that there may have been errors in the method used, and that the investigation was repeated with four changes. They were asked to justify the four changes.

The command word **justify** requires candidates to give evidence to support something – here they were being asked to explain the reason for the change. This is something candidates typically find very difficult, and it was pleasing that so many (85%) were able to justify at least one of the changes. However, only 6% could justify all four changes; this question discriminated very well.

The changes were:

- add buffer to each tube of phenolphthalein phosphate **because pH might affect enzyme activity / changes in pH can denature enzymes**
- place separate tubes containing the enzyme and substrate into the waterbath before mixing together **so that they equilibrate / reach the same temperature**
- use smaller intervals than 10°C **so that the optimum temperature can be identified more precisely**
- stop the reaction before 20 minutes **so that initial rate can be calculated / so that substrate concentration is not a limiting factor**.

Mp1 and 4 were seen most frequently and mp3 was least commonly achieved.

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

(4)

Change ① : buffer solution is used to control the pH ; this is because pH will also alter the tertiary structure of the enzyme changing the active site shape ; affecting the rate of reaction.

Change ② - placing in water baths for 10 mins first allows both the substrate and the enzyme extract to be at the same temperature and equilibrate before mixing , as temperature is the independent variable ; enzyme + phenolphthalein ammonatase should begin at the same time.

Change ③ - using smaller intervals provides you with more data to get a more accurate value for the rate of reaction as you're taking more readings

Change ④ as if you leave in water bath for 20 mins , the water will eventually cool down so temperature is no longer controlled . 5 mins ensures temp stays constant.

ResultsPlus
Examiner Comments

This response scored two marks:

- mp1 on lines 1-3
- mp2 on lines 4-8.

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

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

The students repeated the investigation with these four changes:

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

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

(4)

Stopping the reaction after 5 minutes instead of 20 means less of the enzyme is beans used. is important as it reduces 20 minutes may be too long resulting in the substrate / enzyme concentration becoming the limiting factor and not temperature. Using smaller temperature intervals means that any more accurate graph and any anomalies can be identified as well as changes in enzyme activity being more gradual. Heating the enzyme and substrate seperately means that the they will be at the same temp when combining so they do not have to accumatise to the environment. Using a buffer solution will slow down the chemical reaction between the enzyme and substrate so that they can reach temps being measured.

ResultsPlus
Examiner Comments

This response achieved one mark - this was mp2 on lines 11-13.

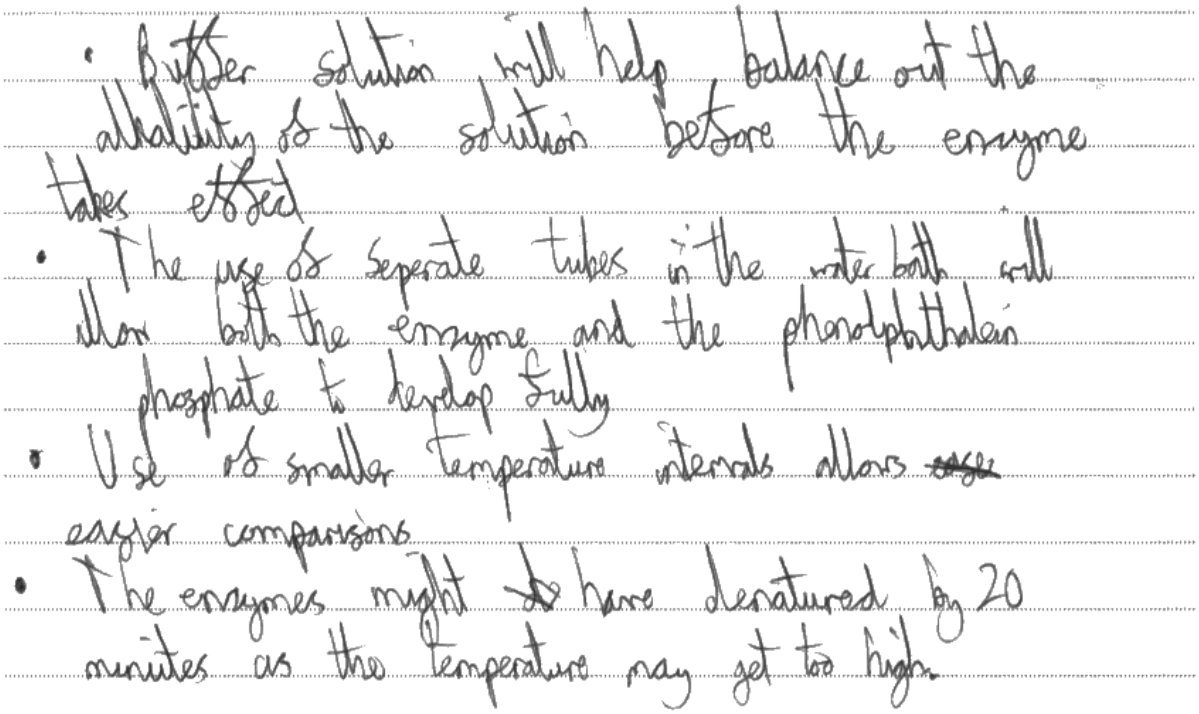
Not mp4 at the start, as they wrote about substrate **and enzyme** concentration becoming a limiting factor.

Not mp3 as it was too vague.

Not mp1 as it was very confused.

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

(4)



ResultsPlus
Examiner Comments

Although this candidate attempted to justify all four changes, they did not score.

The incorrect explanation for stopping the reaction before 20 minutes (so that the enzyme did not denature) was frequently seen.

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

(4)

- Adding buffer solution regulates pH, which can otherwise affect rate of enzyme activity.
- Heating the solutions before means that they are at the desired temperature at the point of first reacting, ensuring each temperature reading is accurate.
- Smaller intervals allows more accurate calculations of increase in absorbance per degree, as well as allowing optimum temperature to be more accurately determined.
- After the initial rate of reaction, other factors limit reaction rate, so comparisons are invalid beyond 5 min.

ResultsPlus
Examiner Comments

This excellent response is a very strong answer, gaining all four mark points.

Question 7(c)

Candidates were asked to give two examples of biochemical processes in plant cells that require phosphate ions.

Suitable processes included:

- synthesis of ATP
- synthesis of nucleotides or nucleic acids
- synthesis of phospholipids
- synthesis of NADP
- regeneration of RuBP
- phosphorylation of glucose (in respiration).

Over 70% of candidates were able to give at least one example, and around 37% achieved both marks. ATP and phospholipids were the most common correct answers.

Those who did not score usually named complex, multi-step processes, eg respiration, rather than focusing on the aspect that required phosphate ions, eg synthesis of ATP.

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

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

(2)

Phosphorylation of ADP to ATP via atp synthase enzyme, requires a phosphate to be added to ADP to resynthesise ATP. During aerobic respiration, glucose must be phosphorylated with addition of a phosphate group to ensure glucose doesn't leave cell and to make unstable so that it breaks into two 3 carbon molecules (GP)

ResultsPlus
Examiner Comments

This strong answer gives more detail than was needed to achieve the marks.

Phosphorylation of ADP to ATP and phosphorylation of glucose are two suitable examples

for full marks.

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

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

(2)

ATP synthesis requires phosphate ions to be joined the ADP. Formation of the cell membrane requires phosphate ions to form the phosphate heads in the phospholipid bilayer that makes up the cell membrane.

ResultsPlus
Examiner Comments

This candidate scored two marks – these were the most commonly seen examples.

Question 8(a)(i)

Q08 tested candidates' understanding of Core Practical 16: investigate the effect of one abiotic factor on the distribution or morphology of one species. It also included formulation of a null hypothesis and completion and analysis of a statistical test.

The context was an investigation into whether the number of tar spots on sycamore leaves (caused by a fungus *Rhytisma acerinum*) is affected by distance from a road. They were told that the fungus causing the tar spots is known to be sensitive to sulfur dioxide and oxides of nitrogen in the air, and grows more slowly when these gases are present. Tar spots were counted on trees in two locations: close to a busy road, and in parkland far from the road.

In Q08(a)(i) candidates were asked to give a suitable null hypothesis for this investigation.

In previous years, this has proved to be challenging for many candidates, so it is very pleasing to see that this year over half scored the mark available. However, many candidates are still finding this difficult. It may help if they remember that a null hypothesis has four main components:

- independent variable: here it is near and far from the busy road
- dependent variable: here it is the number of tar spots on leaves
- the relationship (this will be a difference / correlation / association): here it is a difference because the data is collected in only two areas (near and far from the road). Each of these is linked to a particular stats test – if you know which stats test is being used, you know which relationship to use
- that there will be no (relationship): because it is a null hypothesis. There is no need to include the word significant at this stage.

The format for writing the null hypothesis does not change. It is as follows:

there will be **no (relationship)** in the **(dependent variable)** for **(independent variable)**

so in this case it will be

there will be **no difference** in the **number of tar spots on leaves** for sycamore trees **near busy roads and far from busy roads**.

This is the simplest form of null hypothesis to write. There are other forms of wording but they are more complicated, and it is best to keep it simple if candidates are struggling to get to grips with it.

8 The photograph shows tar spots on a sycamore leaf.

(Source: Nigel Cattlin / Alamy Stock Photo)

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

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

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

The fungus grows more slowly when these gases are present.

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

This is the method the student used.

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

Step 2 Choose 15 leaves from each tree.

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

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

(1)

There will be no difference in the number of tar spots on sycamore leaves on a tree growing close to a busy road and a tree growing far away from busy roads.

ResultsPlus
Examiner Comments

Perfect!

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

(1)

There is no significant difference between sycamore trees close to a busy road and one sycamore tree that is away from the road.

ResultsPlus
Examiner Comments

This null hypothesis includes three of the four elements, but misses out the dependent variable – number of tar spots on leaves. It therefore scores zero.

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

(1)

There is no ~~significant~~ correlation between the mean number of tar spots on a sycamore tree with distance from busy roads.

ResultsPlus
Examiner Comments

This candidate has written about a correlation, rather than a difference, so zero marks.

We know this is not a correlation because the data was collected in two locations (at two values of the independent variable).

For a correlation, the data will be collected at multiple values of the independent variable (usually at least five). For an ecology investigation this will usually involve a transect.

Question 8(a)(ii-iii)

Q08(a)(ii) and (iii) was a *t*-test and analysis of the results.

Part (ii) was calculation of the *t* value.

Candidates were given a table of results including the number of tar spots on 15 leaves from each location, and the means and standard deviation for each location.

They were given the formula to calcuate the *t* value. Most were able to do this successfully, reaching an answer of 2.03. A minus value was allowed at this stage.

Where errors were made and the wrong final answer given, it was often not possible to credit interim values since no working was shown. Where a wrong final answer was carried forward to part (iii), ecf was applied so candidates could still get full marks for part (iii).

Part (iii) was analysis of the data.

Candidates were given a table of critical values and asked to analyse the data to comment on the results of the investigation. There were three main steps:

1. find the critical value: here the number of degrees of freedom was (15 + 15) - 2 = 28, and the critical value (at p = 0.05) was 2.05
2. compare the calculated *t* value to the critical value and either accept or reject the null hypothesis: here the calculated _t_value (2.03) was less than the critical value (2.05), so we accept the null hypothesis
3. write a simple conclusion, including the word **significant**, based on what you have found out: here a suitable conclusion would be "there is no significant difference in the number of tar spots on leaves close to busy roads and far from busy roads".

Errors were made in each of the steps:

- some did not select the correct critical value, because they did not know how to determine degrees of freedom
- some did not know the rules for accepting or rejecting the null hypothesis, and they wrongly chose to reject it
- some got tangled up in writing the conclusion and left parts out, including the word significant.

Overall almost 60% achieved four marks or more on parts (ii) and (iii), showing they have got to grips with this. Almost 20% achieved full marks.

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

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

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

Calculate the value of *t*.

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

where:

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

n is the number of samples in each set of data

S is the standard deviation for each set of data

(3)

$$t = \frac{17.07 - 12.93}{\sqrt{\frac{4.06^2}{15} + \frac{6.78^2}{15}}} = \frac{4.14}{\sqrt{\frac{15\,613}{3750}}} = 2.03$$

Answer 2.03 (3sf)

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

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

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

(3)

df = 15+15-2 = 28. 2.03 < 2.05 (our calculated value is lower than the critical value). This means we can accept the null hypothesis at the 5% significance level ∴ There is no significant difference between number of tar spots on sycamore leaves close to busy roads and away from busy roads.

ResultsPlus
Examiner Comments

Q08(a)(ii)

Full marks for a correct answer (2.03).

Q08(a)(iii)

- mp1 achieved for correct critical value (2.05)
- mp2 achieved for correct comparison between critical and *t* value, and correctly accepting the null hypothesis
- mp3 achieved for a straightforward conclusion containing all the required elements.

An excellent response all round!

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

(3)

At a 5% significance level t is less than the critical region. This means that the null hypothesis can be rejected as there is significant statistical evidence to suggest that there is a difference in the amount of tar spots on sycamore leaves by the near the road and in parkland

ResultsPlus
Examiner Comments

This candidate achieved three marks for Q08(a)(ii) for an answer of -2.03.

However, they scored zero for Q08(a)(iii).

Not mp1 as they did not indicate a critical value in the table or the text.

Not mp2 as they said the t value was less than the critical value, but then rejected the null hypothesis.

Not mp3 as the conclusion referred to amount of tar spots, not number.

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

Calculate the value of *t*.

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

where:

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

n is the number of samples in each set of data

S is the standard deviation for each set of data

(3)

$$\frac{12.93 - 17.07}{\sqrt{\frac{45.9684(6.78)^2}{15} + \frac{(4.06)^2}{15}}}$$

$$\frac{207}{50}$$

$$\frac{-4.14}{\sqrt{3.06456 + 1.09}}$$

$$\frac{-4.14}{\sqrt{2.992 + 1.09}}$$

$$= 0.99436\ldots$$

Answer 0.99

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

(3)

There is no significant difference between the number of tar spots on sycamore leaves at a busy road compared to those not near a road. This is because the calculated value of T (0.99) is not greater than the critical value at P=0.05 with 15 degrees of freedom.

ResultsPlus
Examiner Comments

Q08(a)(ii)

This candidate obtained the wrong final value (0.99) in part (ii).

However, they had enough interim values written in the calculation to score two of the three available marks.

The wrong value was taken forward to part (iii) and treated as though it was the correct value, under ecf.

Q08(a)(iii)

Not mp1 as the wrong critical value was circled in the table (2.13).

Not mp2 as although they stated that their calculated *t* value was not greater than the critical value, they did not state whether to accept or reject the null hypothesis (they should have accepted it).

Mp3 for the conclusion on lines 1-4.

ResultsPlus
Examiner Tip

Always show your interim working. Here the candidate gained two of the three available marks, even though the final answer was wrong.

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

(3)

The value of t, 2.08956776, is lower than the critical value of 2.14. This means the data isn't significant.

ResultsPlus
Examiner Comments

This candidate got the correct t value in part (ii), however they scored zero for part (iii).

Not mp1 as the wrong critical value was selected.

Not mp2 as there is no reference to accepting or rejecting the null hypothesis.

Not mp3 as there is no conculsion. The statement "the data is not significant" is meaningless.

Question 8(b)

Candidates were asked to justify two improvements to the method used by the student.

The command word **justify** requires candidates to give evidence to support something – this is different to the previous question asking candidates to justify something (Q07(b)(ii)) because here they had to suggest the improvements, as well as giving the reasons behind them.

There were four marking points for two marks; these can be summarised as:

1. selecting leaves from more than one tree / selecting leaves from trees in other locations **so that** the results are more repeatable / representative
2. selecting leaves or trees using random sampling **in order to** avoid bias / measuring leaves **in order to** calculate number of spots per cm^2
3. controlling another variable **so that** distance from the road is the only variable affecting number of tar spots / giving an appropriate reason
4. selecting trees at different distances from the road **in order to** test for a correlation /measuring levels of air pollution **in order to** test for a correlation.

Candidates found this very challenging, with only 35% scoring one mark or more. The biggest problem was candidates who gave sensible improvements, but no reasons for them; this was the most common error that we saw.

Where candidates did suggest reasons, there were several commonly seen answers which did not score.

1. A lot of candidates suggested selecting more than 15 leaves from each tree; this was not necessary, as 15 was a big enough sample. Some also suggested that the reason was so a mean could be calculated, but this was done with 15 leaves.
2. Both alternatives of this marking point were seen, and this was the most commonly achieved mark in this question.
3. Some candidates suggested controlling a variable, eg the height the leaves were selected from (which was a good idea), but then gave a reason such as "because height on tree might affect number of tar spots". We were looking for a specific reason linked to the infection, eg that lower leaves are closer to the fungal spores on the ground or that lower leaves are closer to the source of the air pollution.
4. The most common reason given for this was simply to collect more data.

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

(2)

the tree should be chosen at random. Repeat for two more trees in the area.

ResultsPlus
Examiner Comments

This candidate suggested two good improvements, but did not give a reason for either, so scored zero.

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

(2)

Choose more than 15 leaves to have larger sample size. Possibly take leaves from multiple different trees instead of just one tree. Possibly use trees with known distance away from road.

ResultsPlus
Examiner Comments

This candidate attempts to justify their first improvement, but we are not accepting choosing more than 15 leaves.

They make two further suggestions of improvements, but do not justify these, so zero marks.

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

(2)

Use leaves of similar size as this means the leaves are of the same condition have the same surface area available to get tar globs.

Use leaves near different roads and in different parklands as this will reduce bias.

ResultsPlus
Examiner Comments

This candidate achieved mp2 in lines 1-3.

They then attempted mp1 but gave an unsuitable reason – using different locations would make the data more representative, not remove bias.

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

(2)

could measure the number of spots on each leaf certain distances away from the road eg. 10metres, 20metres to find if there was a correlation. Choose a larger number of leaves on each tree for a larger sample size so results are more accurate + valid. / less error.

(Total for Question 8 = 9 marks)

ResultsPlus
Examiner Comments

This candidate achieved mp4 in lines 1-4.

They then suggested choosing more leaves from each tree, so no further credit.

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

(2)

Leaves should be taken from multiple trees in each area to gain a more representative sample and so that anomalies can be identified. Leaves from each tree should be taken from the same position and height on tree as this affects number of tar spots or leaves as fungal spores more effectively at different heights on the tree.

ResultsPlus
Examiner Comments

This strong answer gains mp2 and then mp3 for the idea of same height on tree – candidates had been told that the fungal spores overwinter in dead leaves on the ground, so this was a valid point.

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

(2)

Randomly select the sycamore trees using a random number generator to eliminate bias. Measure leaves from multiple trees in each area to increase the sample size and obtain more representative results.

ResultsPlus
Examiner Comments

This well-written answer scores mp2 and mp1.

Question 9(a)

Q09 tested candidates' understanding of transport in plants, including Core Practical 8: investigate factors affecting water uptake by plant shoots using a potometer.

Q09(a) asked candidates to explain one way in which xylem vessels are adapted for their function of carrying water in plants. There were two marks available for this: the first mark for describing the adaptation and the second for explaining how this facilitated water transport.

The mark scheme included four pairs of linked statements. The most commonly seen answers related to lignin making the vessels waterproof or strong (so they could withstand high pressure) and to them being hollow to allow free water movement.

This question was very well answered.

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

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

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

(2)

Lignin rings around xylem vessel which waterproof the xylem and provide flexibility for xylem for when plant blow in wind

ResultsPlus
Examiner Comments

This achieved mp3 and 4.

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

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

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

(2)

Xylem vessels have pits in their walls to allow the lateral movement of water.

ResultsPlus
Examiner Comments

This response achieved mp7 and 8.

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

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

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

(2)

They have thick walls made of dead tissue to withstand high pressures and volumes of water. This prevents them bursting under turgor pressure and provides them with the ability to transport water against gravity.

ResultsPlus
Examiner Comments

This response did not achieve mp3 as lignin was not mentioned. However it achieved mp4.

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

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

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

(2)

No end walls - allow for co-hesion tension as the water column is able to be pulled up as water molecules cohere/stick together So when water evaporates - water is pulled up in the xylem in a continuous column.

ResultsPlus
Examiner Comments

This response achieved mp1 and 2.

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

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

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

(2)

Xylem vessels are hollow and dead with no cytoplasm so ~~with~~ water has very little resistance to movement in the vessel and ~~more of~~ the vessel also has increased capacity.

ResultsPlus
Examiner Comments

Another response achieving mp1 and 2.

Question 9(b)(i)

Candidates were given a graph showing the rate of transpiration in oat seedlings over one day.

They were asked to calculate the mean rate of change in transpiration from 5 to 13 hours, and to give their answer to 1dp.

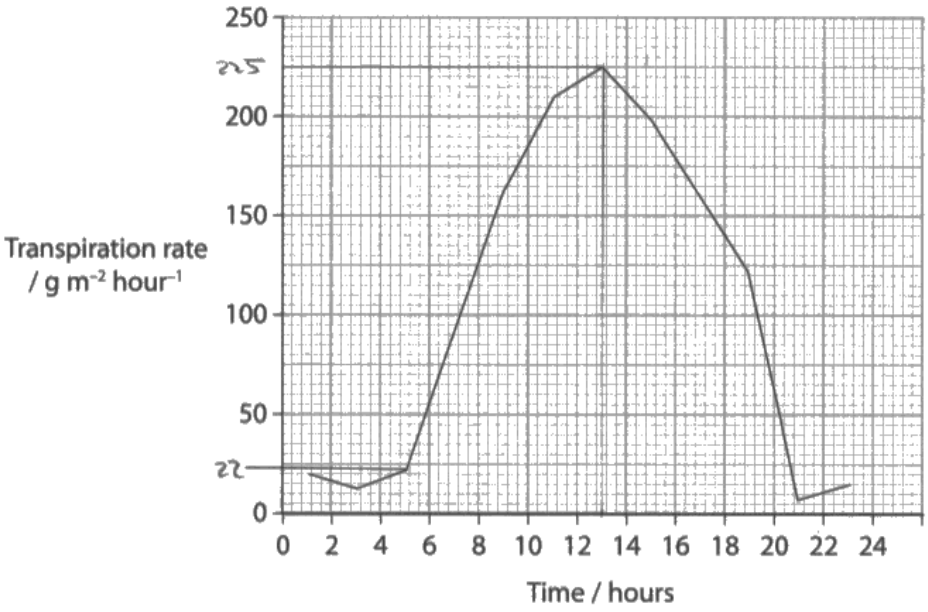
The first step was to read the values for rate of transpiration at 5 and 13 hours from the graph. Candidates should then have carried out a simple calculation, as follows:

(rate at 13 hours - rate at 5 hours)/8 = 25.3 (answers in the range 25.0 to 25.6 were accepted)

Our perception when marking was that candidates did well on this question, but in fact just over half scored the mark available. Problems included:

- not reading values from the graph correctly (including the times) - this was by far the biggest problem
- not carrying out the correct calculation from the readings obtained
- not giving the answer to 1dp.

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



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

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

225 − 22 = 203

$\frac{203}{8}$ = 25.375

= 25.4

(1)

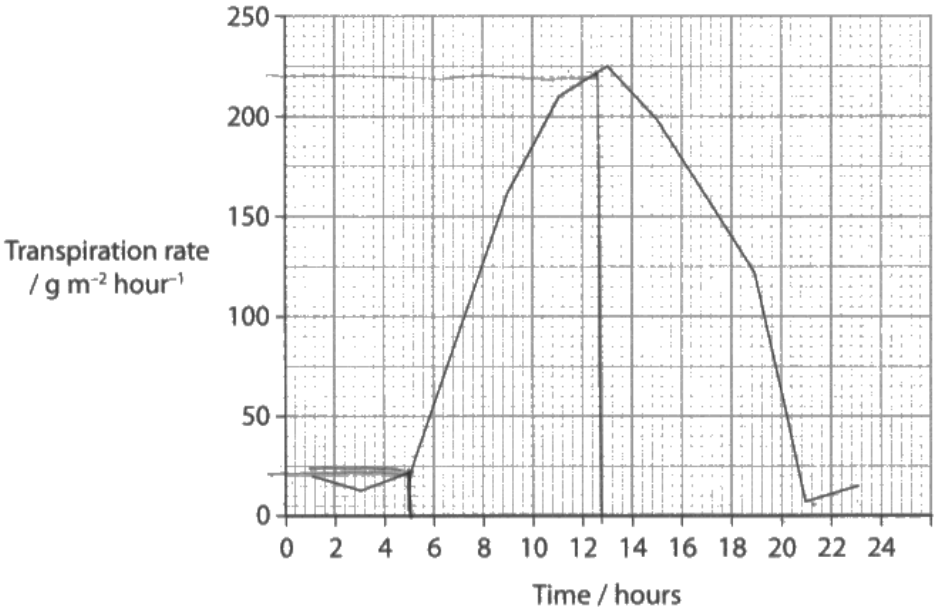
Answer 25.4 g m⁻² hour⁻¹

ResultsPlus
Examiner Comments

This candidate correctly read the two values from the graph within the tolerance allowed.

They subtracted correctly and divided by 8 to achieve the correct answer given to 1dp.

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



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

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

(1)

20 at 5 hours

220 at 13

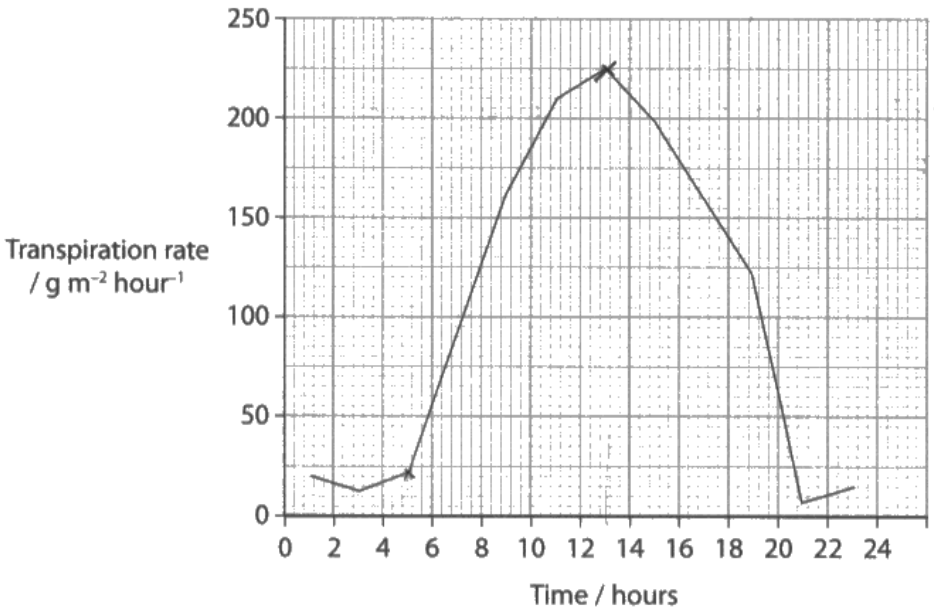
$\frac{220-20}{220} = 0.909$

Answer 0.9 g m⁻² hour⁻

ResultsPlus
Examiner Comments

This candidate did not read the values from the graph very accurately. However, they would still have been just within tolerance if they had divided the numerator by 8 (the number of hours) rather than carrying out what looks like a percentage calculation. So no marks.

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



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

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

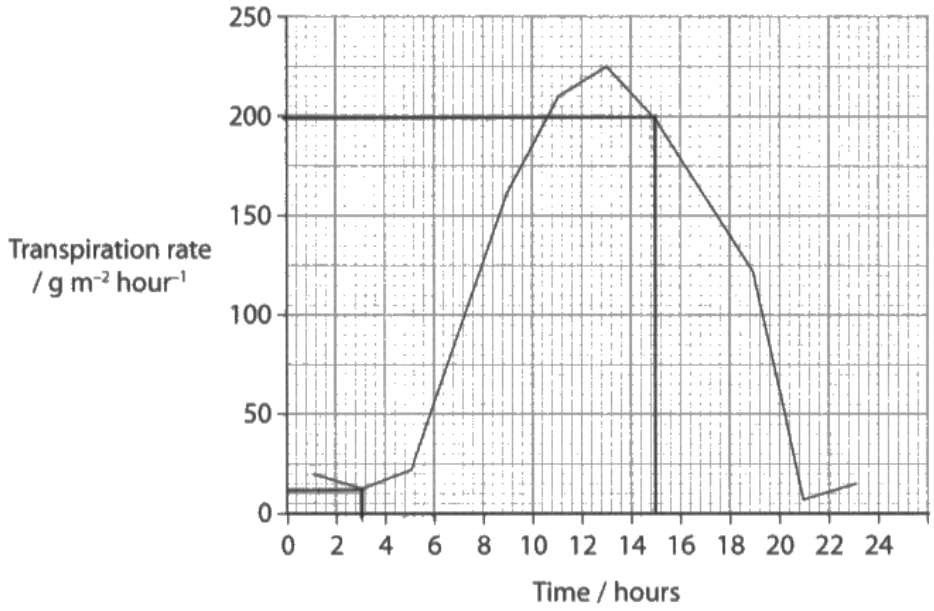
225 − 82.5 = 202.5 (1)

Answer 202.5 g m⁻² hour⁻¹

ResultsPlus
Examiner Comments

This candidate correctly read both values from the graph and subtracted them. They did not carry out the last step (dividing by 8) so did not score.

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



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

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

(1)

$\frac{200 - 12.5}{13 - 5} =$

Answer 23.4 g m⁻² hour⁻¹

ResultsPlus
Examiner Comments

This candidate read a wrong value from the graph (15 hours instead of 13 hours).

Although they carried out the rest of the calculation correctly, their answer was outside the range of tolerance accepted, so they did not score.

ResultsPlus
Examiner Tip

If you are reading any values from a graph, take time to make sure you are doing this accurately, and that you have read the scale properly – you will lose marks if you do not do

this!

Question 9(b)(ii)

Candidates were asked to explain the shape of the graph (showing transpiration rate in oat seedlings) over the 22-hour period.

There were five marking points for three marks and we were looking for clear statements about **what** was happening, **when** it was happening and **why** it was happening, eg between 5 and 13 hours the rate of transpiration increased because light intensity / temperature increased.

Many candidates found this very challenging because:

- they were not able to read time values accurately from the graph. Many took a very relaxed approach to the data, and were often as much as 2 hours out in describing the timing of events
- they did not consider the sense of what they were saying, eg that it became dark at 13 hours (1pm)
- they used imprecise, non-scientific language, eg the sun was out / there was more light, rather than referring to light intensity increasing
- some tried to explain the graph in terms of changes in humidity and wind speed, despite being told these had been controlled.

This question also showed that many candidates have a very shaky understanding of transpiration, and some tried to explain it solely in terms of photosynthesis. We found similar problems when transpiration was last tested in the 2022 series. This is an area which centres could profitably work on, in order to improve understanding.

Overall, only 12% scored all three marks, and almost 40% scored zero. The most commonly seen marking point was mp2, that stomata are closed in the dark; this was the only marking point that did not require an accurate time link.

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

(3)

Transpiration is slow between 0 to 6 hours and 20 to 24 hours as it is dark. The stomata are closed, meaning no gas exchange can take place. There is a peak transpiration at hour 13 as the sun is directly overhead. There is maximum evapouration and the concentration gradient is steep, causing ~~wat~~ more water to leave by osmosis. Between 5 to 12 hours, the rate of transpiration is increasing as the sun is rising and between 14 and 20 hours the rate of transpiration is decreasing as the sun is falling

ResultsPlus
Examiner Comments

This candidate had problems reading accurately from the graph. On lines 1-2 they refer to 0 to 6 hours (should have been 1 to 5 hours) and 20 to 24 hours (should have been 21 to 23 hours).

They use terms like "the sun is directly overhead" and "the sun is falling", rather than referring to light intensity or temperature.

They scored one mark, mp2 on line 2-3 for stomata being closed in the dark.

ResultsPlus
Examiner Tip

If your answer depends on reading times accurately from a graph, make sure you have done this carefully – lack of precision costs marks!

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

(3)

0- 5 hours dunny ~~at~~ early moming when no light means shomata cloted no wate r can eaprrate off leaf so low rate of transpiration. 5-13 light is araulable Shomata open transpiration occurs -rate increases 13 hours is ophmum light intensity of he day all shomata open. 13-21 hours sun set light intensity falls shomata begin to close transpiration decreases. 21 hour night shomata cloted.

ResultsPlus
Examiner Comments

This answer scored three marks:

- mp2 on line 2 for stomata closed in no light
- mp1 on lines 2-3 for low rate of transpiration when no light (not for the statement about 0-5 hours, as no data for 0 hours on graph)
- mp5 on lines 7-9 for 13-21 hours, light intensity falls, transpiration decreases.

Not mp4 as they describe it as optimum light intensity, and do not refer to the effect on transpiration.

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

(3)

· Stays decrease at start, slow increase, rapid increase from 5-13 hours. Then, ~~rapid~~ decreases to 21 hours. Starts to slowly increase to 23 hours. Transpiration rate increases during the day time. ~~or~~ There is more uptake of water, ~~in~~ during the day, more stomata are open for gas exchange, so more water is transpired, more stomata close at night. Stomata open for photosynthesis - to get oxygen out and carbon dioxide in.

ResultsPlus
Examiner Comments

This response scored mp2 only, for stomata closing at night.

They describe the shape of the graph without explaining at the start. When they begin to explain on line 3, there are no links to changes in temperature or light intensity, so no further marks.

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

(3)

- Rate of transpiration increases and peaks at 13 hours then decreases.
- This is because from 5-13 hours the sun is out therefore as the sun rises light intensity increase so more stomata open
- Since more stomata are open the rate of transpiration as increases as there are more points for transpiration to occur.
- 13-21 hours stomata close as the sun sets so, the rate of transpiration decreases.

ResultsPlus
Examiner Comments

This response scored one mark; mp1 on lines 1-4 (rate of transpiration increases... from 5-13 hours... light intensity increases).

Not mp4 as although they say that transpiration peaks at 13 hours they do not explain why.

Not mp5 because although they say transpiration decreases from 13-21 hours, they link this to the sun setting.

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

(3)

Thrs shape is a bell shaped curve as it has an optimum at 13 hrs and has two low points either end at 21 hr and 5hr. As the time reached 5hr the transpiration rate shot from 25 gm^{-2} $hour^{-1}$ to 225 gm^{-2} $hour^{-1}$ in 8 hours. it then fell from 225 gm^{-2} $hour^{-1}$ to 12 gm^{-2} $hour^{-1}$ in 8 hours showing nearly a perfect bell shaped curve and a rising limb from 5hr - 13 hr and a falling limb at 13 hr to 21 hr.

ResultsPlus
Examiner Comments

This candidate scored zero for a description of the graph without any attempt at explanation.

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

(3)

Between 0-5 hours it is dark so most of the Stomata are closed due to lack of light so need for ~~gas exchange~~ large amount of gas exchange for photosynthesis, only needed for respiration. Between 5-13 hours, ~~high~~ light intensity increases and so is temperature, as it is daytime, ~~so high temp~~ so Stomata open and high rate of photosynthesis and transpiration. At 13 hours is the peak transpiration, as it also when light intensity is at its highest so most ~~photo~~ Stomata open. After 13hours transpiration decreases as light intensity ~~decreased~~ so Stomata close a bit and lower temperature so less kinetic energy, so less transpiration. Reaches lowest at 21 hours when light intensity is lowest, so least Stomata open.

ResultsPlus
Examiner Comments

This answer scored three marks:

- mp 2 on lines 1-2
- not mp3 on lines 4-8 as no reference to increase in transpiration rate
- mp4 on lines 8-10
- not mp5 on lines 11-13 as they say after 15 hours (should be after 13 hours)
- mp1 on lines 14-15.

Question 9(c)

Candidates were given diagrams of two types of potometer and asked to evaluate which would be better to measure the rate of transpiration.

Potometer A was a classic Ganong's potometer which measured water uptake through the movement of a bubble along a capillary tube with a scale.

Potometer B was a mass potometer which measured water loss though the change in mass as it was positioned on an electronic balance.

There were six marking points for five marks; 23% of candidates scored zero on this, but around 65% scored one or two marks and 10% scored three marks. Higher scores were rare.

The most commonly seen marking points were mp1, mp3, mp4 and mp6.

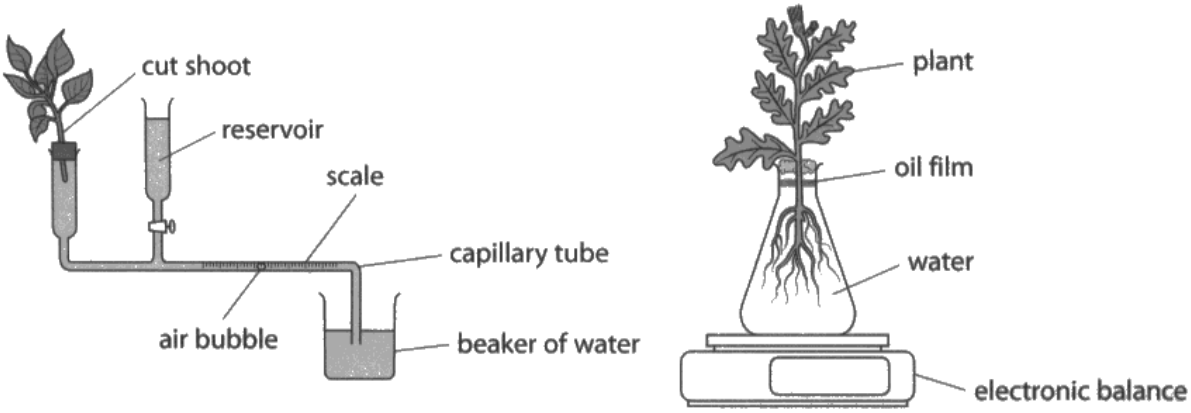
This question showed some common misconceptions:

- that the mass of the water lost would be too small to measure on the balance
- that the mass of water lost could not be converted to a volume, so potometer A must be better
- that the mass of gases lost (through respiration or photosynthesis) would make the results in potometer B invalid
- that the root in potometer B would get in the way, so A would be more accurate
- that the lack of an oil layer on the reservoir of potometer A made it less valid.

It was clear that some candidates had carried out an investigation with a potometer (usually type A), but some wrote about the difficulties of air bubbles in the shoot and the ability to reset the position of the bubble on the scale, without linking this to the measurement of the rate of transpiration.

This was a challenging question which discriminated well.

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



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

(5)

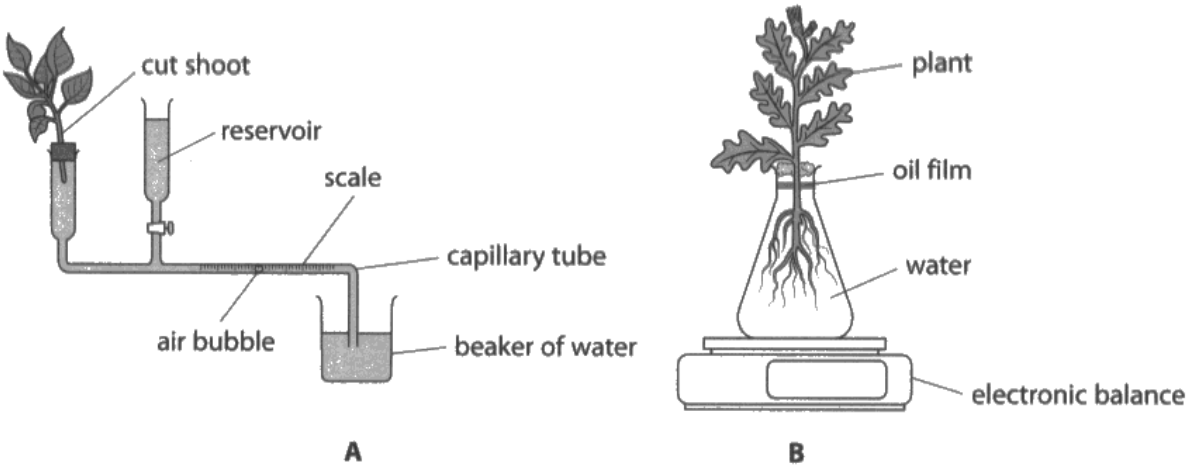
reservoir of water in bubble potometer A makes it ~~easy~~ easier to take repeat readings as the bubble can be reset. it also only requires the shoot of the plant whereas the man potometer B requires the whole plant. bubble potometer only accounts for water uptake, so doesn't directly measure water lost so transpiration not directly measured, ~~some~~ some water used e.g. in photosynthesis/turgidity whereas man potometer measures both water uptake & water lost. electronic balance may be more accurate than the scale for the distance moved by bubble as less human error involved. mass potometer is harder to take repeats as no 3-way tap oil film may not prevent all water evaporating from man potometer. bubble potometer you need to cut shoot underwater to prevent air bubble getting in, as air bubble disrupts transpiration stream, bubble potometer won't work. man potometer is better as it measures uptake & loss of water. cut shoot may not be sealed properly so water may evaporate.

ResultsPlus
Examiner Comments

This was a very strong answer showing understanding of the two types of potometer and the ability to recognise the strengths and weaknesses of each.

It was one of only three to score full marks on this question: * mp4 on lines 1-2 * mp3 on lines 2-4 mp1 on lines 4-5 * mp2 on line 6 * mp6 on lines 8-9 * mp3 again for the idea that air bubbles might disrupt the transpiration stream in Potometer A.

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



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

(5)

it could be argued that potometer B would be better due to having a more accurate reading scale. As A can be distorted by human error as it can be difficult to read and other can differ on what measurement it reads. Electronic scales offer a standardised unbias method, producing more reliable results. B can also be seen as better due to it containing the whole plant as in A only one shoot is used which could potentially be faulty. On the contrary using the whole plant doesn't allow for repeats as things like maturity, health of the plant could be different in repeats. Altering the reliability of results.

This is a thoughtful answer, which scored three of the five marks:

- mp6 on lines 3-5
- mp3 on lines 8-10
- mp4 converse at the end.

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

(5)

A uses the transpiration stream to pull the air bubble forward due to the cohesive forces of water while B measures mass lost due to water loss. A only measures transpiration while B may also include loss of glucose in respiration as CO_2 is also released. Difficult to stop air bubbles getting in near shoot even if petroleum jelly is used in A. B prevents evaporation of its water using oil layer but A does not as water can evaporate from beaker.

ResultsPlus
Examiner Comments

This answer scored one mark only, mp1 on lines 3-4.

It came close to mp3 in the comment about bubbles in the shoot, but did not link this to changes in water uptake.

The comment at the end about the oil layer in Potometer B, and the reservoir without an oil layer in Potometer A did not gain credit, as the reservoir did not need an oil layer.

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

(5)

- both parameters can be used to measure transpiration
- potometer A measures distance of bubble moved whereas potometer B measures mass of water lost
- potometer B is likely less accurate, as water in small amounts will have a low mass, therefore the electronic balance may not detect small changes
- potometer A is likely more accurate as we can see and record any movement of air bubble on the scale.
- potometer A can also be reset using the reservoir, therefore potometer A is likely better and more accurate in measuring rate of transpiration

ResultsPlus
Examiner Comments

This answer scored one mark only, mp1 on lines 4-5.

They came close to mp4 at the end, but did not explain the advantage of it being able to be reset, ie that repeats can be done more easily.

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

(5)

potometer A would be better to measure the rate of transpiration.

ResultsPlus
Examiner Comments

This candidate did not provide any evidence to back up their decision, so no marks.

Question 9(d)(i)

Q09(d) tested knowledge of the movement of sugar from the leaves to the roots of a plant.

In Q09(d)(i) candidates were shown an investigation where a single leaf of a plant was supplied with carbon dioxide containing the radioisotope ^{14}C. They were told that the stem of the plant was cut after a few hours and the cut section was placed on a photographic film, where any radioactivity would cause darkening of the film.

They were asked to shade a labelled diagram of a section through the stem, to show which areas would be darker.

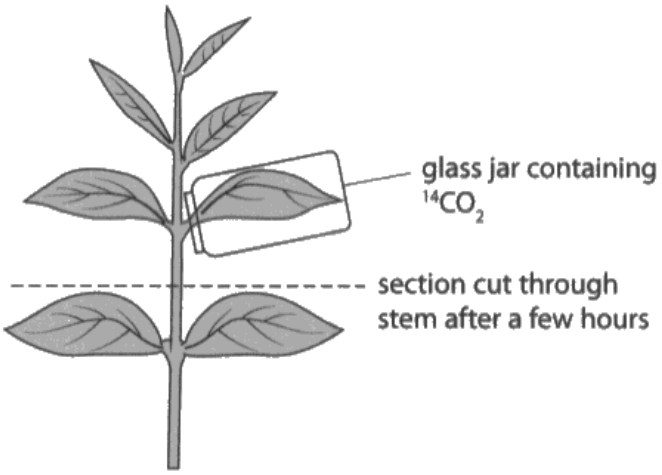
This was very well done, with over 90% of candidates shading the phloem and nothing else.

Candidates who did not score shaded the xylem, the cortex or the whole section. A number left this blank.

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

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

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

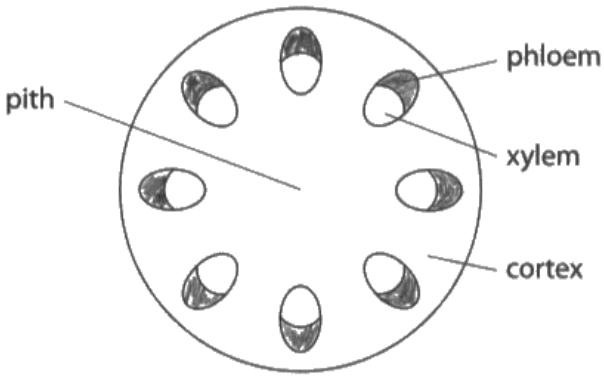


The sugar produced by photosynthesis in this leaf is radioactive.

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

Structures containing radioactive material will cause darkening of the film.

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



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

(1)

ResultsPlus
Examiner Comments

This is what we were hoping to see for one mark.

Question 9(d)(ii)

Candidates were asked to name the radioactive sugar which caused the darkening on the film.

Around 60% were able to correctly name sucrose. The most common wrong answer was glucose, although a variety of other compounds were named including starch, maltose, fructose and carbon monoxide.

Question 10(a)

Q10 tested candidates' understanding of in-situ conservation and human influences on ecosystems in marine habitats.

Q10(a) gave candidates information about legal protection for coastal areas around the UK and asked them to comment on the benefits and difficulties of in-situ conservation in coastal and marine sites. We were looking for benefits and difficulties specific to these sites, not a generalised list. Some candidates found it easier to recognise the specific difficulties, rather than the benefits.

The mark scheme can be summarised as:

1. prevents habitat loss / prevents **named** damage to habitat. We did not accept protects the habitat, as this was given in the stem of the question
2. maintains food chains
3. (stay in own habitat so) does not affect behaviour / less vulnerable to disease
4. increased education / public awareness
5. animals may migrate in and out of protected areas
6. some commercial or leisure activities prevented
7. people may break the law / difficult to enforce the law
8. difficult to monitor species over a large area.

We ignored the idea of cost, as it would be impossible for candidates to quantify this.

This question was generally well done, with over half of candidates gaining at least two marks. MP3, 6 and 7 were most commonly seen. The main problem was responses which were too vague at this level. A small number of candidates confused in-situ conservation with ex-situ conservation, and wrote about the benefits and difficulties of keeping marine organisms in tanks.

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

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

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

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

This is an example of in-situ conservation.

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

(4)

The benefits of in situ conservation is that species that are being conservated are able to stay in their natural habitats. This allows much less disruption to occur to these species. Additionally, in-situ conservation avoids effects of zoos or wildlife parks on the species, like domestication, so they can live how they naturally would. On the other hand, ex-situ conservation can be better than in-situ as it allows conservation experts to have more control over the species they are attempting to conserve. In situ conservation may not protect the species completely, for example fishing and forms of poaching could still take place.

ResultsPlus
Examiner Comments

This response scores two marks:

- mp3 for the idea that it "avoids the effects of domestication so they can live how they naturally would". The comment on "less disruption" was not enough for mp3.
- mp7 for the idea that the species may not be completely protected, eg poaching could still take place. Without the example this marking point would not have been achieved.

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

(4)

Benefits
- Allows the animals to continue living in their habitat
- Does not disrupt the ecosystem

Difficulties
- Expensive
- Hard to ~~manage~~ manage

ResultsPlus
Examiner Comments

While all four of these comments were true, there was not enough detail in any of them for credit.

They did not suggest why it was an advantage for the animals to remain in their habitat, or how the ecosystem was not disrupted, eg by food chains being maintained.

With further information on each point, this answer could have gained three marks.

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

(4)

Benefit of in-situ conservation = stay in their local habitat. This a benefit as it means they have perfect living conditions. This is a benefit as it is a lot cheaper for UK, as it would cost a lot to build and research how to build the same conditions ex-situ.

A difficulty is it is harder to conserve the habitats, as there are 370, this is a difficulty as ~~harder~~ although they ~~are~~ have put regulations to stop humans damaging. No way to stop predators like birds coming into coastal habitats and eating fish. This makes it difficult to conserve in-situ, as keeping species in such a large area = hard to protect all of them from predators like birds.

ResultsPlus Examiner Comments

This response scored zero. The first section (on benefits) contained two main ideas:

- that it was better for organisms to stay in their own habitat because they had perfect living conditions. This was too vague to gain credit
- that it was cheaper than ex-situ conservation; however, the mark scheme made no reference to costs.

The second section (on difficulties) focused mainly on the problems of things being eaten by their natural predators, eg birds eating fish. It is not the role of the MCZ to prevent this happening.

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

(4)

Benefits:

- Creatures have access to natural food sources
- Food chain maintained
- Biodiversity levels maintained.
- Species are not trapped in small enclosures

Difficulties:

- Hard to keep track of species numbers and impossible to help injured species
- Can damage the economy of coastal towns which rely on fishing and marine tourism for money.
- Disease may become an issue
- No breeding programme
- People ignore the regulations

ResultsPlus
Examiner Comments

This well-organised answer gained full marks:

- mp2 for food chains maintained
- mp8 for hard to keep track of species numbers
- mp6 for may damage the economy of coastal towns which rely on fishing
- mp7 for people may ignore the regulations.

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

(4)

benefits:

The animals are not humanised and their behaviour does not change due to human interferance. Ecosystems are protected as ~~as~~ if you remove animals for ex-situ conservation, then food webs can be affected and plants ~~and~~ & pop populations may ~~felt~~ be affected.

difficulties:

The animals are not bound to ~~boarders~~ boarders and they migrate in and out of the protected sites - so there is no guarantee of their saftey. Some damage can still be made ie. illegal fishing, not everyone will still ~~follow the~~ & follow the & law.

ResultsPlus
Examiner Comments

This strong answer achieved full marks:

- mp3 for the idea that behaviour does not change
- mp2 for food webs not being affected
- mp5 for animals migrating in and out of protected sites
- mp7 for illegal fishing and people not following the law.

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

(4)

Benefits: The organisms are in their habitat, therefore it's easier for them to mate and breed. For organism it would be less stressful than kept in tanks.

Difficulties: The marine / coastal organism moves around so if they go outside UK protected area, they are no longer protected. Fisher men may loose their jobs or their income may decrease. Because organisms aren't kept in the tank, it will be harder to monitor the organisms.

ResultsPlus
Examiner Comments

Another strong answer achieving full marks:

- mp1 for less stressful than being kept in tanks
- mp5 for the idea of migrating out of protected areas
- mp6 for the idea of fishermen losing jobs or income
- mp8 for harder to monitor because they are not kept in tanks.

Question 10(b)

Candidates were given information about the importance of seagrass meadows as a habitat, and about a pilot study to plant seagrass meadows off the coast of Wales. There was no credit for copying information from the stem, but credit was given when candidates commented on this, or expanded on it.

The mark scheme contained indicative points in three main areas:

- **E points (general effects of seagrass meadows)** eg carbon storage, protection from coastal erosion, role in food chain, role in protection of commercial fishing, role in maintaining biodiversity, ie supporting a range of species (not just fish), production of oxygen and reduction in ocean acidity;
- **B points (benefits of pilot study)** eg **general benefits**, eg small scale to study effects, contributes to knowledge and research, seagrass is declining very fast so action is needed, increased local biodiversity; and **benefits specific to this study** eg details of method (biodegradable bags, rope pegged to sea floor, bags contain sediment with minerals), should legally protect this newly planted area, uses seeds from UK sites;
- **P points (problems with the pilot study)** eg **general problems** eg factors causing decline of seagrass still exist, existing meadows should be protected by law; and **problems specific to this study**, eg a very small area was planted, seeds were removed from other UK sites and this may damage existing sites, collecting seeds by hand is very time-consuming, very low germination rate, germination takes a long time and there is no long term data on success rate, details of method (pegged-down rope may harm organisms living on the sea bed, bags of seeds may be eaten by fish).

No prior knowledge of seagrass was assumed, but the information given allowed candidates to draw in other areas of the A level specification, and their wider knowledge. This was an opportunity to assess the impact of a project on a real situation, and to bring together a reasoned evaluation. It was pleasing to see so many candidates doing well on this, and almost 70% reached level 2 or above.

The biggest problems were:

- candidates who copied information from the stem and did not comment on it – this did not gain credit
- candidates who wrote only about E points and therefore confined themselves to level 1. Generally, candidates found it easier to write about the E points, perhaps because so many pointers were given in the stem of the question
- candidates who had a header "importance of the pilot project" but then went on to make general E points; these were credited as E points, but it meant than they had not made points about the pilot project and therefore limited which level they could achieve.

Indicative content E1, E4, E5a, E5b, B8, B9, P1, P5a, P5b, P7 and P8 were seen most often, but all indicative content points were seen. Around 26% of candidates achieved level 3, and they produced some excellent, thoughtful answers.

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

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

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

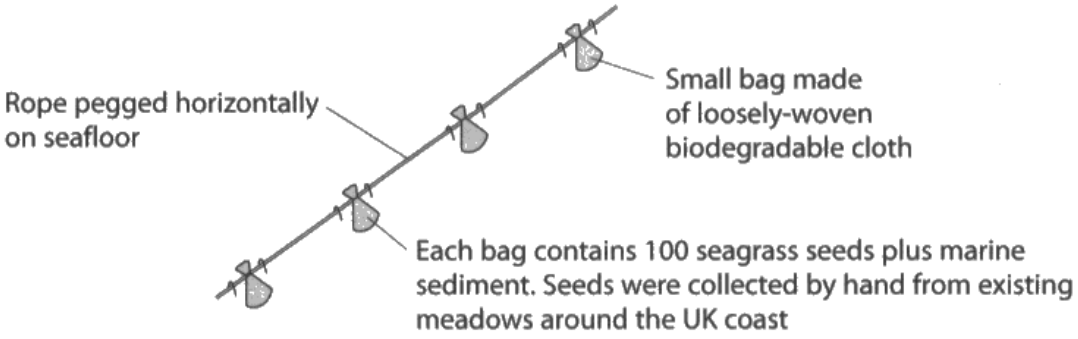
These losses are due to water pollution, damage from fishing, dredging and building ports.

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

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

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

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



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

(9)

seagrass are one of the world's most threatened habitats it is important as it can store at least 0·5 tonnes of carbon per hectare per year this helps to decrease the effects of global warming so it should be protected but only 26% are within Marine protected Areas around 7% of seagrass meadows are lost each year due to water pollution, damage from fishing, dredging and building ports therefore it is mainly due to human activity that seagrass meadows are depleting. It is even more important as they protect the coastline from wave erosion and provide food and shelter for young fish including cod. which is good for the commercial surplus of cod as they are able to grow to an age that they can reproduce and contribute the amount of cod to be fished.

The pilot project plans to have small bags made of loosely-woven biodegradeable cloth and each bag contains 100 seagrass seeds plus marine sediment, the seeds are collected from existing meadows therefore are just replanting the bags are held by a rope pegged horizontally on the seafloor this allows the seagrass meadow to grow from the bags safely it is important that these grow as around the UK, 90% of the seagrass meadows have been lost and only

8,500 hectares remain. the pilot project plans to plant 2 hectares of seagrass meadow off the coast of wales.

ResultsPlus
Examiner Comments

This candidate spent a lot of time copying information from the stem without further comment, and no credit was given for this.

They commented on the general effects of seagrass (E points) and the benefits of the pilot project (B points) and scored two marks:

- E5a for the comments on fishing for cod, halfway down the first page.
- B9 at the bottom of the first page – the pilot project is important because so much seagrass has been lost.

This resulted in Level 1, two marks.

ResultsPlus
Examiner Tip

Don't just copy information from the stem, this will not gain marks. You should always make a comment on the information in the stem – expain why it is important, or why it is having that effect.

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

(9)

- Contributes to large proportion of carbon storage (10%) → loss of this habitat would cause lots of carbon to be released into atmosphere, increasing global warming
- Although it's a large proportion, potentially not large enough to ~~have~~ cause significant damage to the Earth as there are many other forms of carbon storage
- Important habitat for wildlife + prevents coastline erosion. Reduction in seagrass causes ~~many~~ many losses of habitats, reducing biodiversity, potentially causing species to go extinct. Same for coastline habitats protected from erosion by seagrass.

- Large loss in seagrass that could significantly affect points above. 7% being lost each year is very high
- Most threatened habitat, pilot project very important to protect what's left
- Pilot ~~study~~ project may not be useful as it does not solve the problem. Must tackle issues of water pollution, fishing damage, dredging and building ports as this is the main cause

of loss of seagrass as a habitat. Planting new seeds doesn't get rid of main cause of loss of seagrass.
- Planting seagrass can counter the loss. Even if it's being lost, planting may counter balance this loss.
- Planting can have economic benefits. Seagrass habitats is also a habitat for ~~eco~~ commercially imported fishes, which could be sold

ResultsPlus
Examiner Comments

This response scored Level 2, four marks.

They commented on the general effects of seagrass (E points), the benefits of the pilot project (B points) and the problems (P points).

They scored as follows:

- E1 in their first bullet pointed section
- E4 for the comments on preventing coastal erosion and protecting coastal habitats
- B9 for the importance of the pilot project
- P7 for the idea that the things causing decline of seagrass have not changed.

Not quite enough for E5a at the end.

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

(9)

The Sea grass meadows protect coastline from erosion and without this then erosion will be more rapid with farm land being reduced so less crops being made - less room for cattle so less food for people Could lead to food shortages in areas and farmers making less profit due to less land as its been eroded as less Seagrass to protect from erosion. Sea grass provide food and shelter for young fish and around the UK 90% of Seagrass has been lost so young fish will be unable to survive as well due to food not being available and no shelter so they're eaten by predators or just die due to no habitat. This means less fish in the Sea so less food for food source so again could lead to food shortages. Stores 10% of the oceans carbon and if destroyed it will contribute more to global warming as more CO_2 will be released into the earths atmosphere, polluting the earth more.

Pilot project is important to maintain biodiversity of fish and reduce carbon emissions as the Sea grass is food/shelter for young fish and without Sea grass they may be unable to survive and Seagrass can store 0.5 tons of carbon per hectare per year So by the pilot project increasing seagrass - it will absorb more carbon and reduce emmissions

ResultsPlus
Examiner Comments

This response scored Level 1, three marks.

It included general effects of seagrass and achieved the following points:

- E4 for the comments on coastal erosion, E1 and E5a.

Although they had a section starting "Pilot project is important ..." the points they made here were the general benefits of seagrass and not specific to the project, so these did not gain credit as B points.

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

(9)

Seagrass is a very important part of costal habitats, & providing food and shelter to young fish like cod which humans fish to sell making as they are largely in demand. This increases the economy giving making this a positive for positive for Seagrass.

It also stores 0.5 tonnes of carbon per hectare which is a positive as it removes carbon dioxide in the air is increasing due to humans impact like burning deforestation, burning fossil fules and more. Planting more hectare will have a benefit for the enviourment.

Though in the pilot project only 4% of the seeds will germinate after 8 months which is a small amount and may not be worth the cost of

ResultsPlus
Examiner Comments

This answer scored Level 1, three marks.

It included general effects of seagrass (E points) and problems with the pilot study (P points).

This candidate achieved E5a, for the comment on commercial fishing; and two P points for the comments on low germination rate and the idea that it may not be worth the cost.

They did not achieve E1 as although they recognised seagrass stores a lot of carbon (this

was in the stem), "a benefit for the environment" was too vague.

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

(9)

· seagrass meadows are very important. They are a habitat to fishes, increasing cod. The destruction of seagrass leads to there being less habitats for the fish. This means less fish will survive as they will get preyed on, so less reproduce. The population of young fish will decline. Also, less cod means less food for humans. Due to this, there will be an increase in fish farming, and more fishing will take place to find the cod. The damage from fishing will only worsen the loss of seagrass. The seagrass also acts as a source of food for fishes. This will disrupt the food chain, as seagrass are producers, there will be increased competion for the seagrass as food. Only 26% is protected, so 74% un protected.

The pilot project is important as it will increase the amount of seagrass grown. This means that there will be less decline of area covered by seagrass. Project will restore habitats, and also provide food to the other fishes. Other ways to prevent decline of seagrass is to reduce dredging + fishing + polluting water. The project contains biodegradable cloth, so the

means that the cloth must pause the water + have adverse effects. Increasing the area of seagrass will also help reduce carbon released. Carbon is stored in these plants, so releasing it would be bad for the environment. ~~H~~ ~~It~~ stores more than rainforest. this is more important to protect if we want to reduce carbon emissions. Carbon contributes to global warming. Rope is on sea floor so the seeds can grow on the floor. The sediment contain nutrients + minerals required for the plants to grow.

2 hectares may not be enough to prevent all the damage and loses caused. The project is important and should be carried out with more seeds, and more planting sites. Also, only 4% germinate- no data given on survival of the plants grown. No information given on how to the other planting methods.

ResultsPlus
Examiner Comments

This answer scored Level 3, nine marks.

It contained general effects (E points), benefits of the pilot study (B points) and problems (P points), as follows:

First page

Comments on E5a (commercial fishing), E5b (food chains), P7 (problems causing the decline

are still there)

Second page

Comments on B8a (method - biodegradable bags), E1 (climate change), B8b (method - sediment containing minerals), P1 (only 2 hectares), P5a (low germination rate), P5b (no long term data).

So, nine points overall, 3xE, 2xB, 4xP. This meets the criteria for nine marks.

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

(9)

seagrass is important because it acts as a significant carbon sink, storing more than a tropical rainforest. It must be particularly effective at photosynthesis, taking in and sequestering a lot of CO_2. This is important because high CO_2 concentrations put all marine ecosystems worldwide at risk. If there is a high atmospheric CO_2 concentration, it will act as a greenhouse gas, enhancing the greenhouse effect and global warming by ~~reflecting infrared~~ radiating infrared radiation back towards earth. CO_2 will also dissolve in the oceans, decreasing the water pH and causing ocean acidification. Global warming and ocean acidification have a significant risk for both marine animals and plants, causing death and impacting ecosystems. Seagrass helps reduce this risk. Seagrass is further important because it supports local marine ecosystems by providing both food and shelter. It acts as a producer in food webs, capturing energy from the sun and passing it onto primary consumers, thus supporting entire food webs. It also allows young fish to hide and evade predators. As such, if the numbers of seagrass decrease, the numbers of cod will decrease too as they are more likely to get caught and have less food. This then goes on to affect any other species that eat cod, as they lose their food source, and the entire fishing industry who rely on cod exports for money. Additionally, seagrass meadows can reduce coastal erosion. They do this by breaking the high impact waves, decreasing the energy the waves have when they hit the coast. Coastal erosion can have huge impacts on terrestrial ecosystems and people nearby in certain places, so seagrass help protect these. Finally, seagrass also provide biodiversity and genetic variation.

the pilot project is important because there is very little protection of seagrass

meadows worldwide, with less than 2% in MPA. This means they are very at risk and any conservation methods will have a large positive influence. Furthermore, seagrass has experienced a severe population bottleneck, so some form of protection is undeniably needed. The project is effective because it aims to plant more seagrass seeds across a relatively large area. However, the planting of more seeds has been very slow, as it takes time to set up, and then many months for them to germinate. Very few even germinate in the first place, with the most success being just 4%. The project is also on a very limited area, only 2 hectares, when there are 8500 hectares of seagrass around the UK after the population bottlenecks, and loss of seagrass is a worldwide issue, but the project is just off the coast of Wales. Therefore, the project has very little positive influence on such a small scale and with such low germination rates. The biggest issue with the project is that it doesn't attempt to prevent the reason the seagrass are threatened in the first place. It doesn't limit fishing, prevent port construction or reduce pollution, so even if new seagrass do manage to grow, they will still be just as at risk from the stated selection pressures. The root cause needs to be dealt with before recovery of seagrass numbers can take place.

ResultsPlus
Examiner Comments

This very strong answer scored Level 3, 8 marks, as follows.

On the first page

E1 for comments on climate change, E2 for ocean acidification, E5b for the importance in maintaining food webs, E5a for commercial fishing, E4 for coastal erosion.

On the second page

B9 for the importance of the pilot project, and several problems related to the pilot project:

P5b, P5a, P1 and P7.

The answer covered general effects (E points), benefits of the pilot study (B points) and problems of the pilot study (P points), so was a level 3 answer.

There were 10 points overall: 5xE points, 1xB point and 4xP points. It was limited to 8 marks, as the requirement for 9 marks was at least two each from B and P.

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

(9)

Importance of seagrass :

- seagrass acts as a ~~car~~ powerful and effective carbon sink which stores 10% of carbon in the ocean.
- this means if ~~se~~ seagrass population declines further, we will lose carbon sinks, so atmospheric level of carbon dioxide will increase.
- since carbon dioxide is a greenhouse gas, ~~it~~ ~~the~~ the greenhouse effect will worsen (become stronger), which ~~to~~ contributes to and accelerate global warming
- It ~~Seag~~ is a more powerful carbon sink than a tropical rainforest. so it should be prioritized in conservation.
- they protect the coastline ~~to~~ from wave erosion, allowing the soil at the ~~coa~~ coast to remain stable and allows more plant species to be established, there increasing ~~nic~~ niches, thus increasing biodiversity
- allows succession to occur and develop into climax community.
- It provides food and shelter for young fish, so it acts as an important ~~autotroph~~ producer in the food chain ~~and plays a role~~
- If seagrass population declines, there will be less food source for ~~small~~ young fish, (and less shelter, so they are more easily eaten and seen by predators) so ~~small~~ fish population will decline, so ~~the~~ population of its predators will decline too. therefore biodiversity decreases.
- ~~reducing~~ also the light energy harnessed from sun by seagrass decreases, leading to less energy in the food chain, so all species population decreases.

also ~~It does~~ the food web and ecosystem is destabilized ~~as~~ due to rapid decline in population of seagrass

- So lots of young fish don't reach maturity.
- population of commercially important species decreases. So ~~fishing~~ fishing boats catch fewer fish and may negatively affect the income of fishermen

threats to seagrass population:

- only 26% of seagrass meadows are within marine protected areas, which is ~~very~~ too low and ~~it needs to be~~ more meadows need to be protected to conserve seagrass population and biodiversity
- decline in seagrass population ~~over~~ is about 7% each year, which is rapid soon ~~area~~ seagrass will become threatened / endangered
- so water pollution must be controlled (e.g. policies regulating the contents of sewage ~~to~~ / process of sewage treatment from factories e.g.)
- ~~by~~ overfishing must be controlled (e.g. seasonal ban ~~of~~ on fishing introduced, regulating the size of fishing ships, and the waste oil released by ships when ~~to~~ fishing)
- build fewer ports, or use more sustainable building practices

Importance of project:

- it plants seagrass, increasing its population, thus increasing biodiversity and ~~conserves~~ slows down global warming.
- 2 hectares of sea grass is insignificant compared to 8500 in the UK
- planting it off the coast can ~~to~~ help prevent wave erosion.
- % of seeds that germinate is only 4% which is low, and it takes a long time to germinate (8 months) so the effect is slow.
- using biodegradable cloth avoids polluting / harming the environment since it can be broken down by bacteria
- seeds collected by hand is slow. more funding is needed for research for better methods of planting seagrass.

(Total for Question 10 = 13 marks)

ResultsPlus
Examiner Comments

ResultsPlus
Examiner Tip

This very strong answer scored Level 3, 9 marks. It included general effects of seagrass (E points), benefits of the pilot project (B points) and problems with the pilot project (P points), as follows:

First page

Comments on E1 (climate change), E4 (coastal erosion), E5b (food chains), E6 (biodiversity)

Second page

Comments on E5a (commercial fishing), P9 (protection of existing meadows), P7 (factors causing decline still remain), B5 (local biodiversity), P1 (small area), P5a (low germination rate), P5b (long time to have an effect), B8a (biodegradable bags), P6 (time-consuming to collect seeds).

Overall there were 13 points: 5xE points, 2xB points, 6xP points. This met the criteria for 9 marks.

Question 11(a)(i)

Q11 tested candidates' understanding of microbial techniques, including Core Practical 12: investigate the rate of growth of bacteria in liquid culture.

Q11(a) gave candidates information about bacteria grown in liquid culture, which were then counted by serial dilution and plating. A diagram set out a dilution series, and candidates were told how many colonies were counted on each plate. They were also reminded that each colony represented a single bacterium in the original culture.

The mark scheme allowed them to use tubes C, D or E to calculate the number of bacteria, or a mean taken from two or three of these.

Responses to this question were very mixed. Around 35% scored at least one mark; many more knew how to carry out the calculation, even if they made errors as they were doing it. However, some candidates were unsure how to deal with this.

Some candidates forgot that $0.5cm^3$ was taken from the final culture to be plated, and so ended up with an answer half of what it should have been. They could still score mp1.

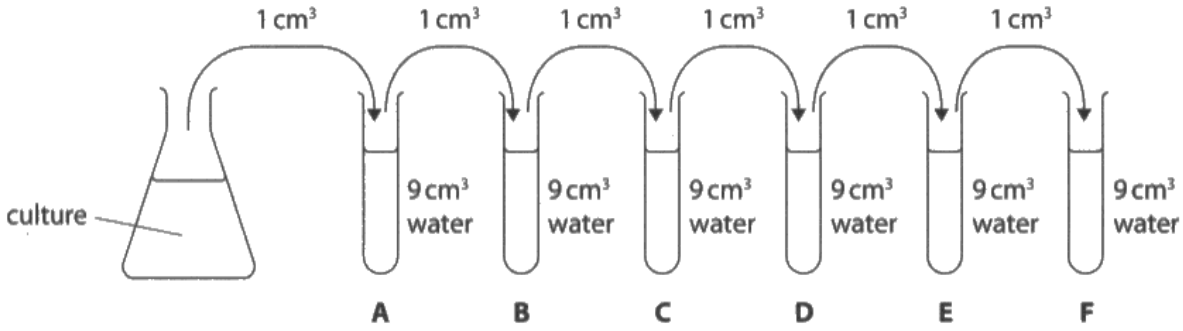
Quite a few candidates obtained an answer which was a factor of 10 out (almost always low); they should be encouraged to use any scaffolding which is provided for them in the question. Here there was a partially completed row in the table to help them to calculate the dilution factor for each tube, but many ignored it.

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

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

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

The diagram shows the dilution series used.



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

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

Each colony represents a single bacterium in the original culture.

The table shows the results obtained.

Tube	A	B	C	D	E	F
Number of colonies on agar plate	*	*	126	13	1	0
Serial dilution factor	1 in 10	1 in 100	1 in 1000	1 in 10000	1 in 100...	

* = too many colonies to count

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

Give your answer in **standard form**.

(2)

Using Tube D ⇒ 13 colonies in 0.5 cm^3.

26 colonies in 1 cm^3.

D is diluted by a factor of 10,000

undiluted: $26 \times 10,000 = 260,000$ original bacteria.

Answer 2.6×10^5 per cm^3

ResultsPlus
Examiner Comments

This candidate used the row in the table on page 1 to calculate how much each tube had been diluted.

They decided to work with tube D, and noted there were 13 colonies from 0.5cm^3 of culture, so 26 from 1cm^3.

They noted that it had been diluted by a factor of 10,000.

They used the fact that each colony represents a single bacterium to obtain a value of 260,000 bacteria.

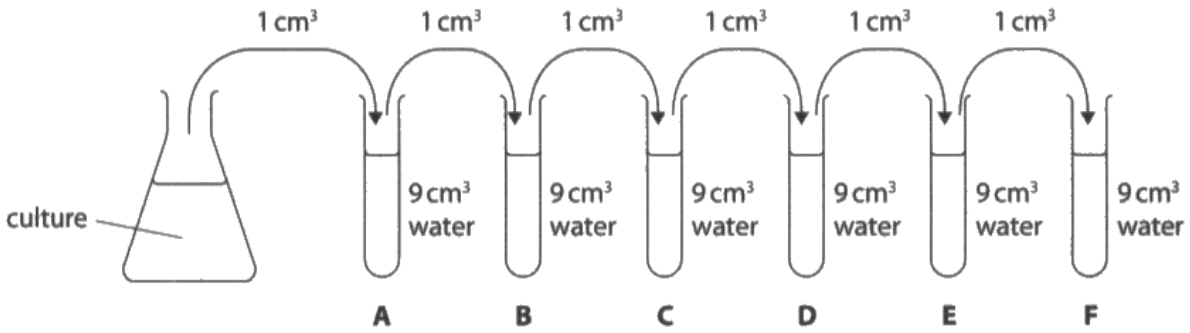
They then correctly converted this to standard form for two marks.

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

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

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

The diagram shows the dilution series used.



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

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

Each colony represents a single bacterium in the original culture.

The table shows the results obtained.

Tube	A	B	C	D	E	F
Number of colonies on agar plate	*	*	126	13	1	0
Serial dilution factor	1 in 10	1 in 100	1 in 1000			

* = too many colonies to count

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

Give your answer in **standard form**.

(2)

1 in 0.0001 cm²

120 x 1000

= 120000

D: 0.0001

13 x 10000

= 130000

$= 1.3 \times 10^5$

Answer 1.3×10^5 per cm^3

ResultsPlus
Examiner Comments

This candidate also completed at least part of the table on page 1 and chose to work with the data from tube D.

Their calculation was correct, but they forgot that $0.5cm^3$ of the final tube was taken and added to the plate, so they should have doubled their final answer.

This scored mp1 only.

ResultsPlus
Examiner Tip

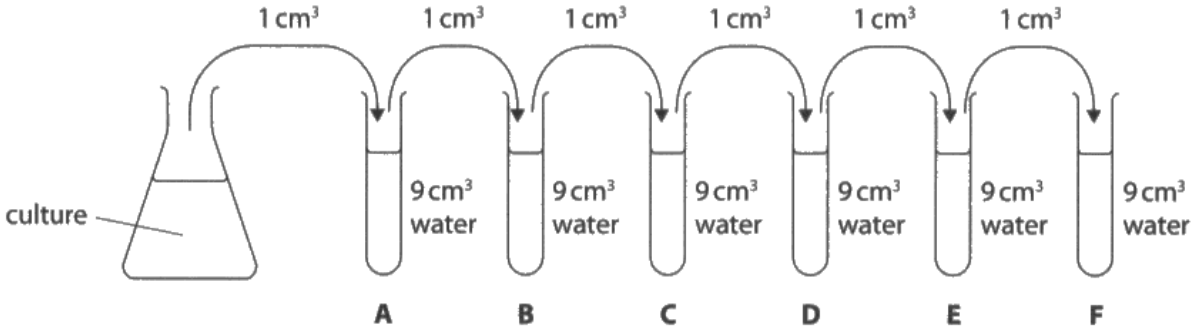
In a multi-step process like this, check your final answer by looking back at the diagram and make sure you have considered all the steps.

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

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

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

The diagram shows the dilution series used.



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

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

Each colony represents a single bacterium in the original culture.

The table shows the results obtained.

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

* = too many colonies to count

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

Give your answer in **standard form**.

(2)

13 in D ($0.5cm^3$)

D has dilution factor of 1 in 1000

∴ 13000 bacteria in $0.5cm^3$

∴ 26000 bacteria per cm^3

or 2.6×10^4

2.6×10^4

Answer 26000 per cm^3

ResultsPlus
Examiner Comments

This candidate did not complete the table on page 1 and they also chose to work with the data from tube D.

Unfortunately, they did not correctly calculate the dilution factor.

They remembered that $0.5cm^3$ of the final tube was taken, and doubled their answer, and gave the final answer in standard form. However it was a factor of 10 out, so they scored zero.

ResultsPlus
Examiner Tip

If you are given a row in a table to complete, it will help you with the calculation.

It is always worth doing this, even if there are no marks for filling it in.

Question 11(a)(ii)

Candidates were given a typical population growth curve for bacteria (where Log_{10} number of bacteria was plotted against time) and asked to explain the shape of the graph.

For each of the four growth phases, we wanted to see **three pieces of information**:

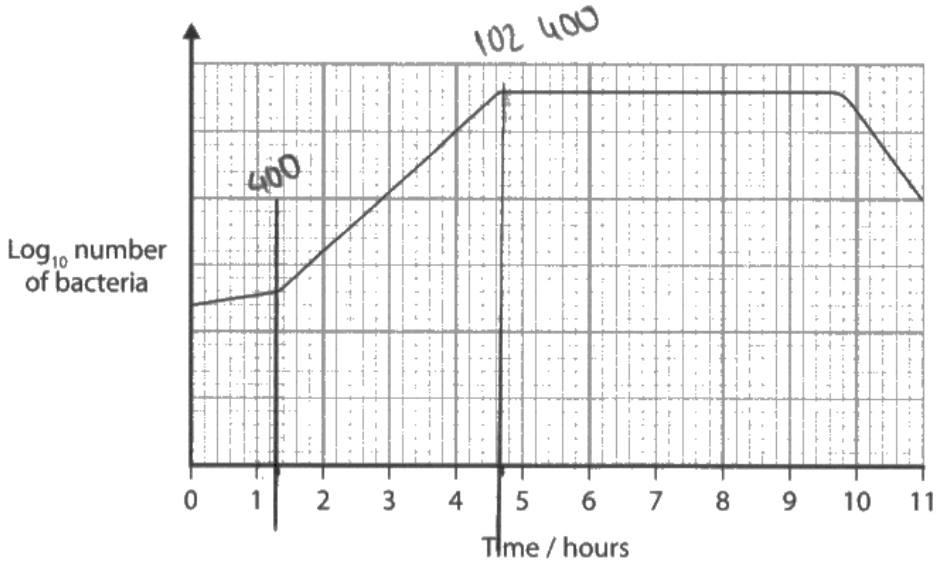
- the name of the phase, or the time it was taking place eg lag phase / 0 to 1.3 hours
- what was hapenening, eg slight increase / slow increase / very little change in numbers of bacteria
- why it was happening, eg bacteria are adjusting to conditions.

This proved very challenging for many candidates. The main problems were that:

- some candidates had difficulty reading the times off the graph (a similar problem to those encountered in Q09(b)(ii)); here it was not such a problem, as they could name the phase instead of giving times
- some candidates named the phase, but did not describe what was happening to the numbers of bacteria; for some reason this was particularly a problem in the death phase
- some candidates did not give a reason for the change in number of bacteria; this was particularly a problem in the log phase.

Many candidates started well and gained mp1, but then left out critical pieces of information in other phases. Mp1 and 4 were most commonly achieved. Overall almost 63% of candidates gained at least one mark. Four mark answers were rare.

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



lag
log
Sr
de

Explain the shape of this graph.

(4)

Bacteria growth curve.
Slight increase at start (lag phase), bacteria are acclimatising (adjusting) to environment. Rapid increase (log phase), reproduction is faster than death rate. Reproduce as have nutrients to do so. Stationary phase where reproduction rate = death rate, so number stays the same. There is limited resources + more competion between bacteria. Decrease at end is death / decline phase. Build up of waste and little nutrients for growth left. death rate faster than reproduction rate so bacteria number decreasing

ResultsPlus
Examiner Comments

This well-organised answer scored all four marks. In each case they identified the **name of the phase of growth**, stated **what was happening** eg slight increase, rapid increase, etc

and gave a reason to explain **why** it was happening.

Explain the shape of this graph.

(4)

this graph begins with a very small rate of increase untill 1.5 hrs it then increases the rate of increase a lot and the gradient becomes steeper on this rising limb from 1.5hrs to 4.6hrs the graph then carries on to a stationary section from time 4.6 hrs to 9.8 hrs at a certain amount of bacteria. there then is a falling limb with a negative steep gradient from time 9.8 hrs to 11hrs (the end) the graph line ends higher than were it started from.

ResultsPlus
Examiner Comments

This candidate scored zero. They did not name any of the phases, and their timings read from the graph were not always accurate.

However, the biggest problem was that they simply described the shape of the graph and did not attempt to explain it at all.

ResultsPlus
Examiner Tip

Read the command word carefully, and make sure you give the information that is required. Giving a description when an explanation is needed will lose marks.

Explain the shape of this graph.

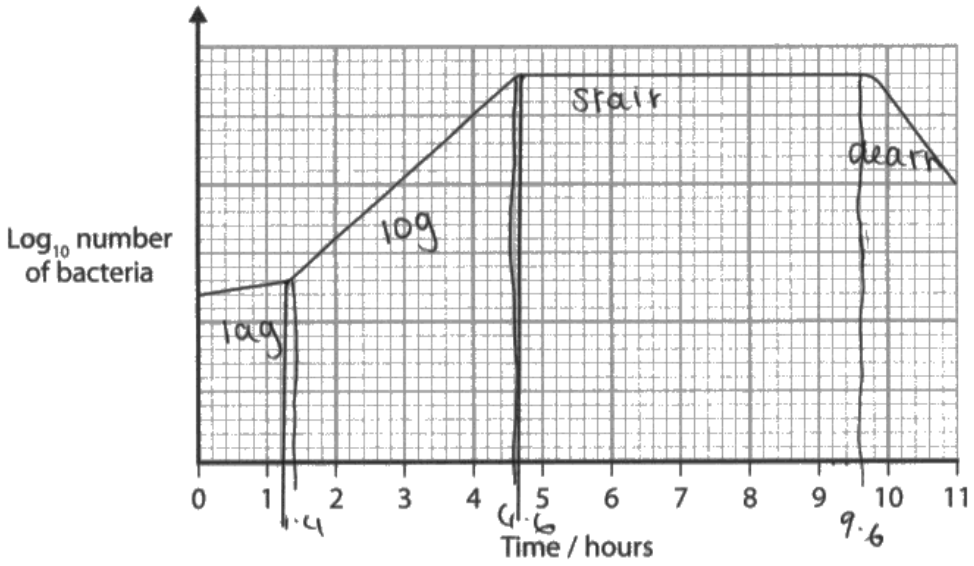
(4)

From 0 to 1.5 hours, the ~~increase~~ $\log_{10}$ number of bacteria increased slowly. Because it is the lag phase, where bacteria are adapting the environment. From 1.5 to 4.5 hours the $\log_{10}$ number of bacteria increased rapidly. Because it is the log phase (exponential phase). Where there's sufficient resources of food and space. So bacteria replicates ~~rapidly~~ rapidly. From 4.5 to 9.8 hours, the $\log_{10}$ number of bacteria remains constant. Because it is the stationary phase, where birth rate equal to death rate because of limited food resources and competition. At last ~~the~~ from 9.8 to 11 hours the number decreased because it is the death phase where rate of death is larger than rate of birth due to less resources and waste product built.

ResultsPlus
Examiner Comments

This candidate also scored four marks. A clear account of what is happening in each stage, and why.

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



Explain the shape of this graph.

(4)

- ~~Par~~ Represents the bacterial growth curve.
- lag phase (0 - 1·4 hours) bacteria is getting used to the conditions, so not much growth.
- log phase (1·4 - 4·6 hours) every division, bacteria doubles resulting in exponential growth.
- Stationary phase (4·6 - 9·6 hours); where dearth rare = reproduction rate
- Dearth phase (9·6 - 11 hours); where death occurs due to build up of toxic waste.

ResultsPlus
Examiner Comments

This response scored one mark, mp1 only. For this stage they named the phase, said what was happening (not much growth) and gave a reason (bacteria getting used to the conditions).

They attempted mp2 and 3, naming both of these phases and saying what was happening,

but did not give a reason for the change in number of bacteria.

For mp4 they named the phase and gave a reason (build up of toxic waste), but did not describe the change in number of bacteria (that it was decreasing).

Question 11(a)(iii-iv)

These were two linked questions.

In part (iii) candidates were asked to calculate the exponential growth rate constant, *k*, for the population growth curve in part (ii).

In part (iv) they were asked to use this to find the mean generation time, *g*.

In both cases, they were given the formula to use.

Candidates managed these questions very well, with over 55% gaining all three marks. Where marks were lost it was usually because they used the values 102 400 and 400, rather than the logs of these values, or because they rounded incorrectly.

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

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

The number of bacteria per cm^3 at the start of this period was 400 and the number 3.4 hours later was 102400.

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

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

Use the formula:

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

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

(2)

$$k = \frac{\log_{10} 102400 - \log_{10} 400}{0.301 \times 3.4}$$

$$= 2.353$$

Answer 2.35

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

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

(1)

$$2.35 = \frac{60}{g}$$

$$2.35g = 60$$

$$g = 25.53$$

Answer 25.53 minutes

ResultsPlus
Examiner Comments

Q11(a)(iii): This candidate calculated the correct value for *k* to 2dp for two marks.

Q11(a)(iv): They correctly used their answer to part (iii) to calculate the value of *g* as 25.53.

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

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

The number of bacteria per cm^3 at the start of this period was 400 and the number 3.4 hours later was 102400.

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

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

Use the formula:

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

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

(2)

$$\frac{102400 - 400}{0.301 \times 3.4}$$

$$= 9966$$

$$= 9966.78$$

Answer 9966.78

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

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

$$9966.78 = \frac{60}{g}$$

(1)

Answer 598006.6449 minutes

ResultsPlus
Examiner Comments

This candidate did not obtain the correct answer to part (iii).

Although it is difficult to tell from their working, the answer of 99667.8 is obtained if the values 102 400 and 400 are used, rather than the log values 5.01 and 2.6. This was a common error.

The answer to part (iii) was carried forward under ecf, so it was possible to obtain the mark for part (iv) if this calculation was carried out correctly.

However, an error was made in the part (iv) calculation, so this candidate scored zero for both parts.

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

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

The number of bacteria per cm^3 at the start of this period was 400 and the number 3.4 hours later was 102400.

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

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

Use the formula:

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

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

(2)

$$\frac{\log_{10}102400 - \log_{10}400}{0.301 \times 3.4}$$

$$= 0.039219594425$$

$$= 0.04$$

Answer 0.04

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

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

(1)

$$0.04 = \frac{60}{g} \qquad \frac{60}{0.04}$$

Answer 1500 minutes

ResultsPlus
Examiner Comments

This candidate made an error in part (iii) by using the value 204 in the denominator (instead of 3.4). Their answer to part (iii) was therefore wrong and scored zero.

It was carried forward to part (iv) under ecf and the part (iv) calculation was carried out correctly, so they scored one mark for this.

Question 11(b)

The previous parts of Q11 had all been about serial dilution and plating. Candidates were now told that measuring turbidity using a colorimeter was an alternative method to measure the growth of a bacterial population. They were asked to assess the advantages of each method.

Many candidates knew the features of the two methods and were able to compare them, for example:

- that turbidity was quick and serial dilution and plating took longer
- that serial dilution and plating counted only living bacteria, but turbidity counted living and dead
- that serial dilution and plating was a direct count, but turbidity required a calibration curve
- that errors were more likely to be made in serial dilution and plating
- that serial dilution and plating did not require expensive equipment but turbidity did.

This question **did not** require information about both methods for each point, as a "Compare and contrast" question would. **It asked for advantages for each method**.

Many candidates wrote about the disadvantages of the methods and, although they clearly knew the features of the two methods, lost marks because they did not answer the question.

Overall, 50% of candidates gained either one or two marks on this question, and around 30% did not score.

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

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

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

(4)

Using a colorimeter to measure turbidity reduces the chances of human error that may come from dilution plating and counting the bacteria by eye. Therefore, it is a more scientific technique. However, dilution plating may be better as dead and living bacteria can be differentiated between through staining. This is not the case with turbidity, the differentiation cannot happen.

ResultsPlus
Examiner Comments

This clear answer included two advantages and scored mp7 and 1.

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

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

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

(4)

Turbidity, Less likely for mistake,
Advantage: More reliable as you can't miscount like you probably will with the dilution plating.
- Can measure Turbidity to find Number of bacteria at higher concentrations.

Disadvantage: Expensive equipment

Dilution Plating
Advantage: More reliable as you actually count how many colonies are there.
Disadvantage: Slower / have to wait for bacteria to be cultured
- Culture could get contaminated

ResultsPlus
Examiner Comments

This answer contained several appropriate ideas: the potential for error, cost, the time it takes to collect results and the possibility of contamination.

However, only one of these was expressed as an advantage, so this answer scored one mark, mp7.

ResultsPlus
Examiner Tip

If the question asks for advantages, make sure this is what your answer gives – you will not

get marks for listing disadvantages.

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

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

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

(4)

- Turbidity is a quicker and easier method however it counts non-viable cells and assumes the distribution of cells is even which may not be the case further turbidity requires comparing absorbance values with a calibrated graph to obtain cell count however this will be different for different types and species of bacteria.
- dilution plating however only counts living cells and obtains a direct cell count however it is very time consuming as making stock dilutions and counting the cells is time consuming further dilution plating requires skill and knowledge as well as expensive equipment to carry out.
- however dilution plating may be a more accurate method at obtaining cell count

(Total for Question 11 = 13 marks)

TOTAL FOR PAPER = 120 MARKS

ResultsPlus
Examiner Comments

This candidate wrote a comprehensive answer which covered both advantages and disadvantages for both methods. The disadvantages were ignored, and they had given enough advantages to gain full marks:

- mp5 and 6 on line 1
- mp1 on line 8
- mp2 on line 9.

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

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

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

(4)

An advantage of turbidity is that it's faster as, unlike dilution plating, the time for incubation of the bacteria is not needed. An advantage of dilution plating is that a calibration curve using known concentrations doesn't need to be generated to measure growth whilst it does with turbidity. ~~An advantage of~~ turbidity is ~~that~~ it counts dead and living cells whilst dilution plating ~~be~~ only counts living so it's an advantage to do dilution plating to only show growth. An advantage of dilution plating is that it gives a direct cell count whilst turbidity gives an absorbance which needs to be ~~some~~ converted into concentration. An advantage of turbidimetry is that it's less prone to human error as stock solutions aren't made up like they are in dilution plating.

(Total for Question 11 = 13 marks)

TOTAL FOR PAPER = 120 MARKS

ResultsPlus
Examiner Comments

This was a very strong answer which gained full marks. The candidate stuck to the brief and described only advantages, but gave supporting comparative information about the

alternative method in each case.

The marking points achieved were:

- mp6 on lines 1-3
- mp2 on lines 3-6
- mp1 on lines 7-8
- mp7 on lines 12-15.

Paper Summary

Based on their performance in this paper, candidates should:

- Ensure that they are familiar with the command words used in this specification, and bear these in mind when answering questions.
- Make sure that they know the key points of all of the core practicals, and are able to modify these if needed to suit a new context, eg changing the concentration of mineral ions rather than changing the concentration of sucrose when investigating growth of a pollen tube.
- Get into the habit of considering the reasons for each step in a practical procedure, as this will help them to justify the steps when asked to do so.
- Identify where errors are likely to be made within a practical procedure, and what the effect of these errors would be.
- Take care when reading values from graphs, and always check the scale that has been used.
- Practise carrying out the mathematical procedures outlined in the specification, including conversion between different SI units, manipulation of a dilution series, calculation of the test value and analysis of stats tests.
- Always show their working in calculations, as marks are often available for interim steps, even if the final answer is wrong.
- When answering level-based questions take account of the information that is given in the stem (in text, diagrams, graphs etc) and use this to inform their answer. Marks are not available for simply copying from the stem, so they should comment on the information given and use their own knowledge to support this.

Grade boundaries

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