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June 2024

GCE Biology B 9BI0 03

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Introduction

There was a wide variety of questions on the paper covering aspects of AS and A2, and overall candidates did well. Questions were set on seven of the sixteen core practicals and many candidates were able to recall the methods followed, as well as being able to explain the reasons behind them. Where they were asked to devise a procedure linked to a core practical, many could write logical, well-structured accounts.

Several indirect practical skills were tested, including commenting on experimental design and evaluating methods, writing a null hypothesis, identifying variables to be controlled, plotting graphs, processing and analysing data and applying scientific knowledge to practical contexts. Overall, these were done well.

Generally, maths questions were done well, although some candidates lacked confidence and would benefit from more practise in several areas. These include making up dilutions of stock solutions, reducing a ratio to its simplest form, carrying out and analysing the results of stats tests and choosing an appropriate stats test.

There were some very strong answers to extended writing questions including the nine-mark levels-based question and some four-six mark questions, and candidates deserve credit for their ability to organise data and express themselves clearly. It was particularly pleasing to see candidates applying their scientific knowledge to real world data and situations.

It is clear that some of the advice given in the 2023 examiners report has been implemented and examiners commented on the quality of many of the answers. Centres are to be commended for the way they have prepared candidates for this exam, and candidates for the hard work they have done.

Question 1 (a)

Question 1 assessed understanding of Core Practical 3 – making a root tip squash to show the stages of mitosis in the meristem.

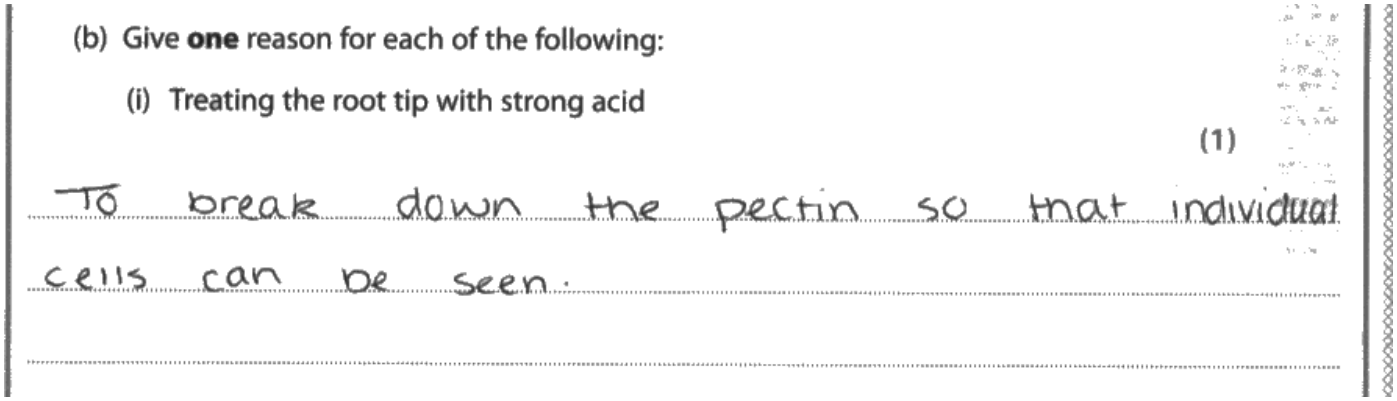
For Question 1(a), the majority of candidates were able to name the meristem as the region of the root tip where cells are actively dividing.

Question 1 (b)(i)

Question 1(b) asked candidates to give one reason for each of the steps in making a root tip squash.

A surprising number were unable to describe the reason for treating the root tip with strong acid. Credit was given for stating that the acid would break down the middle lamella or pectins, or that it would separate layers of cells.

The most commonly seen wrong answers were that it would break down the cell wall, that it would stop the process of mitosis or that it would clean the root tip.


(b) Give **one** reason for each of the following:

(i) Treating the root tip with strong acid

(1)

To break down the pectin so that individual cells can be seen.

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Examiner Comments

This answer scored 1 mark.

(b) Give **one** reason for each of the following:

(i) Treating the root tip with strong acid

(1)

Breaks down plant tissue and membranes so that the cells can be seen. Acid helps to start the mitosis process.

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Examiner Comments

This answer is too vague – "break down plant tissue" is not specific enough to gain credit.

ResultsPlus
Examiner Tip

When you are doing a practical in class, make sure you know the reasons for each of the steps in the process.

Question 1 (b)(ii)

Candidates were asked the reason for adding a stain to the root tip. The purpose of a root tip squash is to be able to see the chromosomes as the cells are dividing, so we were expecting to see this reflected in the answer.

(ii) Adding a stain to the root tip

(1)

to highlight organelles and chromosomes and make them visible.

ResultsPlus
Examiner Comments

This candidate understood that it was the chromosomes that would pick up the stain and become visible.

(ii) Adding a stain to the root tip

(1)

So that organelles can be seen

ResultsPlus
Examiner Comments

This answer did not gain credit as it did not state that the chromosomes would become visible.

(ii) Adding a stain to the root tip

(1)

To stain the chromosomes so that you can clearly tell which stage of mitosis each cell is in.

ResultsPlus
Examiner Comments

This is a strong answer which gained 1 mark.

Question 1 (b)(iii)

Candidates were asked to give a reason for pressing lightly on the coverslip; this part of the question proved more challenging for many candidates. The correct answer is to form a single layer of cells, or a thin layer of cells. Some answers were too vague, eg to spread out the cells, or so that the cells could be seen clearly. Other candidates focused on the need to avoid having air bubbles under the coverslip or to prevent the coverslip breaking.

(iii) Pressing lightly on the coverslip

(1)

To ensure theres one layer of cells, making it clear under a microscope.

ResultsPlus
Examiner Comments

This answer scored 1 mark.

(iii) Pressing lightly on the coverslip

So that cells can be seen

ResultsPlus
Examiner Comments

This answer was too vague and did not score.

(iii) Pressing lightly on the coverslip

To prevent any air bubbles from forming.

ResultsPlus
Examiner Comments

The main purpose of pressing down on the coverslip is to form a thin layer of cells, not to avoid air bubbles.

This answer did not score.

Spread the cells out into a single layer preventing formation of air bubbles.

ResultsPlus
Examiner Comments

Another correct answer which gained the mark.

Question 1 (c)

This question asked candidates to calculate the mitotic index from a drawing of cells in a root tip squash. The formula was provided, candidates were told that there were 39 cells in the drawing and asked to give their answer to one decimal place.

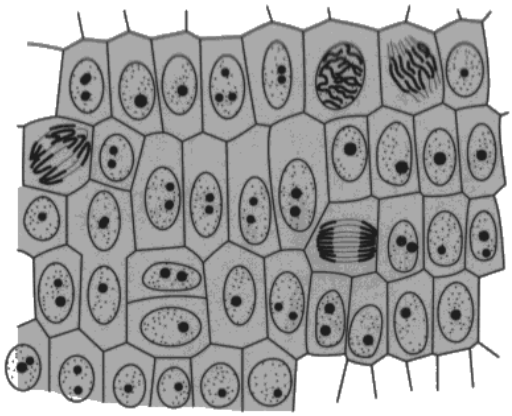
From the drawing, we can see that there are four cells with chromosomes clearly visible, so the number of cells in mitosis is four. We were told that the total number of cells is 39.

Using the formula given, we can calculate the mitotic index as $^{4}/_{39}$ = 10.3

The most common error was to count the dividing cells wrongly – some candidates thought that cells with no visible chromosomes were dividing. Some candidates chose to ignore the total number of cells given in the stem of the question and divided the number of dividing cells by a different number to 39.

(c) The diagram shows cells from a root tip squash.

The total number of cells is 39.



Calculate the mitotic index for this root tip squash.

Use the formula

$$\text{Mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}} \times 100$$

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

(2)

Mitotic index = $\frac{4}{39} \times 100$

$= 0.10256 \times 100$

$= 10.3$

Answer 10.3

ResultsPlus
Examiner Comments

This candidate counted the number of dividing cells correctly, calculated the mitotic index and gave the answer to one decimal place as instructed, gaining 2 marks.

$\frac{21}{39} \times 100 = 53.8$

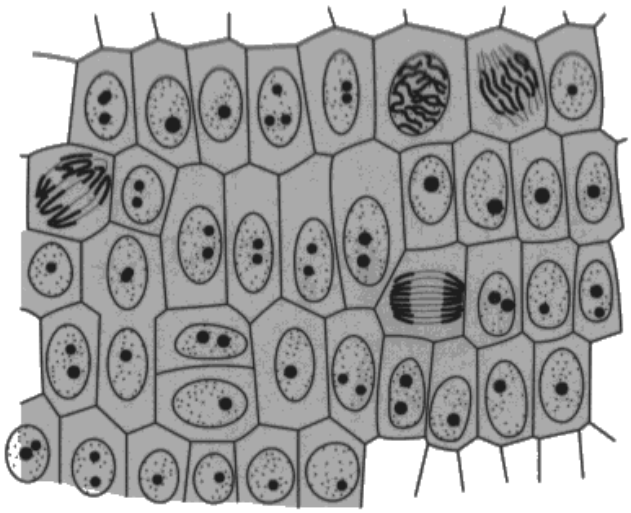
Answer 53.8

ResultsPlus
Examiner Comments

This candidate wrongly identified the dividing cells, so was not able to score mp1 or 2.

(c) The diagram shows cells from a root tip squash.

The total number of cells is 39.



Calculate the mitotic index for this root tip squash.

Use the formula

$$\text{Mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}} \times 100$$

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

(2)

$\frac{4}{35} \times 100 = 11.428571$

Answer 11.4

ResultsPlus
Examiner Comments

This answer achieved mp1 for correctly identifying the number of dividing cells.

The wrong total number of cells was used, so not mp2.

ResultsPlus
Examiner Tip

Always use the information you are given in the stem of the question.

Here you were told that the total number of cells was 39, so there was no need to count them.

Question 2 (a)(i)

Candidates were given a diagram of a nephron, collecting duct and some of the blood vessels associated with this. They were asked to explain how urea enters the nephron.

We were looking for a clear statement that the urea was moving **from** the blood (this could be expressed as capillaries / glomerulus / blood vessel) **into** the capsule.

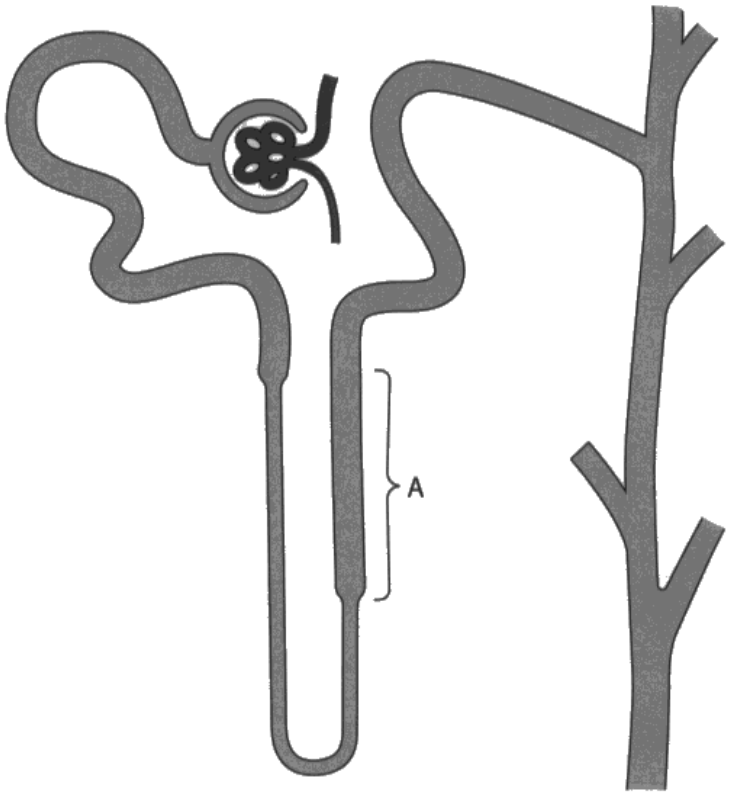
We also wanted to know that high pressure was involved; this could be by stating it was ultrafiltration, or by describing the process.

The most common errors were to be unclear about where the urea was moving from and to, or to fail to name the capsule. Some candidates lost the mark for simply saying it entered the nephron.

2 The mammalian kidney contains over one million nephrons.

One of their functions is to produce urine with a high concentration of urea.

(a) The diagram shows one nephron, collecting duct and some of the associated blood vessels.



(i) Explain how urea enters the nephron.

(2)

Enters due because ~~to~~ of the efferent ~~lumen~~ ~~arteriole's~~ arteriole's lumen being thinner than the afferent arteriole's lumen. This causes blood to be at high pressure, ~~forcing~~ forcing urea into the glomerulus.

ResultsPlus
Examiner Comments

This candidate achieved mp2 for describing the high pressure that moves the urea. However, they did not get mp1 as they said it was moving **into** the glomerulus, which is incorrect.

(i) Explain how urea enters the nephron.

(2)

By ultrafiltration. The efferent arteriole is thinner than the afferent arteriole. As a result this maintains a high pressure, and forces water, amino acids, glucose, an mineral ions out of the blood of the glomerulus and into the bowmans capsule. The urea passes through the fenestrated endothelium, then the basement membrane, then podocyte cells before entering the nephron. These are filtration barriers that filter out larger substances or proteins.

ResultsPlus
Examiner Comments

This candidate scored both marks with a strong answer containing lots of detail.

(i) Explain how urea enters the nephron.

(2)

urea ~~is~~ first enters the nephron by bowman's capsule at the start of the nephron by diffusing from the blood stream.

ResultsPlus Examiner Comments

This answer achieved mp1 for describing the urea moving from the blood into the capsule. However, it did not get mp2, as diffusion was not correct.

(i) Explain how urea enters the nephron.

(2)

Formed in the ornithine cycle in liver ~~by~~ from ammonia.
High blood pressure ~~from~~ through afferent arteriole of glomerulus pushes substances (urea) into bowman's capsule through podocytes.

ResultsPlus Examiner Comments

This answer also scored 2 marks, covering both marking points.

Question 2 (a)(ii)

This question asked candidates to explain how the movement of sodium ions out of the ascending limb of the Loop of Henle (labelled as A in the diagram) resulted in the formation of concentrated urine.

There were four key points we were looking for, for three marks:

- the movement of ions decreased the water potential in the medulla / resulted in a higher level of ions in the medulla than in the nephron
- so water moved out of the descending limb or collecting duct
- by osmosis
- the Loop of Henle acts as a countercurrent multiplier.

Mp 1, 2 and 3 were seen more commonly than mp4.

The most common errors were being confused about which area had the lower or higher water potential; or being confused about which area of the nephron the water was moving out of.

(ii) In the region labelled A, sodium ions are actively pumped out of the nephron into the surrounding fluid.

Explain how this movement of ions results in the formation of concentrated urine.

(3)

The ions being pumped out of the descending limb causes there to be a ~~lower water potential in the medulla~~ higher water potential in the loop of henlé so water moves out of the ascending limb into the blood by osmosis, down a concentration gradient. This means that there will be more ~~urea in urn~~ urine will be more concentrated with urea due to it having a low water concentration

ResultsPlus
Examiner Comments

This candidate gained mp1 and 3.

They did not get mp2 because they incorrectly said that water is leaving the ascending limb.

(ii) In the region labelled A, sodium ions are actively pumped out of the nephron into the surrounding fluid.

Explain how this movement of ions results in the formation of concentrated urine.

(3)

In the ascending limb, it is impermeable to water, so sodium ions being pumped out makes a higher water potential inside. So once it reaches the distil convoluted tubule, most of the water is able to leave via osmosis as there's a lower water potential outside. This means that concentrated urine is formed as the urea is no longer diluted.

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Examiner Comments

This candidate correctly explained that the sodium ions being pumped out of the ascending limb would make the water potential in the nephron higher, for mp1.

They knew that water was leaving the nephron by osmosis, so got mp3.

However, they thought it was leaving the distal convoluted tubule, so did not get mp2.

(ii) In the region labelled A, sodium ions are actively pumped out of the nephron into the surrounding fluid.

Explain how this movement of ions results in the formation of concentrated urine.

(3)

. Na^+ is actively pumped out ∴ the Na^+ concentration inside the nephron is low ∴ to balance this, water also moves out of the nephron via osmosis ∴ resulting in concentrated urine.

ResultsPlus
Examiner Comments

This candidate achieved mp3 for stating that osmosis was involved.

They did not get mp1 because there was no clear statement about ion concentration or water potential in the medulla.

They did not get mp2 because they stated that water was leaving the nephron, without saying which part.

(ii) In the region labelled A, sodium ions are actively pumped out of the nephron into the surrounding fluid.

Explain how this movement of ions results in the formation of concentrated urine.

(3)

Sodium ions moving out the ascending limb means that the water potential of the medullary fluid decreases so water moves out the descending limb by osmosis from high to low water potential. Hypothalamus detects ~~high~~ low water potential in the blood plasma causing pituitary gland to secrete ~~less~~ more ADH so the permeability of collecting duct decreases and ~~less~~ more water is reabsorbed so small volume of concentrated urine is produced

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Examiner Comments

This candidate achieved full marks for the first three marking points.

Question 2 (b)(i)

Candidates were given a bar graph showing the urine concentration for three species of mammal: kangaroo rat, camel and human. They were asked to determine the ratio of urine concentration for the three species.

The values were:

- kangaroo rat 5 500 au
- camel 2 800 au
- human 1 400 au

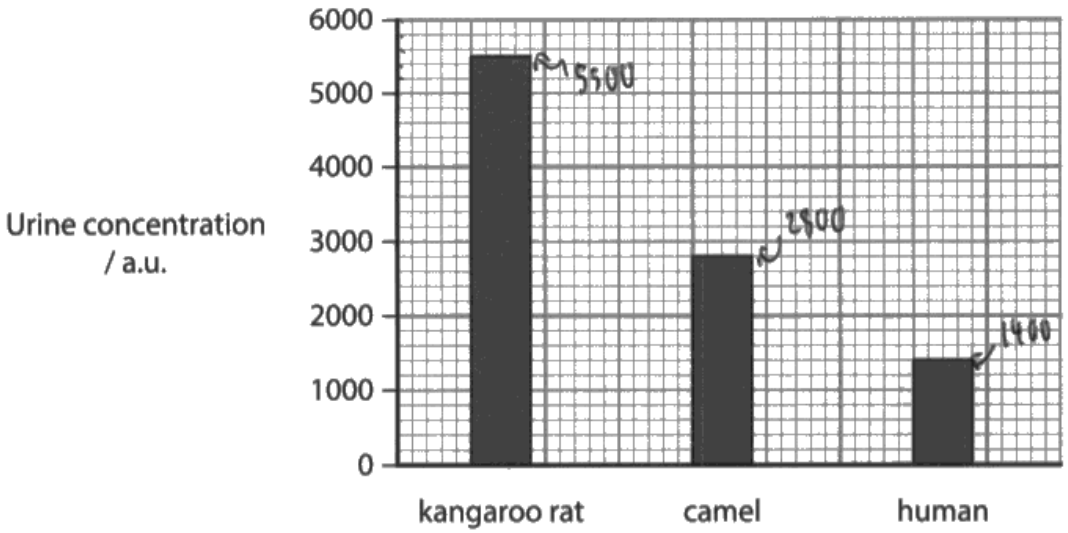
Most candidates read the values correctly from the bar graph.

However, a surprising number did not realise that (if you are not told to calculate the ratio of one number in relation to another) you should calculate the ratio with the smallest number given a value of 1. They simply stated the ratio as 5 500 : 2 800 : 1 400 or in some cases 55 : 28 : 14.

The correct answer was 3.93 : 2 : 1 / 4 : 2 : 1 / 3.93 : 2 : 1.

(b) The concentration of urine varies between species of mammals.

The graph shows the concentration of urine in kangaroo rats, camels and humans.



(i) Determine the ratio of urine concentration for these three mammals.

(1)

÷1400 { 5500 : 2400 : 1400 } ÷1400
3.9 : 2 : 1

Answer 3.9 : 2 : 1

ResultsPlus
Examiner Comments

This answer achieved the mark available for a correct ratio.

(i) Determine the ratio of urine concentration for these three mammals.

(1)

5500 : 2800 : 1400

3.93 : 2 : 1

Answer 4 : 2 : 1

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Examiner Comments

This ratio was also correct, scoring 1 mark.

(i) Determine the ratio of urine concentration for these three mammals.

(1)

rat Camel human

5500 : 3800 : 1400

55 : 38 : 14

Answer 55 : 38 : 14

ResultsPlus
Examiner Comments

This candidate made two errors:

- The value for camel was read incorrectly from the bar graph.
- The ratio was not reduced so that the smallest value was given as 1.

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Examiner Tip

If you are asked to calculate a ratio, always give the smallest value as 1 and calculate the other values in proportion to that.

Here the smallest value is 14, so that becomes 1. The other two values should have been divided by 14 to give the final ratio.

Question 2 (b)(ii)

This question asked candidates to explain one adaptation in the **structure** of the kangaroo rat kidney which would enable it to produce very concentrated urine.

The first mark was for describing the structural adaptation. Most candidates correctly said that the Loop of Henle is very long.

The second mark was for explaining how this enabled it to produce very concentrated urine. We did not give credit for simply saying that more water was absorbed; we were looking for an explanation of why this happened. The best answers included references to a bigger concentration gradient building up / a bigger countercurrent multiplier effect / the fluid in the medulla becoming more concentrated.

There were other possible matched pairs of answers, but those relating to the length of the Loop of Henle were seen most frequently.

(ii) Kangaroo rats live in a desert habitat.

Explain **one** adaptation in the structure of a kangaroo rat kidney that enables it to produce very concentrated urine.

(2)

Has a very long loop of henle so that more water can be reabsorped into the blood, causing urine to be more concentrated

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Examiner Comments

This answer gained mp1, but not mp2 as it did not explain why more water was reabsorbed.

(ii) Kangaroo rats live in a desert habitat.

Explain **one** adaptation in the structure of a kangaroo rat kidney that enables it to produce very concentrated urine.

(2)

It has a much longer Loop of Henle so that it can create a larger concentration gradient so that more water can be taken back up into the bloodstream so urine is very concentrated.

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Examiner Comments

This answer achieved both mark points.

(ii) Kangaroo rats live in a desert habitat.

Explain **one** adaptation in the structure of a kangaroo rat kidney that enables it to produce very concentrated urine.

(2)

It has a very long loop of Henlé. This means that it can pump more Na^+ ions into the medulla, so can lower the water potential of the medulla even more and create and even larger water potential gradient meaning even more water is reabsorbed by osmosis as even more water osmoses out the descending limb

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Examiner Comments

This answer gained maximum marks – it stated that the Loop of Henle was very long, and then gave two correct reasons why this would result in very concentrated urine.

It has a longer loop of henle therefore more concentrated medulla - the medulla has a lower water potential than in humans so more water reabsorbed - less urine.
Also has more ion pumps, again making medulla more concentrated - larger counter current multiplier.

ResultsPlus
Examiner Comments

This candidate also gained maximum marks. They explained the effect of the longer Loop of Henle with three correct consequences:

- Lower water potential in the medulla.
- More ion pumps.
- Larger countercurrent multiplier.

Contain many mitochondria to drive more production of ATP which allows more active transport of ions out of the nephron creating a larger concentration gradient for the osmosis of water out of nephron, leaving behind concentrated urine in nephron.

ResultsPlus
Examiner Comments

This candidate focused on the numbers of mitochondria and the production of more ATP to allow more active transport of ions creating a larger concentration gradient, gaining both marks.

Question 2 (b)(iii)

Candidates were asked to suggest one **behavioural** adaptation they would expect to see in kangaroo rats which would help them to conserve water in a hot desert.

The information is not included in the specification, but we would expect A-level candidates to be able to make a reasonable suggestion. Credit-worthy answers included being nocturnal, burrowing underground or seeking shade under rocks / other named barriers.

We did not give credit for being inactive, or for simply going into the shade if they did not say where this was.

Some candidates suggested physiological adaptations like not sweating, which did not gain credit.

(iii) Kangaroo rats are endotherms.

Give **one** behavioural adaptation that you would expect to see in kangaroo rats that helps them to conserve water in a hot desert.

(1)

Kangaroo rats being nocturnal - only go out to hunt at night when it is less hot

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Examiner Comments

This was a suitable suggestion, gaining the mark available.

Minimise their movement during the hottest part of the day by sleeping in a shaded burrow. **(1)**

ResultsPlus
Examiner Comments

This answer got the mark because it suggested where the shade was.

They won't sweat so they can lose excess water.

ResultsPlus
Examiner Comments

This was a physiological adaptation (not behavioural), so did not get the mark

• burrow under ground as cooler so less water loss

ResultsPlus
Examiner Comments

This was a good suggestion, gaining the mark.

Stay in the shade and avoid sunlight

ResultsPlus
Examiner Comments

This answer was too vague to gain credit.

Question 3 (a)(i)

Question 3 was about membranes in plant cells.

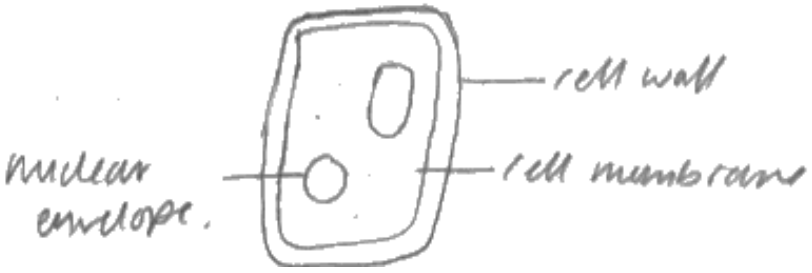
Question 3(a)(i) asked candidates to draw a typical cell from a root as seen using a light microscope, and to label three named membranes. They found both parts of this task surprisingly difficult, with many struggling to include appropriate structures in the drawing.

For mp1 we wanted to see a cell with a cell wall, cell surface membrane, nucleus and vacuole. The shape of the cell was ignored, and many candidates attempted to draw a root hair cell. Any other structures were ignored, apart from chloroplasts which negated the mark, as they are never found in root cells.

For mp2 we wanted to see three labelled membranes: the cell surface membrane, the tonoplast / vacuole membrane and the nuclear membrane / envelope. Other membranes which would not be visible using a light microscope were ignored.

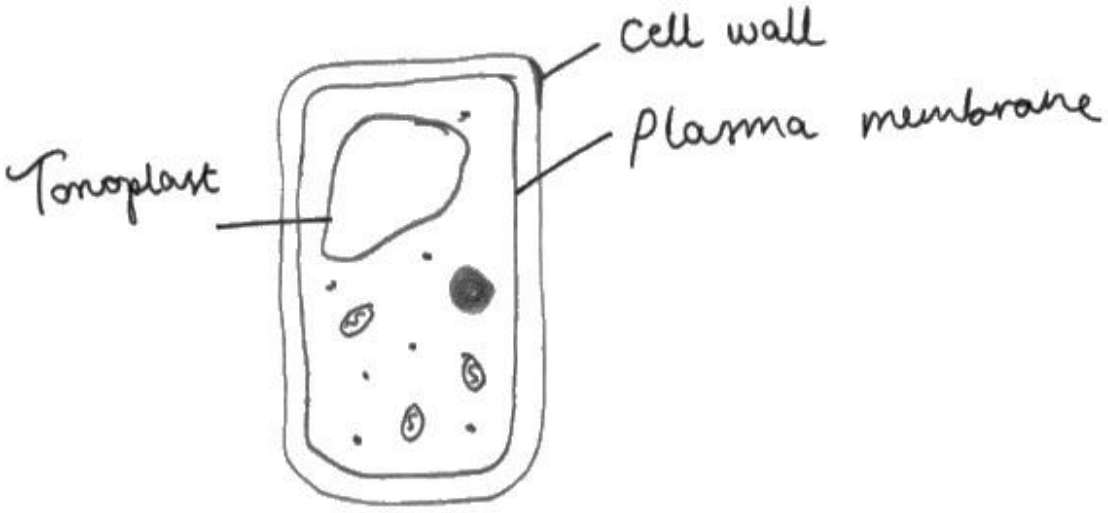
The root cells contain a red pigment, betalain, in the vacuole.

(a) (i) Draw a typical cell from a root, as seen using a light microscope. Label **three** named membranes.



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Examiner Comments

This drawing achieved mp1 only. All the required structures were present, but the tonoplast was not labelled, so it did not get mp2.



ResultsPlus
Examiner Comments

Another drawing which scored mp1 only. Again, all the required structures were present, but this time the nuclear membrane was not labelled.

Question 3 (a)(ii)

Candidates were asked to describe the structure of a membrane in a plant cell for two marks.

Mp1 required them to say it was a phospholipid bilayer. Most did this, and some spent a lot of time describing it in detail.

Mp2 was for saying that there were proteins associated with the membrane, eg channel proteins / intrinsic proteins etc. Some forgot about the proteins, so did not get this mark.

A few candidates described the cell wall in detail, instead of the membrane structure, and were unable to get marks.

(ii) Describe the structure of a membrane in a plant cell.

(2)

A membrane in a plant cell has phospholipid bilayer. This consists of a ~~polar~~ hydrophilic head and a hydrophobic tail so the tails always face in towards each other. There's intrinsic and extrinsic proteins within this bilayer and the membrane is very fluid.

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This is a strong answer which covered all the required information, gaining both marks.

Phospholipid bilayer. Polar phosphate heads, interact with aqueous environment. Non polar fatty acid chains on inside, allow transport of ~~&~~ non polar substances / hydrophobic.

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This candidate described the phospholipid bilayer, achieving mp1, but did not mention the proteins.

~~Contains~~ The ~~the~~ middle lamella which contains Celloluse microfibrils which joins to adjecent microfibrils in ~~the~~ the cell walls ~~of plant cells~~ together. So that plant cells can join together.

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Examiner Comments

This answer was not about membranes, so it did not score any marks.

Question 3 (b)(i)

Question 3(b) assessed understanding of Core Practical 5 – effect of temperature on membrane permeability.

Candidates were given an outline of the stages in the practical, where beetroot cylinders were placed in a known volume of water at different temperatures for a fixed time, before absorbance was measured using a colorimeter. They were provided with a table of results for five groups of students.

Question 3(b)(i) asked them to **describe** the relationship between temperature and absorbance. There were two available marks.

There were 3 marking points:

- As temperature increases, absorbance increases.
- Increase is greatest between 40°C and 50°C / increase is non-linear.
- Absorbance levels off at 50°C.

Any explanations were ignored in this answer. The majority of candidates achieved mp1, and some noticed the large increase between 40°C and 50°C to get mp2.

The most common mistake was to say that absorbance fell at 60°C. Although the mean at 60°C was very slightly below the mean at 50°C, we expected candidates to realise that this was negligible, and within the margin of error.

A few candidates described the relationship in terms of an enzyme-catalysed reaction, writing about optimum temperature; this was not relevant.

(b) A group of students investigated the effect of temperature on membrane permeability using tissue from a beetroot. They used the following method.

1. Tubes containing 20 cm^3 of water were placed in water baths for 15 minutes at 20°C, 30°C, 40°C, 50°C and 60°C.
2. Cylinders were cut from the same beetroot using a standard cork borer, and these were cut into 1 cm lengths.
3. Each piece was rinsed in water and then blotted dry, before being added to a tube in the water bath.
4. After 20 minutes, a sample of the liquid was removed.
5. The absorbance (amount of light absorbed by the red pigment) of each sample was measured using a colorimeter.

The table shows the results.

Temperature /°C	Absorbance					
	Group 1*	Group 2	Group 3	Group 4	Group 5	Mean of groups 2 – 5
20	0.33	0.14	0.07	0.08	0.11	0.10
30	0.57	0.24	0.32	0.33	0.31	0.30
40	0.87	0.53	0.63	0.56	0.51	0.56
50	1.87	1.58	1.63	1.53	1.56	1.58
60	1.93	1.59	1.62	1.49	1.56	1.57

*Group 1 results were excluded from the calculations of the means.

(i) Describe the relationship between temperature and absorbance, as shown by these results.

(2)

(i) Describe the relationship between temperature and absorbance, as shown by these results.

(2)

As temperature increased, absorbance increases. Not a linear relationship. At higher temperatures (between 50 and 60) degrees, the rate of increase of absorbance ~~increases~~ decreases slightly from 1.58 to 1.57

ResultsPlus Examiner Comments

This answer scored mp1 and 2.

Not mp3 as they state that absorbance decreases between 50°C and 60°C.

As temperature increases, the absorbance increases. Because the cell wall is becoming more fluid due to temperatures breaking the hydrogen bonds so more pigment can leak out so a higher absorbance is recorded

There is a massive jump in absorbance between 40°c & 50°c

At 60°c, the absorbance decreases slightly.

ResultsPlus Examiner Comments

This answer also scored mp1 and 2 but not mp3, for the same reason.

You can see that the candidate correctly decided not to explain the change in absorbance in a question that asked for a description.

As temperature increases, absorbance increases. However absorbance decreases as temperature exceeds 50°c, suggesting that the optimum temperature is 50°c.

ResultsPlus
Examiner Comments

This answer gained mp1 only.

Question 3 (b)(ii)

Candidates were now asked to **explain** the results of the investigation. There were four marking points for the two available marks.

We were looking for one explanation of the increase in absorbance

- that increasing the temperature increases the permeability of the membrane
- that betalain molecules could move through the membrane (into the water) if it was damaged or disrupted.

and one reason that the membrane becomes damaged or disrupted

- as the temperature increases the membrane becomes more fluid
- above 40°C / at high temperatures the proteins in the membrane denature (forming gaps).

Many students were able to get at least one of the first pair of marks, scoring one mark.

Mp3 was seen a lot more than mp4. Although a lot of candidates knew that proteins in the membrane denatured, some linked this to (gradually) increasing temperature rather than saying it was at high temperatures or above a specific temperature.

We ignored references to enzymes denaturing, as this was irrelevant here.

DICOTS

(ii) Explain the results of this investigation.

(2)

As temp increases membrane becomes more permeable as the prothens and phospholipids gain kinetic energy - gaps form so pigment leaks out. After 50°c levels off / little change as membrane already very permeable - doesn't become more permeable. The prothens already denatured.

ResultsPlus
Examiner Comments

This candidate clearly explained that permeability increased with increasing temperature, and stated that gaps form so the pigment leaked out (this was mp1 and 2).

They went on to get mp4 as they said that above 50°C the proteins had already denatured.

As temperature increases, the membrane permeability increases as the membrane becomes more fluid and particles have more kinetic energy so the phospholipids begin to separate in the bilayer, so more pigment is released. However, above 50°C, the enzymes denature

ResultsPlus
Examiner Comments

This answer gained full marks with mp1 and 3 in the first two lines (permeability increased as the membrane became more fluid).

They went on to get mp2 as they described the pigment being released, but not mp4 as they referred to enzymes, not proteins.

As temperature increases the particles have more kinetic energy and enzyme rate of reaction increases (20–50°c) Once past optimum temperature the proteins/enzymes denature as hydrogen bonds in tertiary structure break changing the shape of proteins/enzymes so they can no longer transport pigment or function.

ResultsPlus
Examiner Comments

This answer scored zero.

They did not mention permeability or the pigment leaking out through the membrane, so did not score mp1 or 2.

Although they knew that proteins were being denatured at high temperatures, they linked this to pigment not being transported across the membrane, so the context was wrong for mp4.

Increasing temperature disrupt the phospholipid membrane of the vacuole ~~cause~~ (tonoplast) so gaps form in the membrane allowing the red pigment to leak out so solution become more red and dark and will therefore absorb more light causing an increase in absorbance. Increase in temperature cause more disruptio so then are more gaps allowing more red pigment to leak out

ResultsPlus
Examiner Comments

This answer gained mp2 for the description of the pigment leaking out through the membrane, and mp3 for the statement that the membrane was disrupted and gaps form as temperature increases.

Question 3 (c)

Candidates were told in the stem of the question that Group 1 results were excluded from calculations of the means as they were so different from the other groups. In fact, all of their absorbance values were much higher.

This part of the question asked them to identify four errors that Group 1 may have made which would account for this difference in the results. They had already been given the steps of the method the groups of students had followed.

As the absorbance was too high, we were looking for **directional** answers for most marking points

- that there was less than 20cm^3 water in the boiling tube
- that the pieces of beetroot were longer than 1cm
- that the beetroot was left in the tubes for longer than 20 minutes
- that the beetroot cylinder was damaged as the sample was removed (releasing more pigment)
- that the pieces of beetroot may not have been rinsed before being added to the tube
- that a different beetroot was used
- that there was a named error associated with use of the colorimeter, eg lack of calibration, cuvettes scratched etc.

We ignored the following:

- that the pieces may not have been blotted dry (because this would potentially add water into the tube, making the absorbance lower)
- that the waterbaths may not have been at the right temperature (since it is unlikely that all five would have been too hot)
- that the tubes of water were left in the waterbaths for too long at the start (because this should not affect absorbance at all).

Most candidates gave strong answers to this question, showing a good understanding of the practical procedures and the effects of not following instructions carefully.

(c) Group 1 results were excluded from the calculations of the means as they were so different from the other groups.

Identify **four** errors this group may have made which would account for the difference in results.

(4)

- The cylinders may not have been rinsed until the water ran clear
- The cuvettes were held on the clear sides and not the rough sides
- The colorimeter may have been using a red light instead of blue or green
- The colorimeter may not have been calibrated ~~for~~ before starting the test

ResultsPlus
Examiner Comments

This answer scored 2 marks.

One for not rinsing the beetroot and one for a colorimeter error; all three of these were reasonable colorimeter errors, but only one mark was available for this.

The group may not have cut the cylinders from the same root. They may not have rinsed the cylinders and blotted them dry before adding them into a tube of water. They may have waited longer than 20 minutes, before removing a sample of liquid which would have allowed more time for absorbance of the red pigment to occur. They may not have placed them in the correct temperature water baths. for example, they temperatures wouldn't be 20°C, 30°C, 40°C, 50°C and 60°C it could be higher.

ResultsPlus
Examiner Comments

This answer scored 3 marks: one for using a different beetroot, one for not rinsing and one for leaving the samples in the tubes for too long.

Not have set the water baths at the
same temperature.
Cut a cylinder from a different beetroot to the
other groups.
Not have blotted the beetroot cylinder
completely dry
Cut the cylinders into longer or smaller lengths
than 1cm.

ResultsPlus
Examiner Comments

This answer scored 1 mark for using a different beetroot.

They came close to a second mark with their last point but it was not directional, as they said the beetroot might have been longer or shorter than 1cm.

(4)

- They may have not kept 20cm³ of water for a set amount of time.

- cylinders may have not been the same size or mass.

- they may have not used a thermometer to measure the temperature of the water baths

- The temperature in the room may not be thermoally controlled.

ResultsPlus
Examiner Comments

Unfortunately, this candidate did not get any of the marking points.

Two were on the right lines, but not directional (time the sample was in the waterbath and size of cylinder).

The other two were linked to temperature, which we were not crediting.

Question 4 (a)(i)

Question 4(a) assessed knowledge and understanding of Core Practical 9 – the use of a respirometer.

Question 4(a)(i) asked them to describe how to measure the rate of respiration of woodlice collected from a garden. This was generally very well answered, with over a third of candidates gaining at least four marks out of a possible five.

Credit was given for:

- measuring the mass of the woodlice (or using a stated mass)
- describing a respirometer or a detail of setting it up eg placing the woodlice on a platform
- adding a named chemical to absorb carbon dioxide
- measuring the distance moved by the liquid in a stated time
- a method of controlling the temperature or the use of a control tube with an inert material in it
- a method to find the volume of oxygen used
- a method of calculating the rate or giving correct units ie $mm^3\ min^{-1}\ g^{-1}$

The most common errors were:

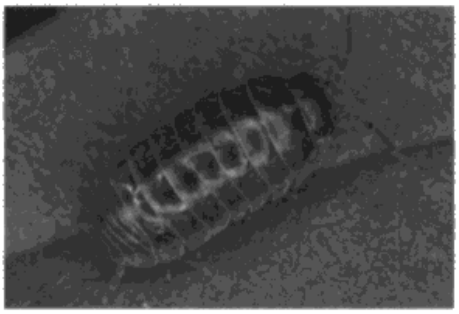
- forgetting to measure the mass
- not being able to name a suitable chemical
- using a gas syringe to collect gas (when it was oxygen **used** that was being measured)
- forgetting to control the temperature
- forgetting that the rate should be given per gram of woodlice.

4 Woodlice are crustaceans found in many gardens and woodland habitats.

There are several species that are native to the UK and Ireland.

They obtain oxygen through gills, which are on their legs.

The photograph shows one species of woodlouse, *Armadillidium vulgare*.



Magnification × 2

(Source: © TED KINSMAN / SCIENCE PHOTO LIBRARY)

(a) (i) Describe how you could measure the respiration rate of woodlice collected from a garden.

(5)

1) Place 10g of woodlice from the garden into a test tube on top of mesh sitting on 10g of soda lime (absorb CO_2). Set up an identical test tube but using 10g of glass beads so it can act as a control.

2) Connect these with a U shaped capillary tube with some coloured dye and a scale to make a respirometer. Ensure equipment is airtight. Begin a timer and leave for 10 minutes.

3) Measure distance moved by coloured liquid and calculate volume of oxygen used ($\pi r^2 \times d$).

4) Use this to calculate rate of respiration in $mm^3\ g^{-1}\ min^{-1}$.

Control - temperature by pre-forming experiment in water bath set to 30°c.

Perform repeats (after resetting the respirometer so dye at 0mm + replacing soda lime) and take mean, discarding any anomalys.

ResultsPlus
Examiner Comments

This is a very strong answer which hit all seven marking points, in this order: 1, 2, 3, 5, 4, 6, 7, 5 (again).

It gained full marks.

(a) (i) Describe how you could measure the respiration rate of woodlice collected from a garden.

(5)

- set up respirometer with $2cm^3$ of soda lime
- add mesh above and add 5g of woodlice onto mesh
- set up other side as control using $2cm^3$ soda lime mesh and 5g of glass beads
- add dropper red dye to capillary tube in centre and add scale
- close 3 way tap forming sealed environment
- leave for 5 minutes and record distance travelled by dye then use distance $\cdot \pi r^2$ to calculate volume of O_2 used
- all CO_2 produced from respiration absorbed by soda lime
- calculate respiration rate as (volume of O_2 used) / (time 5 minutes $\cdot$ 5grams)
- gives rate volume in $mm^3 min^{-1} g^{-1}$
- control temperature using thermostatically controlled room as affects enzyme activity $\therefore$ rate of respiration
- control light intensity

ResultsPlus
Examiner Comments

Another strong answer which gained five marks. This time the marking points were 3, 2, 1, 5, 4, 7.

Not mp6 as they described the calculation as distance minus Πr^2

We did not credit the use of a thermostatically controlled room for mp5, but they had already achieved this with the control tube.

Question 4 (a)(ii)

Candidates were asked to identify one safety issue and one ethical issue involved in their method in Question 4(a)(i), and state how they would minimise these.

The most common errors were:

- not to realise that the safety issue was about the person carrying out the investigation and the ethical issue was about the woodlice
- to only answer half of the question ie to identify the problems, but not state how to minimise them; or to give the solutions, without identifying what the problem was
- to give very vague answers to the ethics issue, eg it is unethical to use woodlice in experiments / woodlice could become stressed.

We were looking for the following points:

Safety

- Soda lime is corrosive so wear gloves / goggles.
- Students may be allergic to woodlice / woodlice may be carrying bacteria, so wear gloves.
- Glass may break (when setting up tube in respirometer) so wear gloves / goggles.

Ethics

- Woodlice may be harmed when being moved, so handle them carefully / return them to the garden after the investigation.
- Woodlice may be harmed by soda lime, so keep them separated from it.
- Woodlice may use up the oxygen in the tube, so provide breaks with the tap open to refresh the air.

(ii) Identify **one** safety issue and **one** ethical issue involved in your method in part (a)(i) and state how you would minimise the effect of these.

(2)

Safety issue

Woodlice can carry harmful bacteria and Pathogens

Ethical issue

Its cruel to the Woodlice

ResultsPlus
Examiner Comments

This answer scored zero.

Although the candidate recognised that the woodlice may be carrying bacteria, they did not suggest how to minimise the effect of this.

There was no suggestion of how to treat the woodlice in an ethical way.

(ii) Identify **one** safety issue and **one** ethical issue involved in your method in part (a)(i) and state how you would minimise the effect of these.

(2)

Safety issue

irritation, using gloves

Ethical issue

affects food chain, return back to habitat

woodlice assumed to have simple nervous system and so feel less pain

harm to animals

ResultsPlus
Examiner Comments

This candidate did not get the safety point, because they did not explain what was causing the irritation.

However, they got the ethics point as they realised that taking the woodlice from the garden may affect the food chain, so they should be put back.

Safety issue

The woodlice brought in may have pathogens/ bacteria that could cause ~~infection~~ people to get sick.

Ethical issue

The woodlice may get stressed being in a small space.

ResultsPlus
Examiner Comments

This candidate identified a safety issue, but did not suggest a way to minimise the effect of it, so did not get the safety point.

Woodlice tend to live in small spaces, so in itself this is not stressful; they were not specific about the risks to the woodlice, so did not get the ethics point.

Safety issue

Allergies to woodlice, if an allergy is triggered call for medical assistance, wear gloves to handle woodlice and minimise contact.

Ethical issue

Removal of live woodlice from their natural habitat into conditions with little factors, can be minimised by releasing woodlice back to the habitat they were collected from quickly after the experiment

ResultsPlus
Examiner Comments

This answer scored both marks.

Question 4 (b)(i)

Question 4(b) was about an investigation into the habitat preferences of woodlice using a choice chamber. This had four equally-sized areas with different conditions: light and damp; light and dry; dark and damp; and dark and dry. Twenty woodlice were added to the choice chamber and their position noted after five minutes. This was repeated three more times to give four sets of data in total.

In **Question 4(b)(i),** candidates were asked to explain which statistical test could be used to analyse the results. A lot of them found this very difficult.

Those who did correctly identify the chi-squared test were usually able to explain that it compares observed with expected results, and therefore gained both marks.

The most frequently seen wrong answer was the t-test.

The student suggested the hypothesis that woodlice show no habitat preference.

- Five woodlice were placed in each of the four sections and left to move.
- The position of the woodlice was recorded after five minutes.
- This was repeated three more times.

The table shows the results obtained.

Section	Number of woodlice in each section of the chamber after 5 minutes			
	Trial 1	Trial 2	Trial 3	Trial 4
Light and dry	2	1	0	2
Light and damp	4	4	1	5
Dark and dry	4	3	3	3
Dark and damp	10	12	16	10

(i) Explain which statistical test could be used to analyse these results.

(2)

- χ^2 test as able to compare expected number of woodlice in each habitat vs observed number of wood lice in each habitat
- test for significant difference between observed and expected ratio's

ResultsPlus
Examiner Comments

This answer scored both marks.

ResultsPlus
Examiner Tip

Make sure you understand when the different statistical tests are used, and what type of data they can analyse.

(i) Explain which statistical test could be used to analyse these results.

(2)

can use a chi squared test as it would be expected that the frequency of each section is equal so we can compare this to the observed frequency can see if there is a significant difference.

ResultsPlus
Examiner Comments

Another strong answer gaining both marks.

Question 4 (b)(ii)

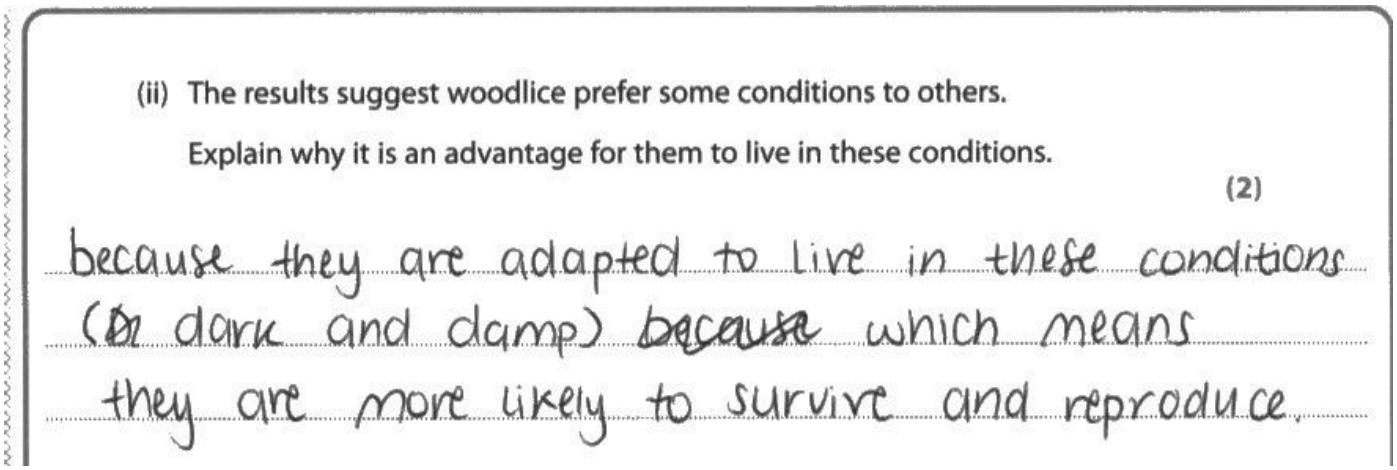
Candidates were told that the results suggested woodlice prefer some conditions to others, and asked why it was an advantage to live in those conditions.

The majority could correctly identify that they appear to prefer dark and damp conditions.

Most could suggest an advantage to being in darkness; the most common answer was to avoid predators.

Some were able to give a reason why damp conditions were an advantage, linking the moist conditions to increased oxygen uptake through the gills on their legs. A small number clearly understood this, but did not get mp2 because they referred to respiration, rather than oxygen or gas exchange.

The biggest problems were that some candidates were thinking about woodlice in their natural habitat, where darkness and dampness are commonly linked and answering in the context of both factors together. Some also brought the variable of temperature into the discussion, saying that dark and damp conditions are often cooler, so this would prevent them overheating. We did not credit references to change in temperature.



(ii) The results suggest woodlice prefer some conditions to others.

Explain why it is an advantage for them to live in these conditions.

(2)

because they are adapted to live in these conditions (ie dark and damp) because which means they are more likely to survive and reproduce.

ResultsPlus
Examiner Comments

This answer was too vague to gain any credit.

The woodlice ~~prefer~~ prefer dark and damp conditions to the others. This is because the most woodlice are found after 5 minutes in the dark and damp conditions. It is an advantage for them to live in these conditions because it is their natural niche, to keep away from ~~their~~ predators. Also, woodlice are ectotherms, and cannot ~~regulate their own~~ thermoregulate on their own via metabolic processes. Therefore they rely on dark and damp conditions so they do not overheat and dry out.

ResultsPlus
Examiner Comments

This answer scored mp1 for the reference to avoiding predators. They did not get mp2 because there was no reference to gas exchange.

O brain oxygen through leg gills so damp conditions make it easy for oxygen to diffuse through gills ~~into~~ Dark conditions make it easier to hide and camouflague away from predators as woodlouse have dark bodies, more likely so will ^survive

ResultsPlus
Examiner Comments

This answer scored both marks.

Question 4 (b)(iii)

Candidates were asked to describe three improvements which would ensure the conclusion was valid. In this question, reasons were not required for any of the improvements suggested, as the command word was simply "describe".

We were looking for:

- setting up the chamber in advance (so that the damp area would be distinctly different to the dry area) or cleaning it between trials (to remove scent trails)
- leaving the woodlice for a longer time
- ensuring all were the same species
- using more than 20 woodlice
- a method which would help to make recording results more accurate, eg taking a photograph to analyse (as the woodlice may still be moving) or a rule to deal with woodlice on a boundary.

We ignored

- ensuring all were the same sex or age, as this would be almost impossible in practice
- the idea of controlling the temperature, since the choice chamber is small and all four areas would naturally be at the same temperature
- the idea of placing all the woodlice in the centre at the start, as this would be impossible in practice
- the idea of recording the position more frequently, since this would not improve validity
- the bald statement to repeat the experiment, as on its own this would not improve validity.

Mark points 2, 3 and 4 were all commonly seen. The idea of cleaning the chamber between trials was seen a few times, usually justified with a good reason. The most commonly seen points that did not gain credit were controlling the temperature and putting the woodlice in the centre at the start.

(iii) Describe **three** improvements that could be made to this investigation to ensure the conclusion is valid.

(3)

* Use more than 20 woodlice (5 per section) larger test group can remove anomalies or remove potential behavioural reasons
* clean the chamber between repeats so smell of previous woodlice doesn't make the woodlice move there
* Use the same ~~breed~~ species of woodlice as may be genetic reasons for the trend

ResultsPlus
Examiner Comments

This answer scored mp4, 1 and 3, gaining full marks.

Use more woodlice. To record their position more frequently during a longer trial. Create more than 4 conditions. After each trial, use a separate choice chamber so that any ~~testing~~ scents are removed. Use woodlice of different ages. Control temperature. Repeat the experiment with each ~~woodlouse~~ woodlice in its own chamber.

ResultsPlus
Examiner Comments

This answer scored mp4, mp2 (for the suggestion of a longer trial) and mp1 (for using a separate chamber so scents are removed).

Question 5 (a)(i)

Question 5 assessed understanding of Core Practical 6 – determine the water potential of plant cells.

Candidates were given a step by step method involving finding the percentage of plasmolysed cells in onion epidermis placed in a range of sucrose solutions. The values they were given were used to plot a graph which was then used to determine the water potential of the cell sap of the onion cells.

Question 5(a)(i) asked the candidates to describe how to prepare $10cm^3$ of a solution with a concentration of 0.6 mol dm^{-3} starting with a stock solution of 0.8 mol dm^{-3}.

A lot of candidates found this very difficult. Some candidates used the formula $C_1V_1 = C_2V_2$

$C_1 = C_2V_2 \div V_1$ $C_1 = 0.6 \times 10 \div 0.8 = 7.5$ so $7.5cm^3$ stock solution and $2.5cm^3$ water.

The correct answer gained 2 marks.

If candidates gave the correct ratio but wrong volumes to add up to $10cm^3$ (or no volume at all) eg 3:1 ratio / add $6cm^3$ stock solution to $2cm^3$ water, they got mp1 only.

The most commonly seen wrong answers were $6cm^3$ stock solution and $4cm^3$ water; and $8cm^3$ stock solution to $2cm^3$ water.

It would be helpful if centres gave candidates the opportunity to practise calculations like this one.

5 Differences in water potential affect the direction of movement of water in and out of cells.

(a) The water potential of plant cells can be determined using plasmolysis.

A plant cell is plasmolysed when it loses water and the plasma membrane moves away from the cell wall. This can be observed when the cells are viewed with a light microscope.

A group of students used the following method to find the osmotic potential of cell sap in onion epidermal cells. The osmotic potential is equivalent to the concentration of the sucrose solution when 50% of cells are plasmolysed.

Step 1: A stock sucrose solution of 0.8 mol dm^{-3} was diluted to make a range of concentrations.

Step 2: A thin layer of onion epidermis was placed in 10 cm^3 of sucrose solution in each tube, and left for 20 minutes.

Step 3: Each piece of onion epidermis was placed on a microscope slide covered with a drop of the sucrose solution in which it had been soaking, and a coverslip placed on top.

Step 4: Using a microscope, the total number of cells in the field of view, and the total number that were plasmolysed, were counted.

Step 5: The percentage of plasmolysed cells in each sucrose concentration was calculated.

(i) Describe how you would prepare 10 cm^3 of a solution of sucrose with a concentration of 0.6 mol dm^{-3} from the stock solution.

(2)

I would had ~~7.5~~ ~~7.5cm~~ 7.5 cm^3 of stock solution in a test tube and add 2.5 cm^3 of dishlled water.

ResultsPlus
Examiner Comments

This answer scored both marks.

ResultsPlus
Examiner Tip

Practise using the $C_1V_1 = C_2V_2$ formula until you feel comfortable with it!

(i) Describe how you would prepare 10 cm^3 of a solution of sucrose with a concentration of 0.6 mol dm^{-3} from the stock solution.

(2)

Use a 6:~~4~~2 ratio of sucrose to water so 6 cm^3 of sucrose and 2 ~~4~~ cm^3 of water.

ResultsPlus
Examiner Comments

This candidate got the ratio right (6:2 is equivalent to 3:1), but the volumes they chose were too low to make 10cm^3 of the solution. It scored mp1 only.

(i) Describe how you would prepare 10 cm^3 of a solution of sucrose with a concentration of 0.6 mol dm^{-3} from the stock solution.

(2)

$0.6 \times 1000 = 600 mol dm^{-3}$ $0.8 \times 1000^3 = 800 mol cm^{-3}$

$800 \div 10 = 80$

dilute 7.5 cm^3 of stock solution with 1.5 cm^3 of distilled water

3:1 ratio

stock : water

ResultsPlus Examiner Comments

This candidate got the ratio right (3:1) and scored mp1. They made an error in calculation (1.5 cm^3 water instead of 2.5 cm^3) and did not get mp2.

(2)

Stock = 0.8 mol dm^{-3}

mix with 3 parts stock solution and 1 part water in order to obtain a concentration of 0.6 mol dm^{-3}

ResultsPlus Examiner Comments

This candidate got the ratio right (3 parts of stock solution to 1 part of water) but did not give volumes. They scored mp1 only.

Question 5 (a)(ii)

Candidates were given the mean results and asked to plot a graph, with points joined by straight lines.

We were looking for:

- axes orientated correctly with headings and units
- accurate plotting of all points on a linear scale
- straight lines joining all points.

It was very pleasing to see that almost two thirds of candidates scored full marks on this.

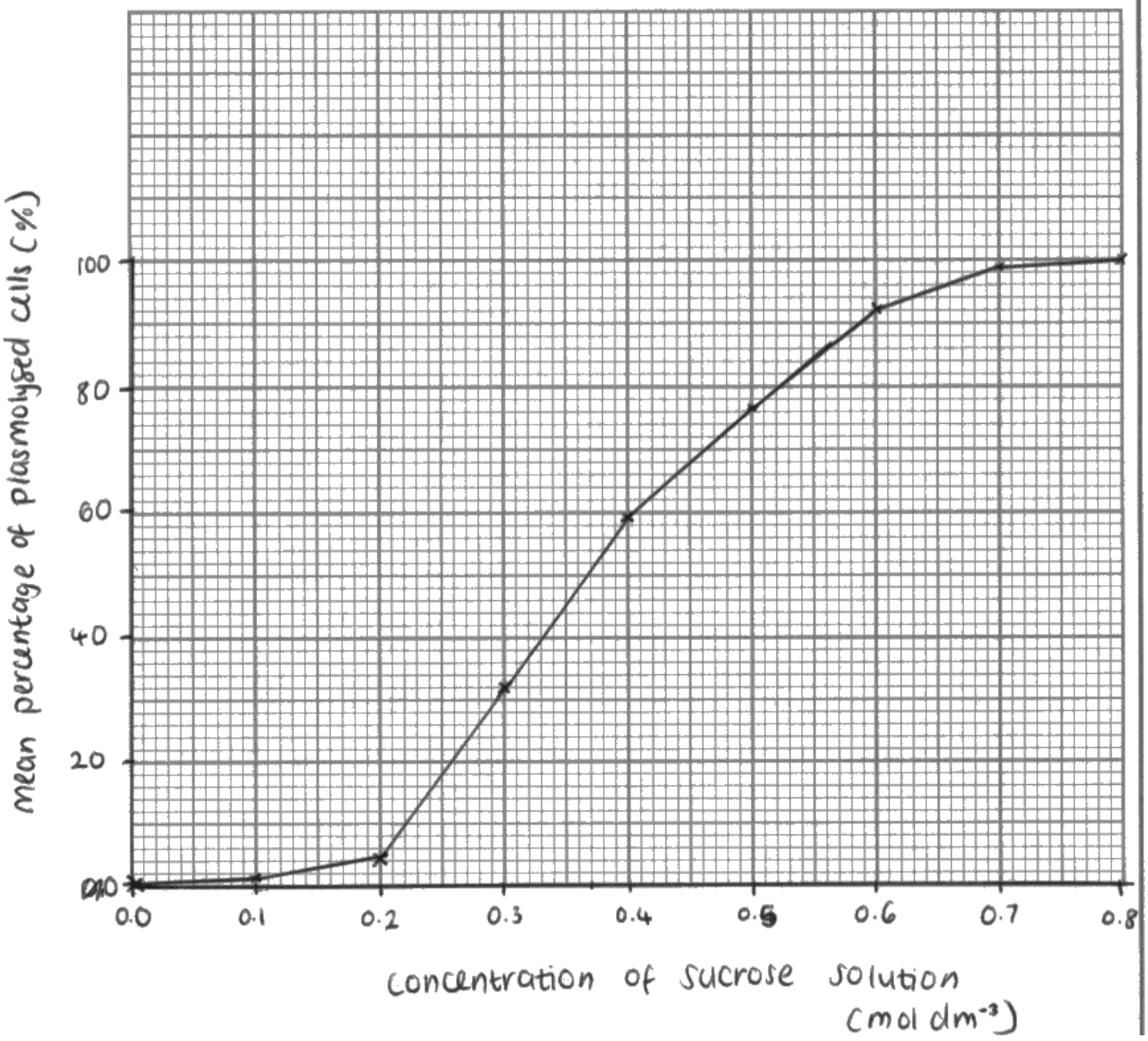
The most common errors were:

- inaccurate plotting when an unsuitable scale was chosen
- not joining all points; some candidates missed joining the origin to the 0.1 mol dm^{-3} point
- not joining points with straight lines as directed; some used a curve and a few drew a line of best fit
- not including units in the headers, or occasionally not adding headers at all
- a small number of candidates had the axes the wrong way round; the independent variable should always go on the x-axis

Plot a suitable graph to display these results.

Join the points with straight lines.

(3)



ResultsPlus
Examiner Comments

This was a good example of one of the many graphs that scored full marks.

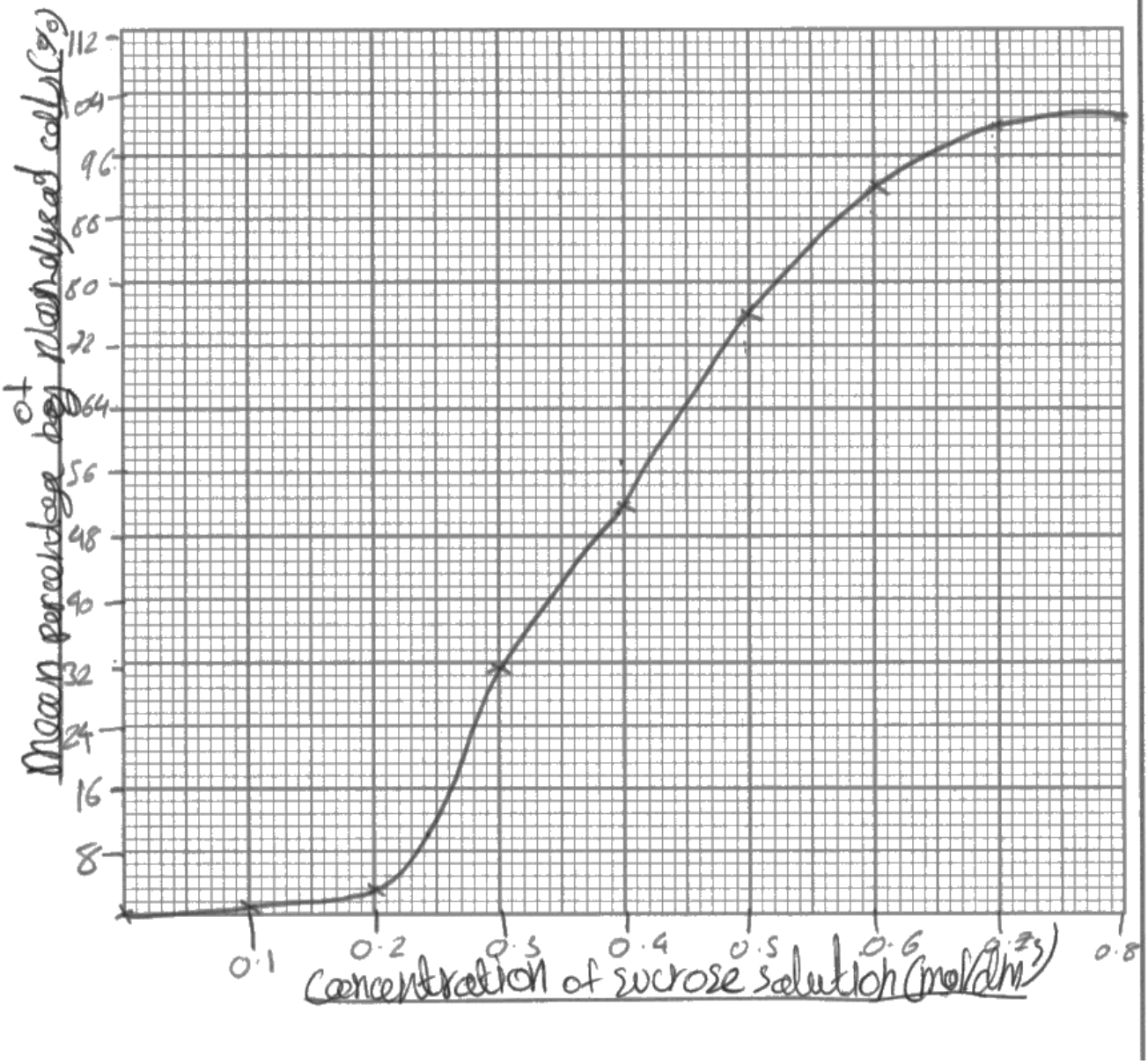
ResultsPlus
Examiner Tip

Always choose a sensible scale that makes plotting easy – this is perfect!

Plot a suitable graph to display these results.

Join the points with straight lines.

(3)



ResultsPlus
Examiner Comments

This candidate made two important errors:

- The scale is difficult to use and this has made plotting difficult. There is an error at 0.4mol dm^{-3} where the point was plotted at about 50% instead of 60%.
- The points are not joined with straight lines.

So mp1 only.

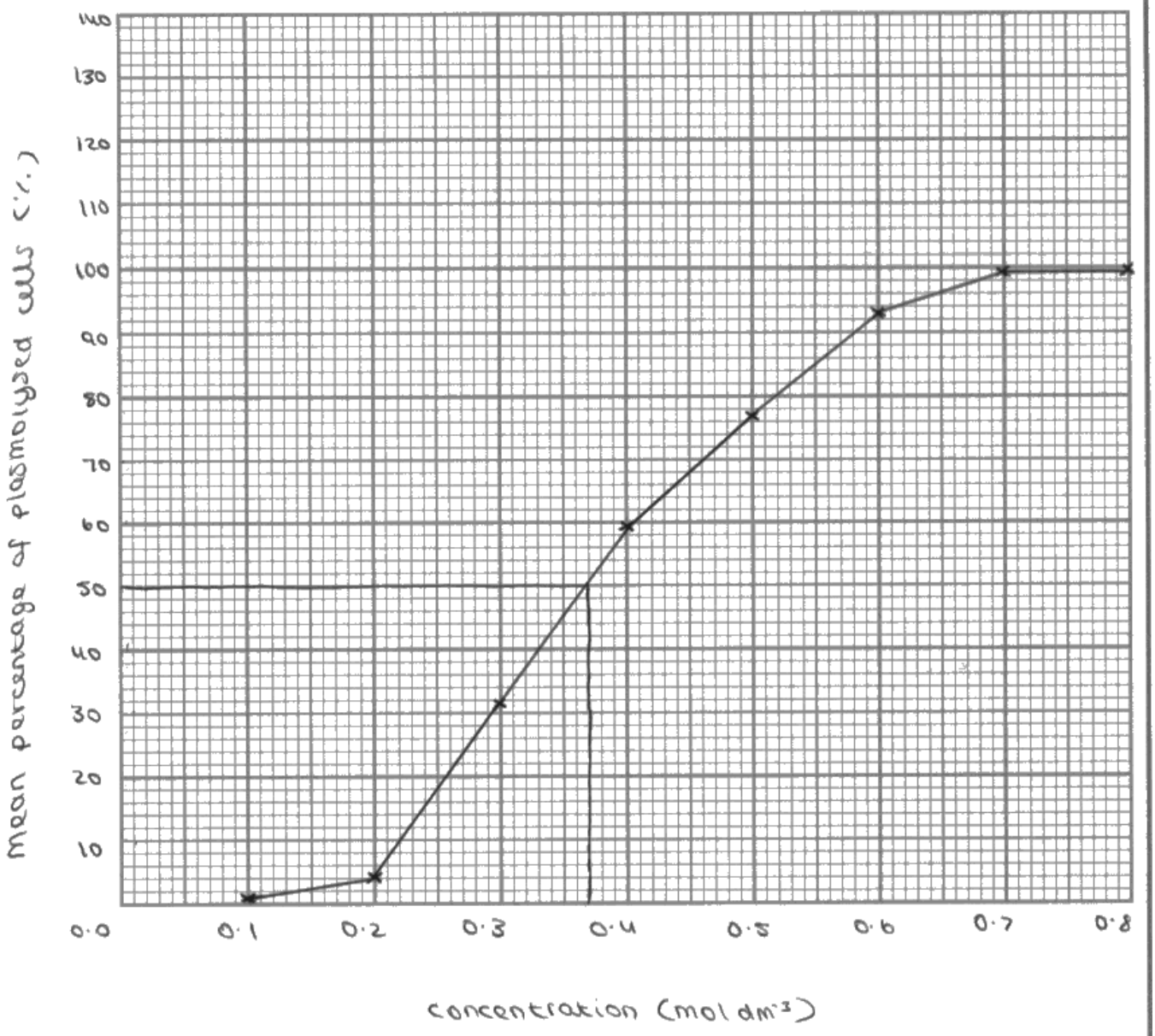
ResultsPlus
Examiner Tip

Always follow the instructions you are given, and make sure you bring a ruler to exams.

Plot a suitable graph to display these results.

Join the points with straight lines.

(3)



ResultsPlus
Examiner Comments

This candidate made two errors which lost marks:

- The x-axis header is incomplete (does not state that it is sucrose solution).
- The point at the origin is not joined to the point at 0.1 mol dm^{-3}

So mp2 only.

Question 5 (a)(iii-vi)

This was a linked series of questions allowing ecf to be awarded if candidates made an error in some parts.

Question 5(a)(iii) asked them to determine the concentration of the cell sap of the onion cells using the graph they had drawn. Reading off the 50% plasmolysis level gave a value of 0.37 mol dm^{-3}; we allowed a range of 0.36 – 0.38 mol dm^{-3}.

Question 5(a)(iv) asked them to use a conversion graph and their answer to (a)(iii) to determine the osmotic potential of the cell sap of the onion cells. The value of 0.37 mol dm^{-3} gave a reading of – 980 kPa. We allowed a range of +/ – 20 to account for small errors in reading off the scale, and allowed ecf (with +/ – 20) for any answer to part (a)(iii).

Question 5(a)(v) asked candidates to write the equation for water potential, either in symbols or words. Many got the terms correct, but not all added them together; some subtracted, some multiplied and some divided. Some candidates referred to oncotic potential or osmotic pressure, which did not gain credit.

Question 5(a)(vi) asked candidates to state the water potential of the cell sap of the onion cells when 50% were plasmolysed.

water potential = turgor pressure + osmotic potential

When the cells are plasmolysed the turgor pressure is 0, so water potential = osmotic potential

For a cell sap concentration of 0.37mol dm^{-3} the cell sap osmotic potential was – 980kPa. If turgor pressure is zero, then water potential is – 980kPa.

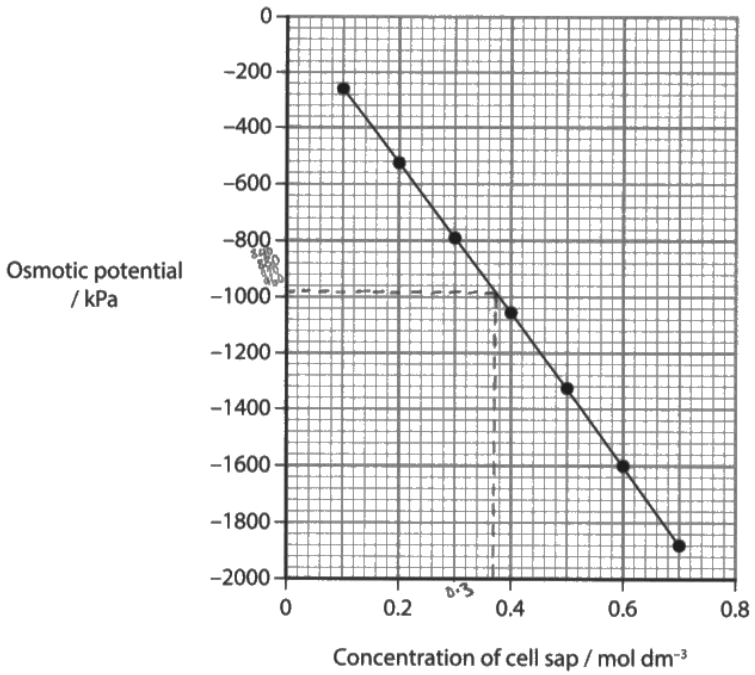
With ecf, we were accepting an answer in part (a)(vi) which matched their answer to part (a)(iv), or the standalone answer of – 980kPa.

(iii) Determine the concentration of the cell sap of the onion epidermal cells, using your graph.

(1)

Answer 0·37 mol dm^{-3}

(iv) This conversion graph can be used to convert the concentration of cell sap into osmotic potential.



Determine the osmotic potential of the cell sap of the onion epidermal cells. Use your answer to (b)(iii) and the conversion graph.

(1)

Answer −980 kPa

(v) Write the equation that is used to calculate the water potential of a plant cell.

(1)

water potential = osmotic potential + turgor pressure

(vi) State the water potential of the cell sap of the onion epidermal cells when 50% of the cells are plasmolysed.

(1)

Answer −980 kPa

ResultsPlus
Examiner Comments

This candidate gave the correct answer for all 4 parts of the question, scoring maximum marks.

Question 5(a)(iii): answer was 0.37

Question 5(a)(iv): answer was – 980

Question 5(a)(v): equation given correctly

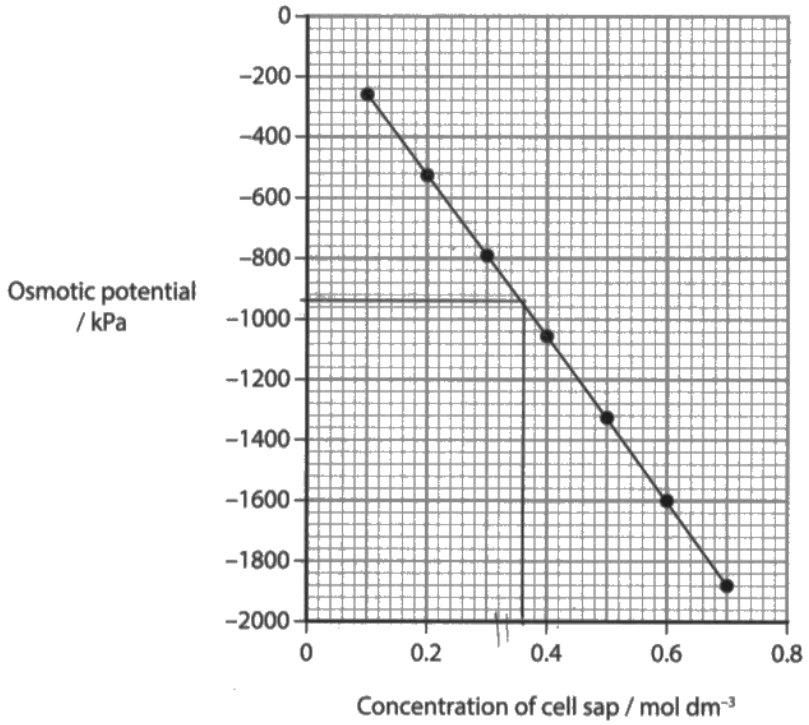
Question 5(a)(vi): answer was – 980

(iii) Determine the concentration of the cell sap of the onion epidermal cells, using your graph.

(1)

Answer 0.365 mol dm^{-3}

(iv) This conversion graph can be used to convert the concentration of cell sap into osmotic potential.



Determine the osmotic potential of the cell sap of the onion epidermal cells. Use your answer to (b)(iii) and the conversion graph.

(1)

Answer −930 kPa

(v) Write the equation that is used to calculate the water potential of a plant cell.

(1)

Water potential = Solute potential + Turgor pressure.

(vi) State the water potential of the cell sap of the onion epidermal cells when 50% of the cells are plasmolysed.

(1)

Answer −930 kPa

ResultsPlus
Examiner Comments

This candidate scored 3 of a possible 4 marks.

Question 5(a)(iii): They read a value within the acceptable range from their own graph for 1 mark.

Question 5(a)(iv): When they used this value on the conversion graph, they misread the scale, getting – 930 (this was outside the range of tolerance), so no mark.

Question 5(a)(v): Equation given correctly for 1 mark.

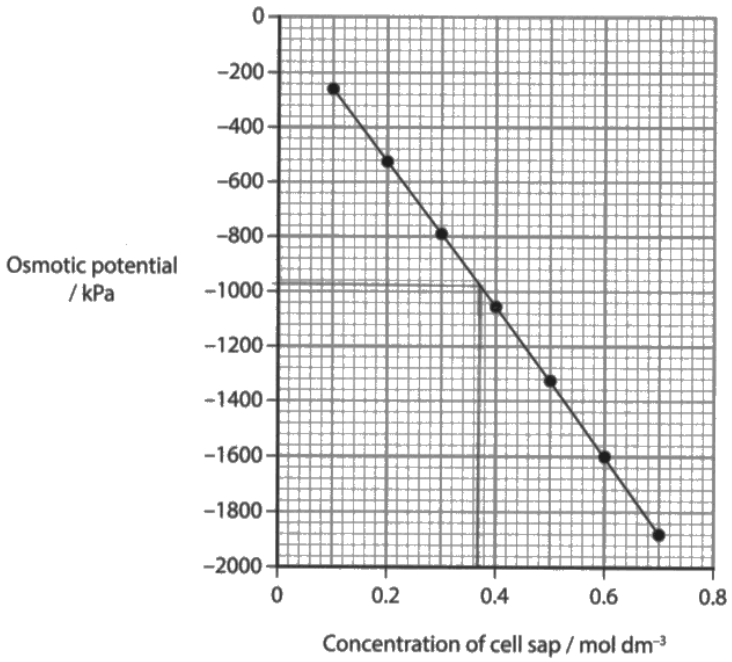
Question 5(a)(vi): Answer to this part matches answer to part (a)(iv) so 1 mark.

(iii) Determine the concentration of the cell sap of the onion epidermal cells, using your graph.

(1)

Answer 0.37 mol dm^{-3}

(iv) This conversion graph can be used to convert the concentration of cell sap into osmotic potential.



Determine the osmotic potential of the cell sap of the onion epidermal cells. Use your answer to (b)(iii) and the conversion graph.

(1)

Answer -980 kPa

(v) Write the equation that is used to calculate the water potential of a plant cell.

(1)

Ψ = turgor pressure + osmotic potential

(vi) State the water potential of the cell sap of the onion epidermal cells when 50% of the cells are plasmolysed.

-980

(1)

Answer 0 kPa

ResultsPlus
Examiner Comments

This candidate gave the correct answer for 3 of the 4 parts of the question, scoring 3 marks.

Question 5(a)(iii): Answer was 0.37. 1 mark here

Question 5(a)(iv): Answer was – 980. 1 mark here

Question 5(a)(v): Equation given correctly, scoring 1 mark.

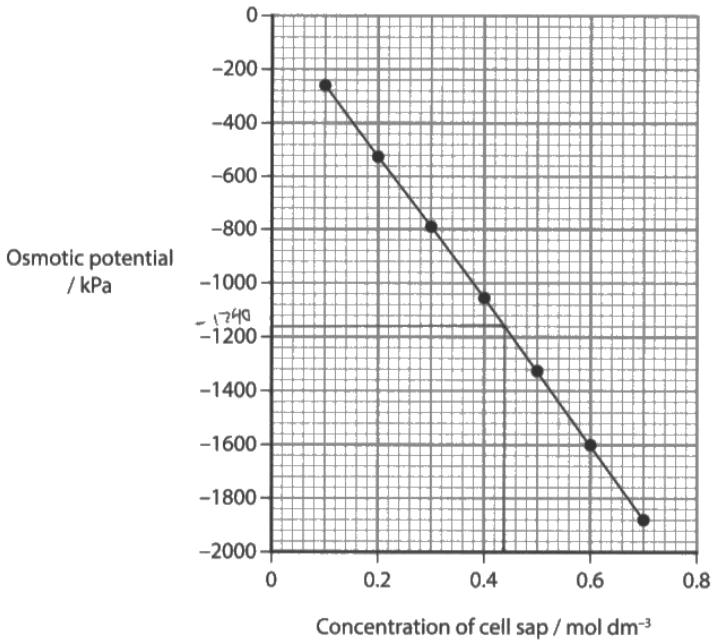
Question 5(a)(vi): Answer was wrong, zero instead of – 980.

(iii) Determine the concentration of the cell sap of the onion epidermal cells, using your graph.

(1)

Answer 0.44 mol dm^{-3}

(iv) This conversion graph can be used to convert the concentration of cell sap into osmotic potential.



Determine the osmotic potential of the cell sap of the onion epidermal cells. Use your answer to (b)(iii) and the conversion graph.

(1)

Answer -1240 kPa

(v) Write the equation that is used to calculate the water potential of a plant cell.

(1)

water potential = turgor pressure + osmotic potential

(vi) State the water potential of the cell sap of the onion epidermal cells when 50% of the cells are plasmolysed.

(1)

Answer -1240 kPa

ResultsPlus
Examiner Comments

This candidate read the wrong value from their own graph, but still managed to score 2 marks of a possible 4.

Question 5(a)(iii) : Wrong answer given (0.44 instead of 0.37). No mark for this part.

Question 5(a)(iv): 0.44 was used on the conversion graph, but the scale was misread, as the candidate did not realise the scale was in descending order (-1240 given instead of – 1160). No mark given.

Question 5(a)(v): Correct equation given for 1 mark.

Question 5(a)(vi) : Answer here matches answer to part (a)(iv), so one mark given under ecf.

Question 5 (b)

This question suggested three modifications that could be made to the method given, and asked why each would improve the validity of the investigation. As the improvements were given to candidates (and they did not have to identify them for themselves), it was disappointing that around 40% did not score on this question.

We were looking for:

- (tissue collected from the same onion) so cells would have the same osmotic potential / water potential
- (all tubes kept in a thermostatically controlled waterbath) because temperature affects the **rate** of osmosis
- (count more than one field of view) as it may not be representative / to increase sample size / to calculate standard deviation / to identify anomalies or outliers.

The most common errors were:

- making vague statements that variables should be controlled to improve validity – we expected explanations that matched the improvement
- saying that cells from the same onion would be the same species or age, without thinking about how this would affect this investigation
- saying to eliminate the effect of changing temperature without saying what it would be. Despite being told numerous times throughout the question that this investigation was about water potential and osmosis, a surprising number of candidates wrote about temperature in terms of membrane permeability or enzymes
- some candidates interpreted the change as meaning that the same field of view was counted twice and thought that this would prevent miscounting
- calculation of standard deviation was seen rarely, but a lot of candidates suggested that the mean could be calculated; this did not gain credit
- there was a lot of confusion about anomalies, with some candidates stating that counting more than once would prevent anomalies, rather than allow them to be identified.

(b) The students modified the method and repeated the investigation. The changes are shown in italics.

Step 2: all pieces of onion epidermis were cut *from a single onion.*

Step 2: tubes containing sucrose solution and onion epidermis layers were left *in a thermostatically controlled water bath* for 20 minutes.

Step 4: the total number of cells in the field of view, and the number that were plasmolysed were counted. *This was repeated twice for each of the sucrose concentrations.*

Explain why each of these changes are likely to improve the validity of this investigation.

(3)

because it makes sure all extraneous variables are controlled for like temperature and onion size. This means that the results are more likely to be accurate because no other factors are ~~having~~ can affe affecting them.

ResultsPlus
Examiner Comments

This was typical of the very generalised answers we saw which did not gain credit.

Step 2 allows that all cells will be the same or similar. Step 2 controls temperature, which will affect the activity of enzymes and the kE of sucrose. Step 4 allows that any anomalies can be identified and nulled, and also allows for meanst means to be calculated.

ResultsPlus
Examiner Comments

This answer scored mp3 at the end for identification of anomalies.

Using the same onion prevents differences in permeability and other qualities of the onion ~~th~~ altering results, by variables other than Sucrose solution concentration.

Controlling water bath temperature allows for more accurate, precise results due to control of condition, being what they claim

Counting more and repeating reduces risk of anomalous result, and larger sample size more representative.

(Total for Question 5 = 12 marks)

ResultsPlus
Examiner Comments

This answer scored mp3 at the end for the larger sample size being more representative. The idea of reducing the risk of anomalous results did not get credit.

In step 1 : cutting pieces of onion epidermis from a single onion is more valid as each onion may have slight differences in water potential and using a single onion makes sure that the age of each sample is relatively the same

In step 2 controlling temperature (at high temperatures) is a good modification as temperature affects rate of osmosis, it increases the kinetic energy of particles and the rate of osmosis is increased, at low temperatures particles have less kinetic energy so this reduces rate of diffusion.

In step 4, repeats improve validity as it allows us to spot anomalies and discard them

ResultsPlus
Examiner Comments

This strong answer scored all three marks.

Question 6 (a)(i)

Question 6 tested the candidates' understanding of the effect of different wavelengths of light and different mineral ion concentrations on the doubling time of duckweed.

Part (a) was about the effects of changing the wavelength of light, using coloured filters. Candidates were provided with a graph showing how the number of plants increased over a 12 day period, and were asked to explain the results.

Most candidates understood that the increase in number of plants could be linked to photosynthesis, and that this was affected by the wavelengths of light the pigments could absorb. However, lack of precise language in explanations cost some candidates marks. There were three marking points for two available marks; these could be expressed in the context of white light (no filter) or filters present.

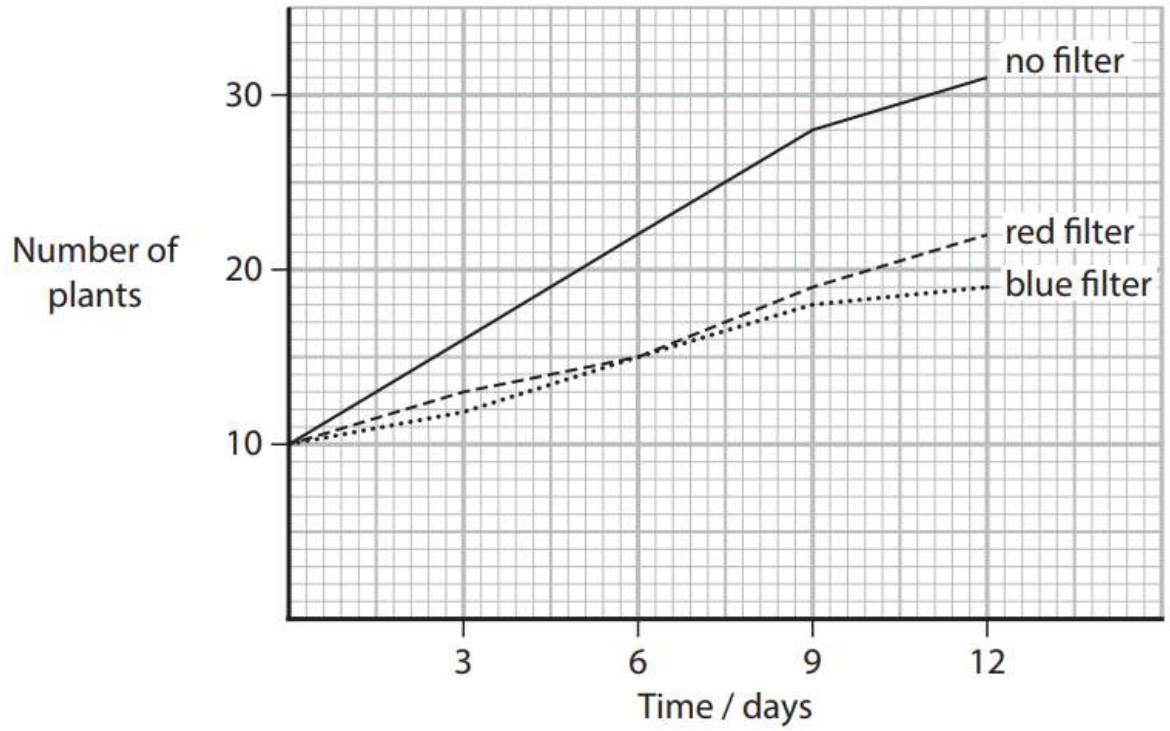
- The **rate** of photosynthesis is greatest when there is no filter.
- Because plants are able to absorb **more** wavelengths of light when no filter is present.
- So **more** named photosynthetic products are made / more glucose results in faster respiration / mitosis occurs more rapidly to produce daughter plants.

Mp2 was most commonly seen.

Some candidates came close to mp 1, but did not refer to **rate** of respiration. Mp3 was attempted less often, and some answers were not directional, ie **more** glucose etc, when no filter was present.

A small number of candidates did not refer to photosynthesis at all in their answer, implying that the colours of light directly affected the increase in number of plants.

The graph shows the results of this investigation.



(a) (i) Explain the results of this investigation.

(2)

The results show that neither the blue nor red pigments are the highest contributing factor as the blue filter has the slowest doubling phase and red ~~in~~ isn't much better. The control worked the best which could also mean it's multiple pigments contributing to the process.

ResultsPlus
Examiner Comments

This candidate did not mention photosynthesis or the absorption of light by the pigments, so scored zero.

(a) (i) Explain the results of this investigation.

(2)

- adding a filter reduces rate of reproduction, both red and blue light absorbed by chlorophyll
- as removes some wavelengths of light ∴ less absorbtion by chlorophyll ∴ less efficient photosynthesis
- blue filter reduces reproduction rate further as more efficient absorbtion of red light
- Similar decrease shows both red and blue wavelengths of light are absorbed by chlorophyll

ResultsPlus
Examiner Comments

This candidate explained how filters removed some wavelengths of light, scoring mp2, but did not get credit for less efficient photosynthesis.

ResultsPlus
Examiner Tip

Avoid the word "efficient" in answers, it is usually not precise enough to gain a mark – try to think about how it is less efficient. Here if the wavelengths of light are reduced, the rate of photosynthesis will be decreased.

This is Core Practical 10.

(a) (i) **Explain the results of this investigation.**

(2)

with no filter, there was the most number of plants grown as all wavelengths of light could be absorbed by chloroplasts for photosynthesis. with filters, only certain wavelengths absorbed, decreasing rate of photosynthesis.

ResultsPlus
Examiner Comments

This answer includes mp2 and then mp1.

(a) (i) **Explain the results of this investigation.**

(2)

The number of plants increased the most with no filter as all wavelengths of light was available for the chlorophyll to absorb hence ~~the most~~ more light dependent reaction and the light independent reaction can occur, producing more GALP to be used to synthesise organic matter for plants to increase

ResultsPlus
Examiner Comments

This answer scored mp2 and then mp3 for the statement that more GALP is produced.

Question 6 (a)(ii)

Candidates were told how the original investigation had been set up and asked how to reduce the time taken for the number of plants to double. Most realised that this was asking them how to increase the rate of photosynthesis, and scored both available marks.

The most common errors were

- to give two points linked to the same factor, eg increasing the intensity of light and moving the lamp closer
- to give a non-directional answer eg provide optimum temperature rather than increase the temperature (from 10°C)

A small number of candidates misunderstood and suggested changes that would decrease the rate of photosynthesis, rather than decreasing the doubling time.

(ii) The shortest time for the number of plants to double was more than 3 days.

Give **two** ways of reducing the time taken for the number of plants to double.

(2)

1 Increase the temperature slightly but not too much that enzymes denature.

2 Add more inorganic ions to the water.

ResultsPlus
Examiner Comments

This candidate scored both marks.

(ii) The shortest time for the number of plants to double was more than 3 days.

Give **two** ways of reducing the time taken for the number of plants to double.

(2)

1 use a ~~specie~~ different species of ca Lomna that asexually reproduces faster.

2 provide optimum conditions ~~temperature~~.

ResultsPlus
Examiner Comments

This answer scored zero.

The first suggestion (of using a different species) does not address the question of how to make the plants reproduce faster.

The second suggestion is too vague to gain credit.

ResultsPlus
Examiner Tip

The question stated "in ideal conditions the doubling time is around three days".

Here you were being asked to think about what those ideal conditions might be!

(ii) The shortest time for the number of plants to double was more than 3 days.

Give **two** ways of reducing the time taken for the number of plants to double.

(2)

1 ~~Increasing~~ Decreasing temperature

lower light intensity of lamp

2 Reducing concentration of dissolved ions

ResultsPlus
Examiner Comments

This candidate knew what was needed for rapid photosynthesis, but misunderstood the question, so lost both marks.

Question 6 (a)(iii-iv)

Question 6(a)(iii) and (iv) were linked questions, about **accuracy** of results.

Candidates were asked for one reason why the results might not be accurate; and to describe a method that could be used to measure the growth of the plants more accurately.

Accuracy is how close a measurement is to its true value. Here the result being measured was the number of plants at 3-day intervals, so candidates were being asked why the number may be incorrect. They were then being asked to suggest a better way to measure the growth rate than counting floating plants.

This pair of questions was generally answered poorly. Many candidates did not appear to understand what they were being asked, and answered in terms of validity, eg that there may have been an additional light source, or that mineral ions were being used up as the investigation continued.

Question 6(a)(iii) All three marking points were seen, but rarely. We did not accept that the plants were difficult to count simply because they were small, since the numbers were relatively low.

Question 6(a)(iv) This part was slightly better done, with some candidates able to suggest a more accurate method than counting. Finding the mass of the plant or measuring the root length were the most common suggestions. However, a number suggested drying the plants in an oven to find the dry mass, before putting them back in the tank to grow for a further 3 days, which clearly would not work.

(iii) Give **one** reason why the results may not be accurate.

(1)

it is difficult to count accurately / distinguish seperate duckweed plants as they're small and there are many that can overlap

(iv) Describe a method that could be used to measure the growth of the plants more accurately.

(2)

measure the dry biomass, leave the duckweeds to dry in an oven and then weigh, carry out seperate investigations, one 3 days long, one 6 days, one 9, and one 12 days long so that the biomass produced at each time frame can be compared.

ResultsPlus
Examiner Comments

This is a very strong answer, scoring maximum marks.

In part (a)(iii), they recognised that the plants may be difficult to count because they overlap.

In part (a)(iv), they suggested measuring the mass and described the use of replicates and dry mass (plants dried in an oven).

(iii) Give **one** reason why the results may not be accurate.

(1)

It may be difficult to count the individual plants in 3d as the plants may end up overlapping, or the smallest plants may not be visible clearly.

(iv) Describe a method that could be used to measure the growth of the plants more accurately.

(2)

Use biomass. Calculate the initial weight of the plants and then measure the fin[illegible] the mass to double [illegible] This D more accurate as it takes into account the growth of each plant, as some could be small, some could be big.

ResultsPlus
Examiner Comments

This candidate scored 1 mark for part (a)(iii) for the statement that it may be difficult to count them because they are overlapping.

They went on to score 1 mark for part (a)(iv) for suggesting finding the weight of the plants. However, they did not give a detail of the technique eg blotting them dry, so did not score the second available mark.

(iii) Give **one** reason why the results may not be accurate.

(1)

Other light way have affected plant growth.

(iv) Describe a method that could be used to measure the growth of the plants more accurately.

(2)

Use same light filters but instead measure ~~length~~ size of an individual plant at intervals of 3 days instead of number.

ResultsPlus
Examiner Comments

This is typical of the many answers which focused on validity rather than accuracy.

In part (a)(iv) they came close to getting a mark, but measuring the size of the plant was not detailed enough to gain credit.

ResultsPlus
Examiner Tip

Avoid giving "size" as a variable – think about what you could measure and state that instead, eg length / width / area / mass

Question 6 (b)

Question 6(b) described a second investigation with duckweed where the concentrations of mineral ions provided were changed. Growth of plants was monitored over four weeks with three different concentrations of fertiliser.

Candidates were asked to **explain** the effect of increasing fertiliser concentration on the growth of the duckweed. Generally, this was very well answered, with many scoring full marks.

Most candidates were able to give a concise conclusion, that increasing the concentration of fertiliser increased the growth, and go on to explain why.

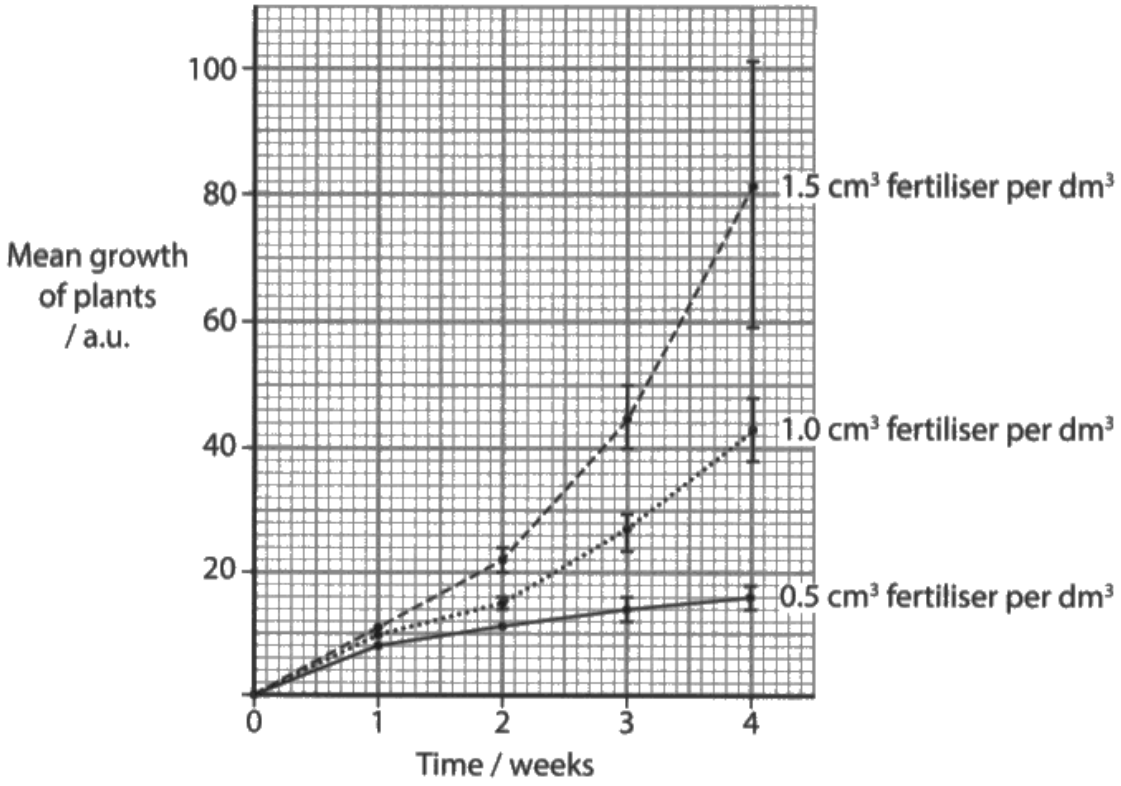
Some described the conclusion, which gained credit, but spent a lot of time describing the error bars on the graph, which did not answer this question.

(b) In another investigation, the student grew duckweed plants in water containing a fertiliser.

The fertiliser contained nitrate, phosphate and magnesium ions.

Three concentrations of the fertiliser were used, with all other conditions kept constant.

The graph shows the results of this investigation.



Explain the effect of increasing fertiliser concentration on the growth of these plants.

(3)

Increasing fertiliser concentration increased mean growth ~~because the plant~~ of plants because they are recieving more mineral ions like nitrate, phosphate and magnesium. These mineral ions are all used in growth, for example nitrates are used to produce amino acids ~~and protein~~ which then form proteins.

ResultsPlus
Examiner Comments

This candidate gained mp1 for the conclusion. They picked out relevant information from the stem about the three minerals found in the fertiliser, but only gave a use for nitrate, gaining mp2.

They achieved 2 marks of a possible 3.

(3)

Increasing fertiliser increases plant growth. 1·5 and 1 don't have overlapping standard deviations so results are more accurate than 0·5. 0·5 starts to level of towards 3 to 4 weeks. More fertiliser means more nitrate ions for amino acids. More phosphate ions for DNA RNA, ATP and ADP. More magnesium ions for chlorophyll.

ResultsPlus
Examiner Comments

This candidate covered all 4 marking points.

Mp1 for the conclusion.

Mp2 for a use of nitrate ions.

Mp3 for a use of phosphate ions.

Mp4 for a use of magnesium ions.

This was typical of many of the strong answers we saw.

Explain the effect of increasing fertiliser concentration on the growth of these plants.

(3)

- 1.5 cm^3 of fertiliser significantly increased mean growth of plants compared to the other 2 concentrations
- after 4 weeks mean growth of plants at 0.5 cm^3 was 16 a.u however at 1.5 cm^3 it was 81 a.u
- mean growth is very similar at all fertiliser concentrations after 1 week

ResultsPlus
Examiner Comments

This answer gained mp1 for the conclusion in the first sentence.

The rest of the answer did not gain credit as it was a description of the results, not an explanation.

ResultsPlus
Examiner Tip

Always look carefully at the command word – here it was explain.

~~Increasing the fertiliser increases the~~
The use of fertiliser increases the mean growth of plants. The higher the ~~concentration~~ volume used the higher the mean growth. Increased fertiliser increasing the ions available to the plant for the building of amino acids, the creation of membranes, and for the production of chlorophyll. These all are necessary for plant growth.

ResultsPlus
Examiner Comments

This answer scored mp1 for the conclusion.

Although they knew that amino acids, membranes and chlorophyll were important for growth, these were not linked to specific mineral ions, so this candidate did not achieve mp2, 3 or 4.

Question 6 (c)

Question 6(c) told candidates it had been suggested that duckweed could be grown in water polluted with organic waste from cows and that the duckweed could then be processed to make food for poultry and cattle. They were asked to use the information in the question to comment on this suggestion.

To recap, they had been told that:

- in ideal conditions, the number of duckweed plants could double in three days
- temperature and light were critical for this process
- increasing the concentration of fertiliser significantly increased growth rate.

Credit was not given for simply repeating this information, but it was given when the information was applied to the new context, ie producing animal feed from duckweed. We were looking for the following ideas:

- that the duckweed would clean the water, by removing excess mineral ions
- that in the right conditions it would grow very fast, making a lot of food quickly
- that it was cheap (because it was using waste products) or sustainable (because there was a lot of waste to use)
- that there is evidence that the concentration of fertiliser affects growth (because error bars do not overlap)
- that it needs ideal conditions to grow fast, eg large area to float in a single layer or warm temperature
- that the mineral ions in fertiliser might not be in the right proportions for duckweed, or that not all required ions may be present
- that the growth of duckweed might have negative effects on other aquatic life (if it was grown in a pond)
- that rapid growth was not certain at high levels of mineral ions (because error bars were large)
- that there was a risk that the feed might carry disease or be contaminated with bacteria from the organic waste.

Many candidates found this very challenging and were not able to apply the information to the new context. The most frequently awarded marks were for comments on cost or sustainability; comments on effects of fertiliser being significant (as error bars were not overlapping), or effects on growth not being certain (as error bars were large); comments on the proportions of mineral ions being wrong for the growth of duckweed; comments on negative effects on other aquatic life; comments on the risk of transmission of disease to the animals eating the feed produced from duckweed.

This answer illustrated several of these points and scored the maximum 4 marks:

6c. The organic waste may have a greater concentration of mineral ions that the plants can used. As shown by the non-overlapping standard deviations, the greater the concentration of fertiliser, the greater the mean growth of plants. fI there is a great growth rate of the duck weed, ti allows the food stock to be replenished quickly. The organic waste will contain carbon compounds that the decomposers breakdown and they release carbon dioxide into the air around them, which means that there will be an increase in the amount of carbon fixation ni the light independent reactions so more GALP can be produced. As well, the excrement will contain nitrogen, magnesium and phosphate compounds which will be broken down again by decomfosers and released into the water. This allows there to be a sustainable source of food as it will be recycling the nutrients, like mineral ions.

(c) It has been suggested that duckweed could be grown in water polluted with organic waste from cows.

These plants could be processed to make feed for poultry and cattle.

Analyse the information to comment on this suggestion.

(4)

this suggestion could be valid as organic waste contains ions like artificial fertilisers and increasing fertiliser concentration increased growth over error bars don't overlap so increased concentration of these ions had a significant effect. however, the organic waste may not contain all the ions needed for growth as some are used by the cow and high concentration of waste may prevent water uptake. using

ResultsPlus
Examiner Comments

This answer covered 2 points and scored 2 marks for:

- the idea that increasing the concentration of mineral ions had a significant effect on growth because the error bars did not overlap
- the idea that the organic waste might not contain all the mineral ions the duckweed needed.

Information in the results show higher fertiliser concentration does benefit plant growth as the 0.5cm³ condition plateaus at just 1 week of growth, reaching 16 a.u only by 4 weeks, compared to 1.5cm³'s 82 a.u at 6 weeks. This could show that organic waste from cows - also high in nitrate magnesium and phosphate - could benefit duckweed growth too. Furthermore the cow waste may prove to grow duckweed not just taller but faster, 1.5cm³ fertiliser surpassing the 1.0cm³ 4 week mark at just 3 weeks. This would be beneficial for the rearing of duckweed to be feed as it would provide higher yields faster, while size* in processed feed matters less. However the results also show higher ion concentration leads to higher variability in crop size, the range of 1.5cm³ being beyond 40 a.u compared to the 10 a.u. range of the next biggest concentration. This is not useful for farmers reading feed as they would want reliability and consistency in their feed yields. Also the plants must be treated externally **(Total for Question 6 = 14 marks)**

* of crop

to be cleared and reduce risk of disease spread ~~so that~~ in the faeces which can be time and money consuming.

ResultsPlus
Examiner Comments

This strong answer covered 4 of the points, scoring 4 marks for:

- there is evidence that concentration of mineral ions affects growth of duckweed
- that rapid growth gives a high yield of animal food faster
- that there is variability in (duckweed) crop size which leads to uncertainty for farmers
- that there is the risk of spreading disease from the organic waste.

Question 7 (a)

This question assessed understanding of Core Practical 12 (growth of bacteria in a liquid medium) although credit was also given for growing bacteria on agar plates.

Candidates were told that a student investigated the antibacterial properties of turmeric, a spice made from the root of a plant, and that they suggested the hypothesis *"an extract made from turmeric root will reduce the growth of bacteria".*

They were asked to devise a valid method to test this hypothesis. There were nine marking points for six available marks; to summarise, credit was given for:

- a suitable method of growing bacteria (in liquid medium or on agar plates)
- a suitable method of applying the turmeric extract
- procedure followed with and without turmeric (different concentrations were allowed, as long as one of them was zero concentration)
- a suitable time or temperature for growth of bacteria
- a method of collecting results that matched the method of growing bacteria and the method of applying the turmeric extract
- use of a statistical test for difference, eg a t-test, or use of replicates and standard deviation
- a description of aseptic technique.

There were two further marking points (relating to method of making the root extract or making a known concentration of extract) which were rarely seen. However, many candidates scored very highly on this question, demonstrating their knowledge of the techniques and their ability to write a clear and logical answer.

The most common errors were to leave out details, or to give a method of collecting results which did not match the method of growth of bacteria or the method of applying the turmeric extract, eg mixing the turmeric extract into the molten agar, then suggesting measuring zones of inhibition. A surprising number dripped the turmeric extract directly onto the agar plates, on top of bacteria, rather than using paper discs soaked in the extract.

7 Turmeric is a spice made from the root of the plant *Curcuma longa*.

It has been used in traditional medicine for many years.

(a) A student investigated the antibacterial properties of turmeric.
The student suggested the hypothesis:

An extract made from turmeric root will reduce the growth of bacteria.

Devise a valid method to test this hypothesis.

(6)

Collect 5 Petri dishes and using an inoculating loop and the correct aseptic techniques dip in to a solution of e coli and spread over 5 plates of agar jelly. Prepare 5 different solutions of turmeric solution each with a different concentration (0.2, 0.4, 0.6, 0.8, 1.0 g moldm^{-3}). Soak 5 different discs with each of the different concentrations of agar turmeric solution and place the disk each disk on the different agar jelly plates and write the concentration on the plate with marker. Ensure temperature and pH are controlled to reduce external factors affecting the results and make sure the turmeric has all been collected from the same plant. Incubate the plates for a week and then measure the zones of inhibition using a ruler. Then record the results on a graph for concentration of turmeric solution compared to area of zone of inhibition.

ResultsPlus
Examiner Comments

This answer came close to many of the marking points, showing that the candidate had an understanding of the processes involved. However, lack of detail resulted in a final score of 2 marks. Marks were awarded for:

- adding bacteria to agar plates
- using paper discs to apply the turmeric extract.

The following points could not be given:

- aseptic technique was mentioned, but not described
- a range of concentrations was suggested, but zero was not included
- the incubation temperature was not given, and a week was not a suitable time
- the zone of inhibition is mentioned, but it is not clear what is being measured.

ResultsPlus
Examiner Tip

When describing a practical procedure, always include details.

Independent variable; presence of tumeric extract

Dependent variable; growth of bacteria using bacterial lawn on agar plate and measuring zone of inhibition once tumeric added with ruler or in liquid culture measuring turbidity using calibrated colorimeter.

Control variables; bacteria species (some may/may not be effected) needs to be constant.

Temperature (incubate at 22°c) so below human body temperature (may effect growth)

Time allowed to grow for

Use antimicrobial spray on any work surfaces, flame innoculating loop from handle to tip when transferring bacteria and work near a lit bunsen burner.

Cover paper disc in tumeric (soak in tumeric extract/ solution of same volume + concentration) and place in centre of agar plate with bacterial culture on it. (get culture by spread plating + incubating 24h)

Leave to incubate for 24hours and calculate area of inhibition (if present) to see if growth was stopped

Repeat 3x to calculate mean and standard deviation.

ResultsPlus
Examiner Comments

This strong answer scored 6 marks for:

- mp3 for bacteria grown on an agar plate
- mp6 for suitable temperature
- mp9 for description of flaming the inoculating loop
- mp4 for use of paper discs
- mp7 for calculating the area of the clear zone
- mp8 for repeating and calculating standard deviation

They did not score mp5 as although they stated that the independent variable was the presence of turmeric extract, there was no control disc used.

Extract a solution from tumeric. Add to an agar jelly to make a tumeric jelly. Use an easily identifiable bacteria, using aseptic techniques such as cleaning work space, ~~with~~ and working next to a bunsen burner. Have one plate with no tumeric and one with. Using the streak plating method, spread bacterial solution across the jelly. Make sure to sterilise the enocculated loop using a busen burner and only slightly lifting the lid of the plate. Use bacterial stock solution. Incubate the plates for 24 hours at 25-30°C (body temperature) then see if the bacteria have grown, using ruler to compare area. plot graph with results and use standard deviations and a t-test to acknowledge significant difference.

ResultsPlus
Examiner Comments

This candidate used a different method to apply the turmeric extract, mixing it into the agar, achieving mp4.

They clearly had one plate with turmeric and one plate without, which gained mp5.

They did not have a suitable method of collecting results so did not get mp7; "see if bacteria have grown" is too vague and area is irrelevant here. Counting colonies would have been much better.

They used a t-test to find out if there as a significant difference, achieving mp8.

They also achieved mp9, 3 and 6.

Question 7 (b)

This question provided candidates with information about the design and outcomes of a trial comparing turmeric extract with an existing drug for the treatment of joint pain. It tested their ability to critically analyse information and make judgements, which is a key part of working scientifically.

There were some excellent responses to this question, with many candidates providing thoughtful and detailed answers. For full marks, we were looking for a mixture of comments on the design of the trial (which had some clear faults), as well as the outcomes of the trial. Generally, the description of the outcomes was better, and some candidates confined themselves to this, scoring a maximum of four marks.

The most commonly seen marking points were 6, 7, 8 and 9, although all were seen.

The most common error was to misread the graph about weight loss and state that fewer patients had weight loss with Drug A, rather than that there was a lower mean percentage weight loss (we are not told anything about the number of patients affected). Regarding the design of the trial, some thought that 139 was a large number of patients for a trial to replace an existing drug with a new treatment, and few commented on the short duration of the trial, only 28 days.

We did not give credit for suggesting that there were differences in the number of patients who reported 50% improvement in pain levels or those rated as having good or excellent outcomes by doctors; the percentages given in the graphs were very similar, the sample size was small (only 139) and there were no error bars.

Analyse the data to discuss the suggestion that curcumin should be used to replace Drug A as a treatment for knee pain.

Use information about the design of this trial **and** the results to support your answer.

(6)

Curcumin should be used to replace Drug A:
·Curcumin has less side effects so less disruptive to life
·Around 12% of patients using curcumin reported side effects
·Compared to around 38% of patients ~~q~~ with effects from Drug A
·Curcumin has higher rating of having excellent/good outcome at around ~~88~~ 95% compared to around ~~86~~ 90% of patients with Drug A saying this
·Curcumin shows 1.6% weight loss compared to 0.2% in Drug A - weight loss may reduce inflamation and immobility
·~~86~~ 92% of patients reported at least 50% improvement in Pain levels at day 28 with ~~cc~~ curcumin
Curcumin should not be used in replacement:
·Higher rating of pain improvement in Drug A at around 96% compared to around 92% in curcumin
·Higher dosage of 500mg of curcumin given compared to 50mg of Drug A, so requires higher dosage
·Curcumin needs to be given 3 times a day, Drug A only needs to be given twice
·Only 139 patients included - relatively small population size in comparison to people who have joint pain
·Only done for a month - long term effects not seen
·People over the age of 65 not included - they may have more severe pain

(Total for Question 7 = 12 marks)

ResultsPlus
Examiner Comments

This answer scored 5 of a possible 6 marks for:

- mp7 for the comment on side effects (lines 2-4)
- mp9 for the comment on weight loss (lines 8-9)
- mp1 for the comment on number of patients in trial (lines 19-20)
- mp 2 for the comment on the length of the trial (line 21)
- mp3 for the comment that people over 65 were excluded (lines 22-24).

We did not award mp6 or 8, as the candidate suggested that there was a difference in outcomes.

Both Drug A and Curcumin had similair results in terms of percentage of patients who reported improvement in pain levels. This suggests that the two are similair in effectiveness. Especially as they both had similair ratings in percentage of patients with good outcomes by doctors.

However, Drug A had a higher percentage of patients who reported negative side effects like nausea and vomiting than Curcumin whereas curcumin had a higher percentage of patients who experienced weight loss - which may not necessarily be a bad side effect. Therefore, Curcumin could be argued to replace drug A due to having fewer negative side effects.

However, the curcumin group was given a higher dosage and more often than the Drug A group therefore more curcumin is needed to have the same effectiveness as Drug A.

Furthermore, the doctors measurement of improvement is not very objective, someones rating of 5 in pain may be someone elses 2 in rating therefore results may not be very accurate representations of effectiveness.

In addition, both drugs were only administered for 28 days. Drug A is an existing treatment therefore the side effects are more known whereas Curcumin, the long term effects are not known therefore it cannot be considered to replace Drug A without researching it long term.

ResultsPlus
Examiner Comments

This answer also scored 5 of a possible 6 marks for:

- mp6 and mp8 (lines 1-5)
- mp7 (lines 6-7)
- mp5 (lines 15-17)
- mp2 lines 18-22).

We did not award mp9 as they stated that a higher percentage of patients experienced weight loss with curcumin.

~~Only~~ The results show that drug A and curcumin produce very similar % of patients with decreate in pain (about 95% patients) showing they have a similar effect. Curcumin produces fewer side effects in patients (12% not 38%) which means they are likely to be a better treatment, But curcumin causes many more people to experience weight loss. This sideeffect may be dangerous for some people if their weight get too low, but could benefit some if they are overweight as it reduces there chances of type 2 diabetes. Both drugs produced excellent or good outcomes for almost all patients. The lack of side effects from curcumin suggests it should replace drug A as treatment. The drugs have only been tested on a limited age range (38 to 65) and may have different effects on older or younger people. The effects have only been monitored for 28 days so long term effects are unknown and the patients with ~~severe side eff~~ diseases were excluded so it isn't a representative sample of the entire population and is a small sample so effects on wider population are unknown.

(Total for Question 7 = 12 marks)

ResultsPlus
Examiner Comments

This answer scored maximum marks for:

- mp6 (lines 1-3)
- mp7 (lines 4-6)
- mp8 (lines 11-12)
- mp3 (14-17)
- mp2 (lines 17-19)
- mp1 (lines 21-22).

Question 8 (a)

Question 8 assessed Core Practical 16 (the effect of an abiotic factor on the distribution of a species) as well as the use of a statistical test to analyse the data.

The context was the abundance of celandine along a transect from a path into a beech woodland. The method was described and candidates were provided with table of results.

Question 8(a) asked them to give a null hypothesis for this investigation.

We were looking for a clear statement that included the **type of relationship** being tested (here a correlation), the **dependent variable** (the abundance or number), the **name of the organism** being studied (celandine), and the **independent variable** (distance from the path) ie. there is no correlation between the number of celandine and the distance from the path.

Many candidates lacked confidence in making a null hypothesis, and it would be helpful if centres could give them the opportunity to practise this skill.

The most common errors were to refer to difference, rather than correlation (even though part (b) told candidates that a Spearman Rank correlation co-efficient was calculated); to use vague terms like relationship or effect, rather than correlation; to refer to plants in general, rather than the species being studied; or to propose a hypothesis that described how the number of celandine would change rather than a null hypothesis.

8 The photograph shows a celandine plant, *Ficaria verna*, that is commonly found in woodlands in the UK.



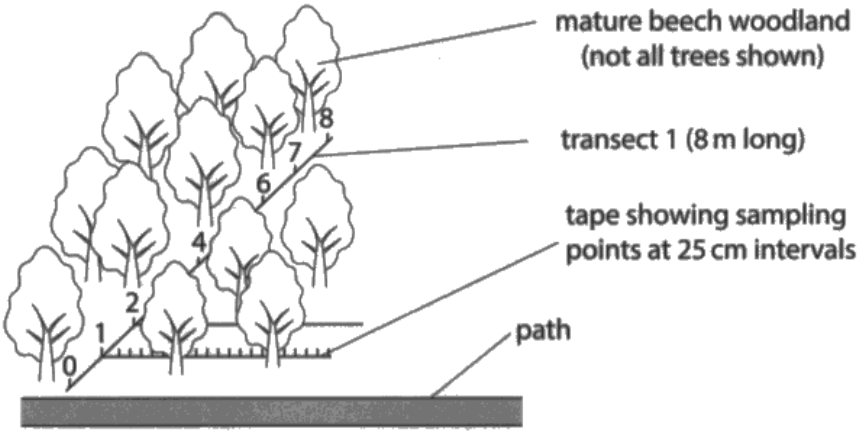
(Source: © TH FOTO-WERBUNG / SCIENCE PHOTO LIBRARY)

A student noticed that many of these plants grew in a mature beech woodland, but seemed to be less abundant as the distance from a path increased.

The student investigated the distribution of celandine using this method:

- set up a transect at 90° to the path (transect 1)
- at 1 metre intervals along the transect, place a tape parallel to the path
- record the presence or absence of celandine every 25 cm along the tape
- repeat for two more transects in the woodland (transects 2 and 3).

The diagram shows the arrangement of the transect and the tape.



(a) Give a null hypothesis for this investigation.

(1)

There is no correlation between distance from path and number of
cuandune plants

ResultsPlus
Examiner Comments

This clear null hypothesis is exactly what we were looking for, and gained the mark.

There will be no difference in the abundance of celandine plant as as the distance of the path increases.

ResultsPlus
Examiner Comments

This was the most common mistake we saw.

A difference will only be used if you are comparing two sets of data – here there were nine sets of data, so it must be a correlation.

The distance from the path has no effect on the abundance.

ResultsPlus
Examiner Comments

This candidate made two important mistakes:

- "Has no effect" is too vague to gain credit when writing a null hypothesis.
- They did not include the name of the species being studied.

(a) Give a null hypothesis for this investigation.

(1)

There will be no ~~difference~~ relationship between on the number of trees Ficaria verna along the line transect ~~symbols of if it is walked~~ and distance from the path.

ResultsPlus
Examiner Comments

This null hypothesis was correct apart from one important word – "relationship" is too vague, it should be correlation.

Question 8 (b)

Question 8(b)(i) gave candidates a table of data and asked them to calculate the correlation co-efficient, r_s.

Rank values, d values and d^2 values were all calculated for candidates, and the formula for r_s was given.

Many candidates had been well-prepared for this type of question and were able to carry out the calculation gaining the full three marks.

The most common errors were to:

- add up the d^2 values wrongly
- use n = 8, rather than n = 9
- to use n = 88.9 (which was the sum of the mean values – this error was seen quite a few times)
- to forget to subtract the intermediate value from 1
- to give the final answer to the wrong number of significant figures.

Many gave the final answer as – 0.967. The minus suggests that it is a negative correlation, and this was accepted for 3 marks. However, candidates should remember to ignore the minus sign when interpreting the r_s value in part (b)(ii).

Question 8(b)(ii) asked candidates to use the r_s value they had calculated to explain the conclusion that could be drawn from the investigation. There were three available marks:

- mp1 was for selecting the correct critical value from the table of values given. As there were 9 pairs of values, the critical value at p = 0.05 was 0.700 and at p = 0.01 it was 0.833. Either of these was acceptable.
- mp2 was for correctly comparing the critical value to their calculated r_s value, and either accepting or rejecting the null hypothesis.
- mp3 was for a conclusion that stated there was (or was not) a significant correlation between the number of celandine plants and distance from the path.

Ecf was allowed for incorrectly calculated values from part (b)(i) being used in part (b)(ii).

The most common errors were to:

- use the wrong number of pairs of values, and therefore read off the wrong critical value
- write that – 0.967 is less than the critical value of 0.700. The minus sign should be ignored, so 0.967 is greater than 0.700
- be confused about when to accept or reject the null hypothesis
- leave out the word "significant" in the conclusion.

(i) Calculate the correlation coefficient, r_s.

Use the formula:

(3)

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

Where:

$\sum$ = the sum of

d = the difference between each pair of ranks

n = the size of the sample (number of pairs of values)

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

$$r_s = 1 - \frac{6 \times 236}{9(9^2-1)}$$

$$= 1 - \frac{6 \times 236}{9 \times 80}$$

$$= 1 - \frac{1416}{720}$$

$$= 1 - 1.966667$$

$$= -0.967$$

Answer -0·967

(ii) The table shows some critical values for this correlation coefficient.

Number of pairs of values	Level of significance		
	0.10	0.05	0.01
4	1.000	–	–
5	0.900	1.000	–
6	0.829	0.886	1.000
7	0.714	0.786	0.929
8	0.643	0.738	0.881
9	0.600	0.700	0.833
10	0.564	0.648	0.794

Analyse the data to explain the conclusion that can be drawn from this investigation.

Use the table of critical values and your calculated correlation coefficient.

(3)

This table shows that there definitely is statistical significance as 0.967 > 0.833 meaning that there's ≤ 1% chance that these results were down to chance so it is fair to reject the null hypothesis as there is a very strong negative correlation between distance from path and abundance.

ResultsPlus
Examiner Comments

This candidate achieved full marks for both parts of the question.

In **Question 08(b)(i)** they calculated the right answer (0.967), and set out the working clearly, so all steps could be seen.

In **Question 8(b)(ii)** they indicated the correct critical values in the table, and chose one of them for comparison in the text, gaining mp1.

They correctly said that 0.967 is greater than 0.833 so the null hypothesis should be rejected, gaining mp2.

They concluded that there was a strong negative correlation between distance from the path and abundance and that there was a less than 1% chance that these results were due to chance, ie they were statistically significant. This gained mp3.

(i) Calculate the correlation coefficient, r_s.

Use the formula:

(3)

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

Where:

$\sum$ = the sum of

d = the difference between each pair of ranks

n = the size of the sample (number of pairs of values)

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

sum of d^2 = 64 + 36 + 16 + 4 + 1 + 1 + 16 + 49 + 49 = 236

9 number of pairs of values.

$n = 9$

$n^2 = 81$

$n^2 - 1 = 80$

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2 - 1)}$$

~~$r_s = 1 - \frac{6\Sigma}{}$~~

Answer −0.967

$$r_s = 1 - \frac{6(236)}{9(80)}$$

$= -0.9666...$

$= -0.967$ (3S.F.)

(ii) The table shows some critical values for this correlation coefficient.

Number of pairs of values	Level of significance		
	0.10	0.05	0.01
4	1.000	–	–
5	0.900	1.000	–
6	0.829	0.886	1.000
7	0.714	0.786	0.929
8	0.643	0.738	0.881
9	0.600	0.700	0.833
10	0.564	0.648	0.794

Analyse the data to explain the conclusion that can be drawn from this investigation.

Use the table of critical values and your calculated correlation coefficient.

−0.967(3S.f) (3)

The correlation coefficient was ~~0.968~~

At 0.05 significance level, −0.967 is less than 0.700

$-0.967 < 0.700$.

The correlation values are between −1 and 1.

In this case, −0.967 is very close to −1, meaning the data is showing negative correlation.

ResultsPlus
Examiner Comments

This candidate scored full marks for **Question 8(b)(i)**.

However, there were mistakes in **Question 8(b)(ii)**.

They scored mp1 for identifying the critical value as 0.700.

They did not achieve mp2 because they wrote that – 0.967 is less than 0.700; the minus sign should have been ignored.

They did not achieve mp3 because they did not state that the correlation was significant, or state what was correlated to what ("the data" is too vague).

(i) Calculate the correlation coefficient, r_s.

Use the formula:

(3)

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

Where:

$\sum$ = the sum of

d = the difference between each pair of ranks

n = the size of the sample (number of pairs of values)

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

$n = 19 + 17 \cdot 3 + 14 \cdot 7 + 12 \cdot 0 + 8 + 8 \cdot 3 + 4 \cdot 3 + 2 \cdot 3 + 3 \cdot 0$

$= 88 \cdot 9$

$\sum d^2 = 64 + 36 + 16 + 4 + 1 + 1 + 16 + 49 + 49$

$= 236$

$1 - \frac{6 \times 236}{88 \cdot 9(88 \cdot 9^2 - 1)}$

$= 0 \cdot 99798...$

$\approx 0 \cdot 998$

Answer 0·998

(ii) The table shows some critical values for this correlation coefficient.

Number of pairs of values	Level of significance		
	0.10	0.05	0.01
4	1.000	–	–
5	0.900	1.000	–
6	0.829	0.886	1.000
7	0.714	0.786	0.929
8	0.643	0.738	0.881
9	0.600	0.700	0.833
10	0.564	0.648	0.794

Analyse the data to explain the conclusion that can be drawn from this investigation.

Use the table of critical values and your calculated correlation coefficient.

(3)

Since the calculated value ~~is gre~~ (0·998) is greater than the correlation ~~of~~ coefficient (0·700), we can reject the null hypothesis.
Therefore the two variables (~~a~~ distribution and distance from path) are significantly different.
$p > 0.05$, so this result is not due to chance.

ResultsPlus
Examiner Comments

In **Question 8(b)(i)** this candidate scored mp1 for correctly calculating the sum of d^2 as 236.

They used the wrong value for *n* (it should have been 9, because there were 9 pairs of values, but here they used 88.9 which was the sum of the means from the table). Therefore, they did not score mp2 or 3.

In **Question 8(b)(ii)** they correctly identified the critical value as 0.700, scoring mp1.

They correctly stated that their calculated value of 0.998 was greater than the critical value (ecf was allowed here from part (b)(i)), and that the null hypothesis should be rejected, gaining mp2.

They did not get mp3, as they referred to a significant difference, not correlation.

ResultsPlus
Examiner Tip

Always set out your working clearly in calculations. This allows you to get credit for intermediate values if you make a mistake and get a wrong final answer.

Question 8 (c)

Question 8(c) asked candidates to identify one abiotic factor that might influence the distribution of celandine plants; to describe a method that could be used to measure how it changed along the transect; and to explain why the factor would change along the transect and how this might affect the growth of celandine plants.

The key to success in the whole question (which was worth seven marks) was choosing a factor that you were happy to write about in parts (c)(ii) and (c)(iii).

For **Question 8(c)(i),** most candidates were able to identify one suitable abiotic factor. There were many that could be chosen, eg light intensity, humidity, temperature, soil pH, soil humus content, soil mineral content and soil water. Light intensity was the commonly chosen factor, although all of the others were seen. Where the mark was lost it was usually for choosing a biotic factor, eg trampling or grazing, or for imprecise language, eg choosing sunlight instead of light intensity.

Question 8(c)(ii) asked candidates to describe a method that could be used to measure how the factor changed along the transect. There were three marking points:

- Mp1 was for the use of suitable equipment, eg meter or probe if appropriate; or a suitable procedure, eg weighing, drying and reweighing to find water content.
- Mp2 was for standardising the use of the equipment or procedure, eg holding the meter at a constant height above the ground or inserting the probe into the soil at the same depth. This was often forgotten.
- Mp3 was for where the data was collected, eg at every point where plants were counted / in every quadrat / at 1m intervals / at 25cm intervals. Some candidates lost mp3 because they ignored the method given at the start of the question and invented a new one.

Question 8(c)(iii) asked candidates to explain why the factor would change along the transect and how this might affect the growth of celandine plants. There were four marking points for three available marks.

Mp1 was for a clear statement of how the factor would change (increase or decrease) along the transect.

Mp2 was for a simple explanation of why the factor would change in this way.

Mp3 was for a comment on how this would affect plant physiology.

Mp4 was for a directional explanation of how this would affect the growth of the plants.

This was generally well done, with many candidates achieving three marks. Some did not give a clear statement for mp1 and some did not give a directional explanation for mp4. Some candidates struggled to get mp2 and 4 if they had chosen a less obvious factor.

(c) (i) Name **one** abiotic factor that might influence the distribution of celandine plants.

(1)

Light ~~intensity~~ ~~exposure~~ exposure.

(ii) Describe a method that could be used to measure how this abiotic factor changes along the transect.

(3)

Along the transect, take ~~a~~ and record the light intensity systematically (every metre) across. Also ~~take~~ record abundance of Celandine plants using transects every metre. Record in a table. Repeat abundances at every metre, in order to calculate mean abundances. Draw a graph of abundance of Celandine plants against light intensity.

(iii) Explain why the factor you have chosen would change along the transect **and** how this affects the growth of celandine plants.

(3)

Tree cover changes, ~~and~~ decreases, as the transect goes toward the path and away from the woodland. This affects growth of celandine plants because ~~as~~ towards the path, and away from trees, ~~your~~ celandine will receive more light. As a result, ~~a~~ a higher rate of photosynthesis, more ~~ATP~~ cyclic and non-cyclic phosphorylation, and more reduced NADP produced, so therefore more ATP and glucose produced in the Calvin cycle. Allow plants to respire more and grow more, since they will have more glucose and ATP.

Higher abundance of celandine plants further from the woodland, and closer to the path due to higher light exposure.

ResultsPlus
Examiner Comments

This student achieved the mark for **Question 8(c)(i)** as they had written light intensity in their answer to Question 8(c)(ii).

In **Question 8(c)(ii)**, they only achieved mp3, as they did not describe **how** to measure the light intensity.

In **Question 8(c)(iii)**, they achieved mp1, 3 and 4.

(c) (i) Name **one** abiotic factor that might influence the distribution of celandine plants. non - living.

(1)

Water availability.

(ii) Describe a method that could be used to measure how this abiotic factor changes along the transect.

(3)

Use a line or belt transect parallel path. Place quadrats along and calculate number of plant along quadrats. Measure water availability in soil using a probe. Draw a graph to see the correlation between water availability and distance from path.

(iii) Explain why the factor you have chosen would change along the transect **and** how this affects the growth of celandine plants.

(3)

Water availability may change if path is made of impermeable material such as concrete. Tramping on path could affect water availability. Water contains mineral ions such as Nitrate ions. Water needed in respiration for photolysis. Water is needed for transpiration and is a transport medium. Water is needed by all plants including Ficaria verna.

ResultsPlus
Examiner Comments

This answer scored the mark for **Question 8(c)(i)**.

In **Question 8(c)(ii)** the candidate scored mp1 for the use of a probe, but did not say where the readings would be taken or attempt to standardise the method.

In **Question 8(c)(iii)**, the candidate scored mp3 only.

The statement that water availability would change was not enough for mp1, and there was no logical explanation of the change for mp2. Mp4 was not awarded because there was no link to how this would affect growth.

(c) (i) Name **one** abiotic factor that might influence the distribution of celandine plants.

(1)

temperature

(ii) Describe a method that could be used to measure how this abiotic factor changes along the transect.

(3)

use a digital temperature reader and measure at regular intervals along the transect. In areas closest to mature beech woodland, the temperature will be more, and as you progress down the path, to more shaded regions, the temperature readings will decrease

(iii) Explain why the factor you have chosen would change along the transect **and** how this affects the growth of celandine plants.

(3)

As you go further down the woodland path, it is more likely to have trees etc which provide shade and cooler environments, hence decreased temperatures. This means that less photosynthesis occurs in shaded, cooler regions and so growth of celandine plants is decreased as a result.

ResultsPlus
Examiner Comments

This answer scored 1 mark for the choice of temperature in **Question 8(c)(i)**.

In **Question 8(c)(ii)**, only mp1 was achieved (for the digital temperature reader); at regular intervals along the transect was not enough for mp3.

In **Question 8(c)(iii),** they scored mp1 and 2, for the idea of trees shading the plants, so they were cooler. There was not enough detail for mp3 or 4.

(c) (i) Name **one** abiotic factor that might influence the distribution of celandine plants.

(1)

Light intensity

(ii) Describe a method that could be used to measure how this abiotic factor changes along the transect.

(3)

20 metres long.

Use line transect from high to low light intensity. Place gridded quadrat at 1 meter intervals along the transect and count the number of squares that contain celandine. Calculate percentage cover at each interval. Use a light ~~meter~~ probe to measure light intensity at each interval. Plot a graph of light intensity and % cover.

(iii) Explain why the factor you have chosen would change along the transect **and** how this affects the growth of celandine plants.

(3)

May change due to object in the way or greater angle between sun and ground. Higher light intensities will increase growth in celandine plants due to higher rates of photosynthesis, which synthesises more ATP for mineral ion uptake and more glucose made.

ResultsPlus
Examiner Comments

This answer scored the following marks:

Question 8(c)(i): 1 mark.

Question 8(c)(ii): 2 marks (mp1 and 3).

Question 8(c)(iii): 1 mark, mp4 only. No clear statement of how the factor changes, or why, eg due to trees shading the plants. The reference to higher rate of photosynthesis was not precise enough.

Question 9 (a)

Question 9 was about natural selection in peppered moths.

In **Question 9(a)** candidates were given some background information about peppered moths and asked to explain how natural selection could have led to the increase in numbers of the dark form in industrial areas between 1848 and 1895.

This was generally answered very well, with almost 30% of candidates gaining full marks and over 50% achieving three out of four marks.

Mp1 was the least commonly seen mark, with some forgetting to explain where the dark moths came from. Almost all got mp2 for describing how camouflage increased survival of the dark moths in industrial areas, or the light moths in rural areas.

Some lost mp3, 4 and 5 because their answers were not in context, ie they referred to an advantageous allele, without saying that it was for dark wing colour; generic answers about natural selection will never score full marks when a particular context is being assessed.

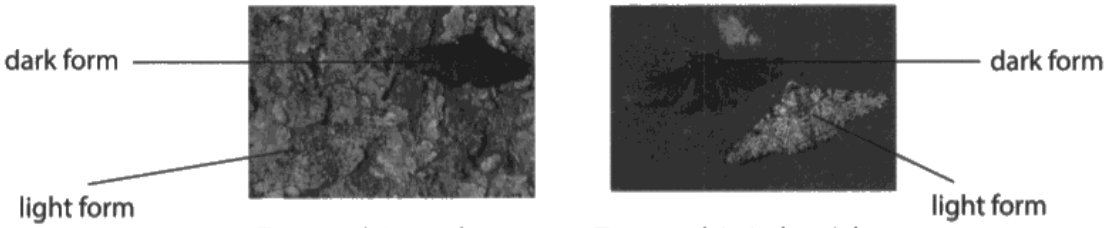
Some lost mp4 because they referred to a **gene** being passed on: all moths inherited a gene for wing colour, with some carrying the allele for dark wing and some carrying the allele for light wing.

Some lost mp5 because they said that the allele frequency for dark wing changed over time, instead of increased; or because they referred to the number of dark moths increasing rather than the frequency of the allele increasing.

9 Peppered moths, *Biston betularia*, are found in many parts of the UK.
Two forms of this species are found, a light form and a dark form.

Peppered moths sometimes rest on tree trunks during the day. In rural areas with clean air, the tree trunks are often covered with lichen. In industrial areas the trees have less lichen on them due to air pollution.

The photographs show both forms resting on tree trunks.



Tree trunk in rural area

(Source: © MICHAEL W. TWEEDIE / SCIENCE PHOTO LIBRARY)

Tree trunk in industrial area

(Source: © STEPHEN DALTON / NATURE PICTURE LIBRARY / SCIENCE PHOTO LIBRARY)

Peppered moths are often preyed on by birds.

(a) Until 1848, light peppered moths were the only form recorded.

In 1848, a single darker form of the moth was observed in an industrial area in the north-west of England.
In 1895, 98% of peppered moths in this industrial area were the dark form.

Explain how natural selection could have led to these changes.

(4)

Darker moths ~~are~~ have a selective advantaged as they are less likely to be killed by predators as they cannot be seen in industrial area. Due to air pollution in industrial areas trees are darker as they have less lichen. Dark moth is camouflauged more likely to survive and reproduce and pass on advantageous allele. Increasing frequency of allele therefore ~~now~~ (98 %) high percentage of darker coloured moth in industrial areas.

ResultsPlus
Examiner Comments

This answer scored mp3, 2, 4 and 5.

Natural selection so selection pressure of industrial area. Beneficial allele passed onto the offspring. This beneficial allele allows peppered moth to be in the dark form

ResultsPlus
Examiner Comments

This answer scored mp3 for the idea that the beneficial allele was for dark colouration.

Dark moths had better chance of survival in industrial areas as trees without lichen acted as selection pressure. Peppered moths passed on the dark form gene to their offspring which increased the other allele for this gene in the gene pool. ~~as they had a better chance~~

Some light form moths carried the gene for the dark form. ~~The~~ As polution increased and more less trees without lichen became common, moths with dark form had a better chance of survival.

ResultsPlus
Examiner Comments

This answer scored mp2 only.

They came close to mp4, but it could not be awarded because they described the gene being passed on, not the allele.

In a population of light peppered moths, a mutation results in a dark phenotype. Industrialisation and air pollution acts as the selection pressure. Light moths unable to camouflage and are visible by the birds therefore a decrease in light moths. Dark moths with the advantageous allele survive and reproduce, increasing the allele frequency of the allele resulting in a dark phenotype. More reproduction over generations, inheritance of dark phenotype allele, majority of moths have advantageous allele. (survival of fittest)

ResultsPlus
Examiner Comments

This very strong answer achieved maximum marks, covering all 5 marking points.

Question 9 (b)

This was the nine-mark, levels-based question. Candidates were given data: results of two historical studies carried out on peppered moths, and map data showing comparative proportions of light and dark forms in the 1950s and 1970s. They were also told that more recent studies had revealed new evidence about their main resting place during the day and their main predators.

They were asked to discuss the validity of the following suggestion: that the change in proportions of peppered moth forms is an example of natural selection.

The command word **discuss** requires candidates to explore all aspects of the situation being considered and to investigate it using reasoning.

The indicative content was divided into four areas.

- Investigation 1: predation by birds.
- Investigation 2: recapture of light and dark moths.
- Investigation 3: map data.
- Confounding data (which included aspects of experimental design).

To achieve Level 1, candidates could make points from any of the four areas.

To achieve Level 2, candidates must make points from at least two areas.

To achieve Level 3, candidates must make points from at least three areas, and for seven or eight marks, this must include confounding points.

Generally, candidates did very well on this question, using the information given and their own knowledge of natural selection and experimental design to build strong arguments. There were many excellent, logically-structured answers which gained nine marks. Credit was not given for simply repeating the steps of natural selection, which had been tested in Q09(a); we were looking for an analysis of the studies described.

Candidates seemed to realise the need for a balanced answer which included consideration of all of the studies described, and their own analysis of the data. Overall, 44% achieved Level 3, 29% achieved Level 2 and 21% achieved Level 1, with around 6% of candidates failing to score at all, usually for leaving the pages blank.

The most common misconceptions related to the following:

- that only the light form were peppered moths, and that only the light form rested on the underside of branches
- that moths were simply migrating from one area to another, not that the proportions were changing due to different survival rates
- that moths were being eaten by bats during the day while they were resting on branches, rather than at night when they were flying
- that bats are not found in the UK
- the ways that bats find their prey.

The indicative content given in the mark scheme was not exhaustive, and many candidates gained credit for other relevant suggestions.

It has been suggested that the change in proportions of peppered moth forms is an example of natural selection.

Discuss the validity of this suggestion.

(9)

Investigation 1 suggests it may be a result of natural selection as birds are more likely to eat moths which stand out against the tree. Also because there was a higher proportion of the dark form in the 1950s when it was more industrial However investigation 2 shows that light form moths are almost equally likely to be in industrial areas and rural areas, which could suggest that they survive in both regions and so natural selection is not occurring.

The Investigation 3 found that the main predator of peppered moths are bats rather than birds which will also rest on underside of trees and prey during night

-light moths more likely preyed on

ResultsPlus
Examiner Comments

This answer scored 4 marks.

Investigation 1: one point made

Map data: they refer to the higher proportion of dark moths in the 1950s (which is an implicit comparison with the 1970s), gaining a point. However, they do not develop this argument further or refer to proportions in different parts of the country.

Investigation 2: they make one confounding point (that the light moth numbers were almost equal in industrial and rural areas).

They also refer to the main predator being bats, not birds, gaining a further confounding point.

It has been suggested that the change in proportions of peppered moth forms is an example of natural selection.

Discuss the validity of this suggestion.

(9)

It is unlikely that the change in proportion is due to natural selection. The theory of natural selection comes from the concept that the birds can't see dark moths as easily on light moths when there is an absense of lichen, however investigation #3 shows that even though there is little change in the amount of lichen. Investigation 3 also found that birds are not the most common predator. The most common predator is nocturnally bats. This explains some of the data in investigation 2. Whilst there is variation in the colouring of moths present between industrial & rural areas, there are overall more naked moths recaptured in industrial areas than rural areas. Bats are more common in rural areas suggesting that the moths ~~are~~ have more predators than in industrial areas. Because of this, colour is no longer a beneficial allele and so the numbers of dark & light moths will even out.

ResultsPlus
Examiner Comments

This answer scored 3 marks.

It shows a good understanding of some of the relevant points, but these are not developed enough to gain credit in some cases. This is frustrating, as there is a lot more that this candidate could have said and would have scored much better.

In lines 5-6 they refer to a confounding point, about the lichen cover not changing, but do not develop this further by relating it to the increase in light form moths in the 1970s.

They gain a point for saying that the main predator of peppered moths is bats, a second point for suggesting that bats may be more numerous in rural areas than industrial areas and a third point for linking this to the proportions recaptured in Investigation 2.

If this level of analysis had been applied to the other studies, this answer would have scored highly.

It has been suggested that the change in proportions of peppered moth forms is an example of natural selection.

Discuss the validity of this suggestion.

(9)

Natural selection refers to how certain alleles continue to be passed on as they provide an adaptive advantage in terms of survival. In investigation 1, we can see that on lichen-covered trees (which are lighter), birds ate 2x dark moths vs light moths. This is because the dark moths were easier to detect compared to the light moths, therefore more dark moths were eaten. In investigation 2, using the mark-release-recapture method, more dark moths were recaptured in the industrial area and more light moths were recaptured in the rural area. The industrial area is more likely to have less lichen-covered trunks due to pollution, so the trunks are likely to be darker. Therefore, the darker moths are better adapted and camouflaged, so survived. However, there is less likely to be more lichen-covered trees in rural areas, so light moths are more camouflaged and better adapted, so a higher % were recaptured. However, this Mark-Release-Recapture method has some flaws, for example, if bands are used to mark moths, the bands may have fallen off; birth and death occurs; migration may occur. These factors reduce the validity of the data produced in investigation 2. In both investigation 1 and 2, we are not told the total number of each moth form in the sample, which reduces the validity of the results due to its impact on generalisability. With regard to investigation 3, there are 3 factors that we need to consider. Firstly, we are told that in the 1970s, when there was less pollution, there was a higher proportion of light than dark moths in industrial areas, but the amount of lichen had not changed significantly. ~~The assumed that the~~ Therefore we cannot assume causation in terms of

the amount of lichen causing the change in the number of each form of moth. There may merely be a correlation between the two, but we cannot assume causation. Secondly, during the day, when most predators are awake, the moths do not even rest on the trunks where lichen is located, but on the underside of high branches. Predators such as birds tend to also locate themselves up high in the branches, which may affect the number of moths they see - it may be easier to spot the dark moths from a closer range, suggesting it is not natural selection causing the change. Finally, we are told that it is not birds who are the main predators, rather it is the bats. Bats are not found in trees in the UK, ~~so~~ yet it is the birds that are located in trees. Bats may be found in dark places, where maybe light forms are easier to see compared to dark moths, therefore causing a decrease in the population of the light form moths. In conclusion, ~~there~~ there is evidence to suggest that the dark form moth may have been better adapted during the industrial era, hence its profound survival. However, we cannot assume causation in the way that this was the only reason ~~does~~ for the change in the peppered moth proportions, and there are many other factors to consider like location of the moths, its habitat, and its predators.

ResultsPlus
Examiner Comments

This is a very strong answer which gained 9 marks.

It is clear and well-structured, logically working through the data given in the question.

On page 1, they gain one point for the discussion of Investigation 1.

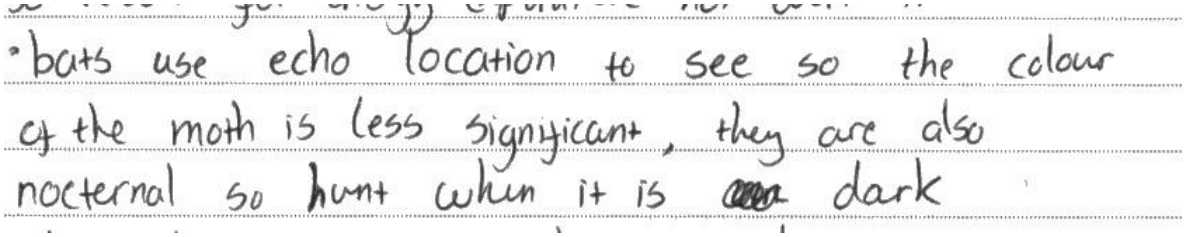
They go on to gain two points for the discussion of Investigation 2: that more dark moths survive in industrial areas (not just that more were recaptured) and that more light moths survive in rural areas.

They gain two further points for describing a possible flaw in the mark-release-recapture technique and for recognising that we are not told the sample size for Investigations 1 and 2; these are confounding points.

At the bottom of the first page, they go on to gain a further point when discussing Investigation 3, that the lichen cover had not changed when the number of light form moths increased in the 1970s.

On page 2, they gain credit for recognising that if the moths do not rest on the tree trunks, the camouflage against lichen is less important, and that bats are the main predators. We were not able to give further credit in relation to bats, as they incorrectly stated that UK bats do not roost in trees (most of them do), and that the light forms may be easier to see, when bats hunt by echolocation.

However, they gained a final point when they suggested that there may be a correlation between pollution and the survival of the dark form but this does not prove causation and that other factors eg predators, location, habitat may be involved.


• bats use echo location to see so the colour of the moth is less significant, they are also nocternal so hunt when it is dark

- does not state sampel size of moths
- does not state sex of moths this affects behavior
- only conducted once so means not able to be calaulated, outliers and anomalous results not identified
- marking moths makes them stand out more which may increase predation
- larger decrease of ∴ dark moth in rural than light moth in industrial suggesting the dark allele is either ~~dek~~ very advantageous or very disadvantgous dependant on ~~eon~~ environment conditions
- ∴ light moths recaptured was about the same in Rural and industrial
- since diffrent locations used, predators and prey may vary so derease could be due to less pray or more predators present.
- ~~not a direct comparison between~~
- number of factors which contribute towards ∴ of moths ~~colour~~ colour.
- dark and light moths may interbreed.

ResultsPlus
Examiner Comments

This is another excellent answer, containing lots of relevant details and a logical argument.

They were particularly effective in picking out confounding arguments, eg about bats and their method of hunting, sample size, mark-release-recapture technique, light form moth survival in Investigation 2, and in suggesting other factors which may be involved.

They also provided detailed analysis of the map data gaining 9 marks in total.

It has been suggested that the change in proportions of peppered moth forms is an example of natural selection.

Discuss the validity of this suggestion.

(9)

Not told how many of each coloured moth are placed on the tree trunk - if not the same number of each - invalid. can see in scotland which is more rural, there is 100% the light form as the black moth would be visible. After 20 years still 100% white moths which suggests the allele for black moth never even entered the area.
We arent told how the data in experiment 3 was obtained.
Because pepper moths actually rest on the underside of branches, by placing them on the trunk in Experiment 1 they were made more likely to be eaten - so the results may not be valid as humans interfered - not natural. Also it was recorded how many moths were eaten by birds - but bats (main predator) werent considered. The capture - mark - recapture method shows that more dark moths in industrial and light in rural but actually in industrial still 13.1% light recaptured. other factors like temperature havent been considered. No mention of how the moths were recaptured - may be harder to capture a certain colour. The amount growing on trunks hasnt changed significantly. In 1950 many more black moths in the areas in England but as industrial areas return to pre-industrial more white moths

The graph map shows in the central areas which have maybe more pollution there are more black moths

Thus suggests natural selection has occured and pollution levels are the selection pressure

But we dont have data on industrilisation or pollution levels in the different areas

so cant conclude this. Also correlation doesnt always imply causation.

The investigation can be done again and look at how bats are dispersed and eat the moths.

whilst the scientist found birds were twice as likely to eat the dark moths there are no figures to allow a quantative comparison or a statistical test.

Other factors like light intensity and O_2 conc not considered
Bird and Bat population sizes not considered
Overall suggests there is natural selection
But more data like pollution level needed

ResultsPlus
Examiner Comments

This is another very strong answer, gaining the full 9 marks.

This candidate approached the problem from a different angle, identifying all of the flaws in the argument for natural selection and linking them to the studies described.

They start with a confounding point about sample size, linked to Investigation 1. They recognise a second flaw in this investigation – that the moths were placed on tree trunks, which is not where they usually rest; and a third, that bats are the main predators of these moths, not birds.

Moving on to Investigation 2, they note that the number of light moths recaptured in industrial areas was high (still 13.1%), that other factors may be involved. They also note that the method of recapture was not given and that some colours of moth may have an advantage.

For Investigation 3, they recognise the change in proportions of dark and light moths between the 1950s and 1970s, but had already stated that the lichen cover had not changed. They correctly point out that we are not told the pollution levels or amount of industrialisation in the areas highlighted on the map.

They finish by saying that the investigations should be repeated, including further information for the areas highlighted on the map ie bats and bird population sizes, the level of pollution and light intensity. These are valid points and gained credit.

Question 10 (a)(i)

Question 10 was a series of linked questions about respiration rate in yeast. It covered three separate investigations.

Question 10(a) investigated the respiration rate with two different sugars used as substrates; sucrose and lactose. When sucrose was used, yeast was able to respire. Lactose was used under two different conditions; once with the enzyme lactase added (in which case respiration took place) and once with no lactase added, when no respiration took place.

Q10(a)(i) gave candidates a graph of the volume of carbon dioxide produced over time and asked them to calculate the initial rate of respiration for sucrose. This required them to draw a tangent to the curve at the start of the investigation and read off values from the graph to calculate the rate in $cm^3\ min^{-1}$.

Most candidates seemed familiar with how to do this, but some were not accurate enough with their tangent or reading of the scale. The range allowed was 0.028 – 0.032 $cm^3\ min^{-1}$.

10 During respiration, yeast cells break down sugars to produce carbon dioxide and ethanol.

The respiration rate of yeast is affected by several factors. It can be estimated by measuring the rate of production of carbon dioxide gas.

(a) Scientists measured the rate of respiration of yeast using the sugar sucrose as a substrate.

Sucrose —yeast→ CO_2 + ethanol.

This was repeated using the sugar lactose with and without lactase.

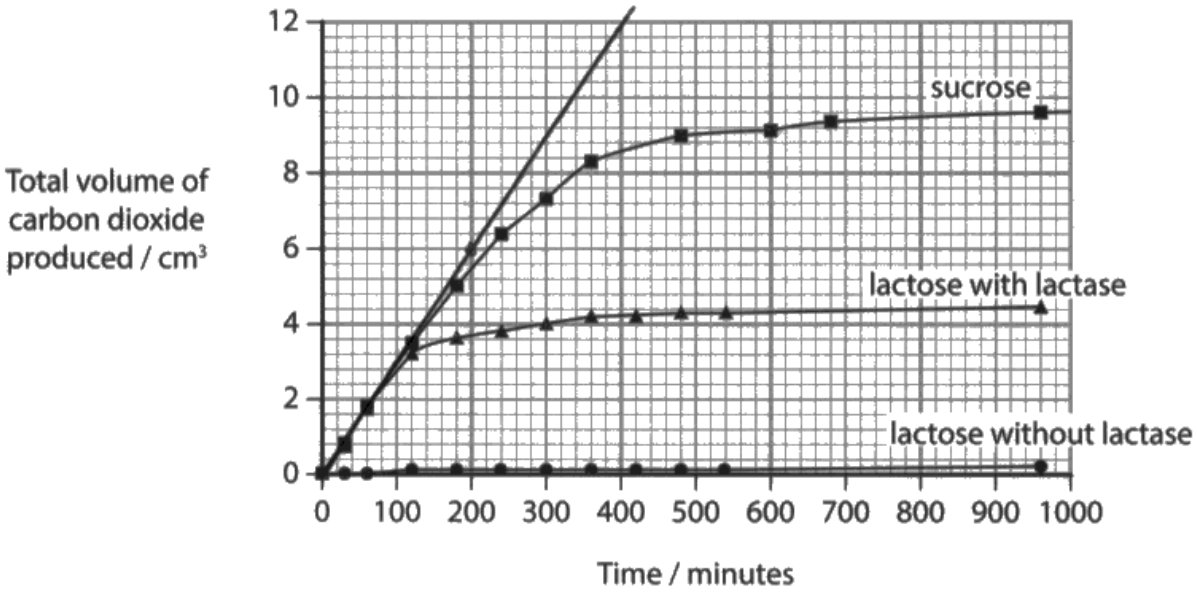
Lactase is an enzyme that hydrolyses lactose.

lactose —lactase→ CO_2

lactose —NO lactase→ CO_2

The same concentrations of both sugars were used and the suspensions were incubated at 30°C.

The graph shows the results.



(i) Calculate the initial rate of respiration of yeast with sucrose.

(1)

$\frac{6}{200} = 0.03$

Answer 0.03 cm³ min⁻¹

ResultsPlus
Examiner Comments

Here the candidate drew the tangent accurately and read the values off the graph correctly to score 1 mark.

10 During respiration, yeast cells break down sugars to produce carbon dioxide and ethanol.

The respiration rate of yeast is affected by several factors. It can be estimated by measuring the rate of production of carbon dioxide gas.

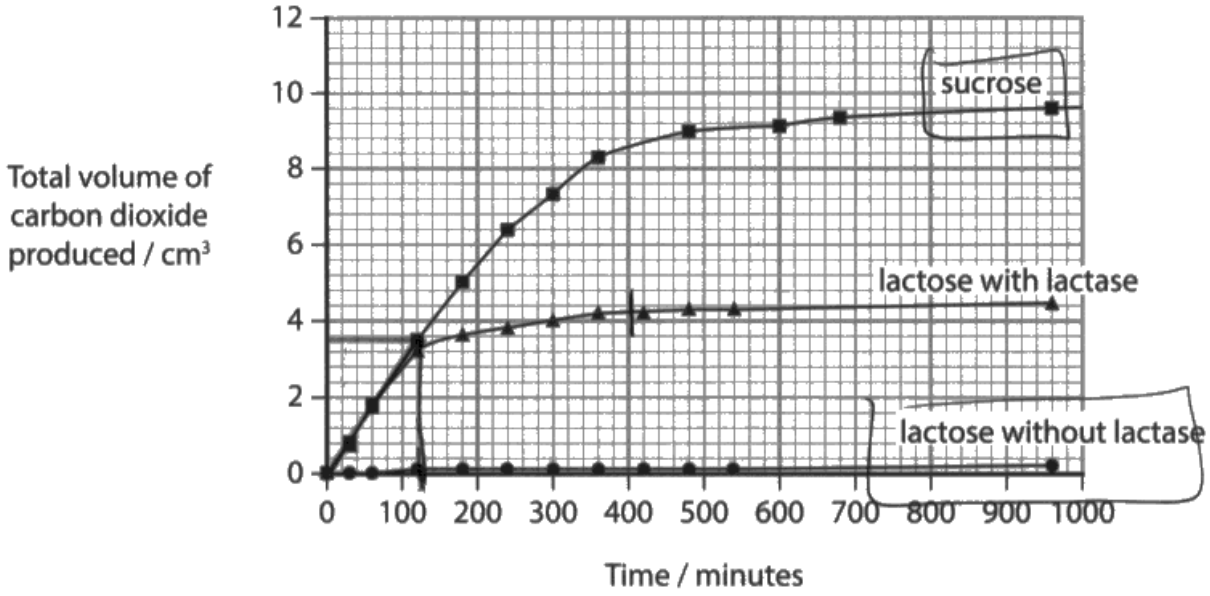
(a) Scientists measured the rate of respiration of yeast using the sugar sucrose as a substrate.

This was repeated using the sugar lactose with and without lactase.

Lactase is an enzyme that hydrolyses lactose.

The same concentrations of both sugars were used and the suspensions were incubated at 30°C.

The graph shows the results.



(i) Calculate the initial rate of respiration of yeast with sucrose.

(1)

$\frac{3.6}{120} = 0.03$

Answer 0.03 $cm^3 min^{-1}$

ResultsPlus
Examiner Comments

This candidate read the values directly from the graph, without drawing a tangent. This can be risky, as it is harder to read the values accurately when the numbers are small; here they got the right answer, achieving the mark.

10 During respiration, yeast cells break down sugars to produce carbon dioxide and ethanol.

The respiration rate of yeast is affected by several factors. It can be estimated by measuring the rate of production of carbon dioxide gas.

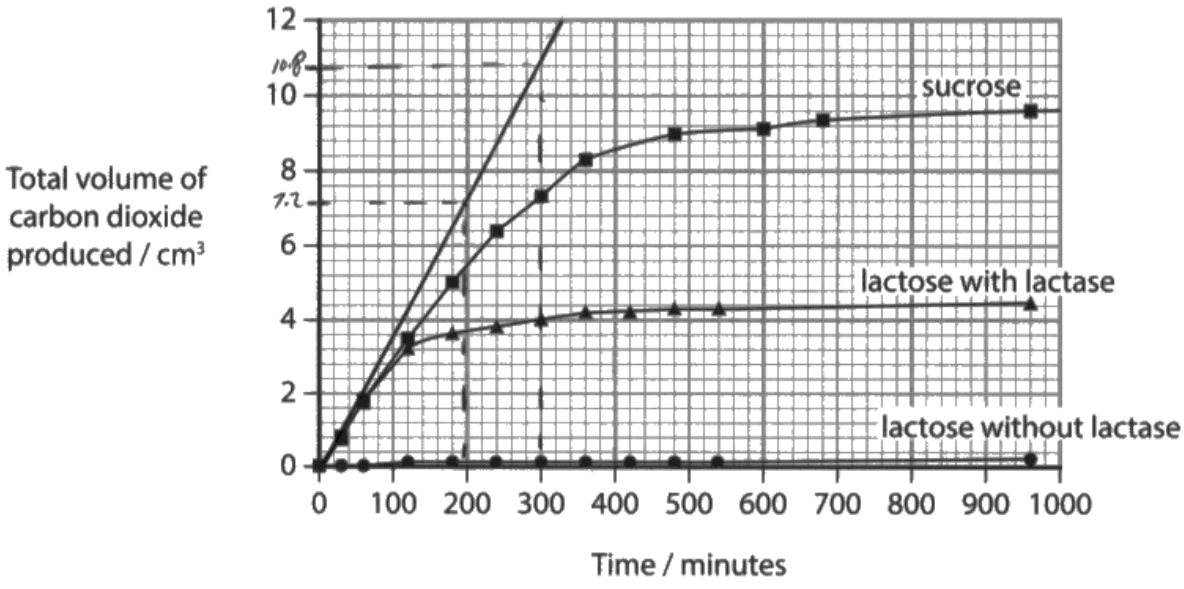
(a) Scientists measured the rate of respiration of yeast using the sugar sucrose as a substrate.

This was repeated using the sugar lactose with and without lactase.

Lactase is an enzyme that hydrolyses lactose.

The same concentrations of both sugars were used and the suspensions were incubated at 30°C.

The graph shows the results.



(i) Calculate the initial rate of respiration of yeast with sucrose.

(1)

$\frac{10.8 - 7.2}{300 - 200} = \frac{3.6}{100}$

$= 0.036$

Answer 0.036 $cm^3 min^{-1}$

ResultsPlus
Examiner Comments

The tangent was not accurately drawn, so the final answer was outside the acceptable range.

10 During respiration, yeast cells break down sugars to produce carbon dioxide and ethanol.

The respiration rate of yeast is affected by several factors. It can be estimated by measuring the rate of production of carbon dioxide gas.

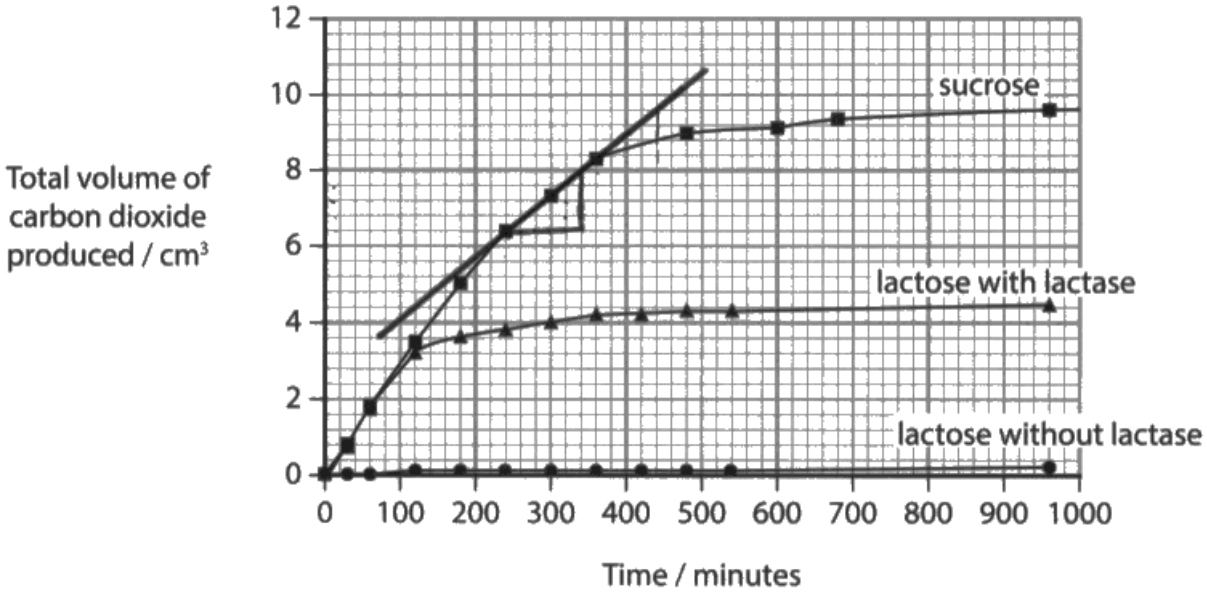
(a) Scientists measured the rate of respiration of yeast using the sugar sucrose as a substrate.

This was repeated using the sugar lactose with and without lactase.

Lactase is an enzyme that hydrolyses lactose.

The same concentrations of both sugars were used and the suspensions were incubated at 30°C.

The graph shows the results.



(i) Calculate the initial rate of respiration of yeast with sucrose.

(1)

$\frac{\Delta y}{\Delta x}$ $\frac{1.6}{100}$

Answer 0.016 $cm^3 min^{-1}$

ResultsPlus
Examiner Comments

The tangent drawn here was in the wrong place for the calculation of initial rate.

10 During respiration, yeast cells break down sugars to produce carbon dioxide and ethanol.

The respiration rate of yeast is affected by several factors. It can be estimated by measuring the rate of production of carbon dioxide gas.

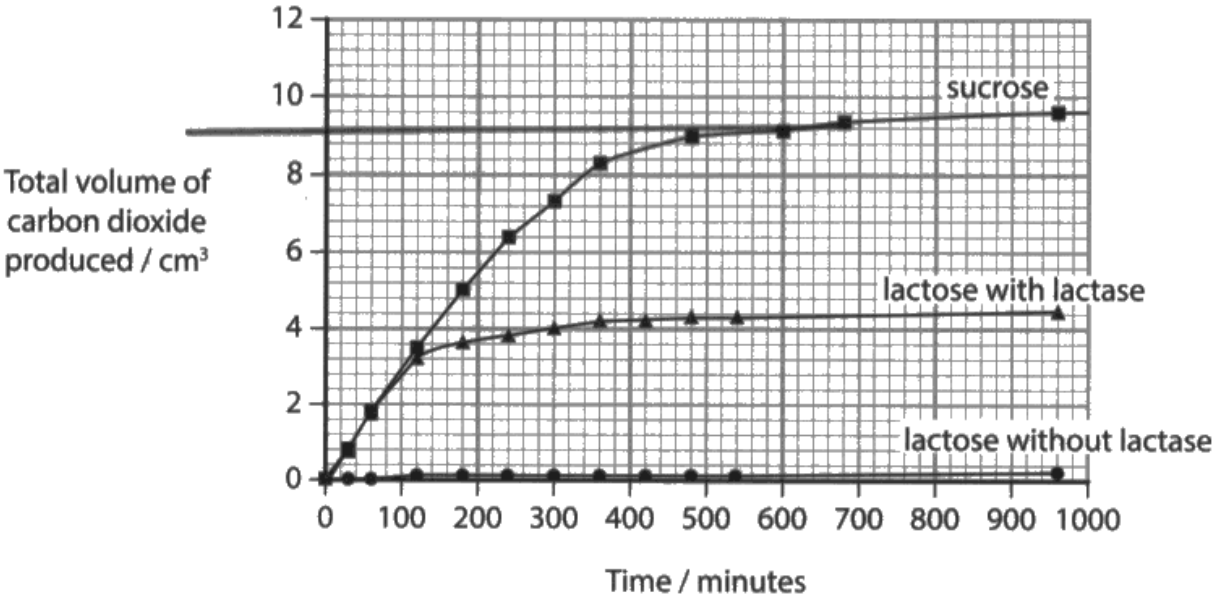
(a) Scientists measured the rate of respiration of yeast using the sugar sucrose as a substrate.

This was repeated using the sugar lactose with and without lactase.

Lactase is an enzyme that hydrolyses lactose.

The same concentrations of both sugars were used and the suspensions were incubated at 30°C.

The graph shows the results.



(i) Calculate the initial rate of respiration of yeast with sucrose.

(1)

600 mins → 8·6

$\frac{8 \cdot 6}{600} = 0 \cdot 0143$

Answer 0·0143 $cm^3 min^{-1}$

ResultsPlus
Examiner Comments

This candidate made two important mistakes.

- They were attempting to calculate the overall rate, rather than the initial rate.
- They read the value on the y-axis wrongly, as they did not understand the scale.

ResultsPlus
Examiner Tip

Always check the scale on a graph – here the scale on the y-axis goes up in intervals of 0.4, not 0.2

Question 10 (a)(ii)

In Question 10(a)(ii), candidates were asked to use the graph to compare the results for sucrose to lactose without lactase. There were four marking points for three available marks.

Generally, candidates did well on this, with almost two thirds gaining at least two marks.

Most realised that yeast was able to use the sucrose to respire, producing carbon dioxide, gaining mp1. Most realised that without lactase, lactose could not be broken down, gaining mp2.

Some also realised that yeast did not produce carbon dioxide when lactose without lactase is added, but did not always link this to respiration not taking place.

Mp4 was least commonly seen: that respiration stops when all of the sucrose is used up.

(ii) Explain the results for sucrose compared with **lactose without lactase.**

(3)

Lactose is a disaccharide of glucose and galactose but without the lactase enzyme they yeast could not hydrolyse the lactose into its monosaccharides so could not use it ~~for this~~ as a respiratory substrate. Sucrose is made of glucose and fructose and the yeast had the appropriate enzymes to hydrolyse this into its monosaccharides so could use both monosaccharides in respiration. Rate slowed after 600 minutes as the sucrose was being used up and was used up after 1000 ~~minutes~~ minutes.

In the investigation with lactose but no lactase, the small amount of CO_2 produced was due to respiration of sugars stored in the cells yeast's cytoplasm.

ResultsPlus
Examiner Comments

This very strong answer covered all 4 marking points (and lots of additional information), gaining maximum marks.

(ii) Explain the results for sucrose compared with **lactose without lactase**.

(3)

- sucrose can easily react and be used for respiration ∴ has a quicker rate of respiration
- lactose is not readily able to react ~~with~~ ∴ has a slower rate of respiration.

ResultsPlus
Examiner Comments

This answer achieved mp1 only. It does not address the breakdown of lactose for mp2 and does not state that it cannot be used in respiration for mp3.

Question 10 (a)(iii)

In Question 10(a)(iii), candidates were asked to explain the effect of lactase on the respiration rate of yeast in the first 400 minutes.

The graph showed that although the initial rate of respiration for lactose with lactase was very similar to the rate for sucrose, the rate began to plateau at around 200 minutes, and by 400 minutes respiration using lactose with lactase had stopped. The volume of carbon dioxide produced was roughly half of that produced with sucrose.

There were four marking points for three marks:

- mp1 that lactase breaks down lactose into glucose and galactose; many got this point
- mp2 that yeast can only use one of these sugars (glucose) for respiration; this was seen reasonably frequently
- mp3 so the volume of carbon dioxide is around that half that produced by sucrose; this was hardly seen at all, even by those who knew that only one of the sugars could be used
- mp4 that respiration stops when the glucose (substrate) is all used up; this was attempted, but not always achieved. Some referred to lactose being used up, and some referred to rate of respiration levelling out, rather than respiration stopping.

Some candidates seemed very confused by the idea that there was more than one enzyme-controlled reaction happening at the same time, ie that lactase added to the flask was breaking down lactose to give glucose, and that the enzymes in yeast were then using the glucose as a respiratory substrate. In weaker answers, it was common to see the idea that the breakdown of lactose by lactase produced carbon dioxide directly.

Some candidates became confused between monosaccharides and disaccharides; some thought that sucrose was a monosaccharide because it did not need to be broken down before respiration could take place; some thought that lactose was a monosaccharide because it produced half as much carbon dioxide.

(iii) Explain the effect of **lactase** on the respiration rate of yeast during the first 400 minutes.

(3)

Lactase increases the rate of ~~reaction~~ respiration because it catalyses the breakdown of lactose into glucose ~~which~~ as it reduces the activation energy required. However the rate of respiration levels off at 400 mins because all the substrate has been broken down, and used up.

ResultsPlus
Examiner Comments

This answer gained mp4 only.

It did not get mp1 because only one of the sugars produced when lactose is broken down was named.

It did not get mp2 because it did not state that glucose is used in respiration.

(iii) Explain the effect of **lactase** on the respiration rate of yeast during the first 400 minutes.

(3)

First 400 minutes rate of respiration of yeast increases in a linear way before levelling off as substrate is all used up so fewer enzyme substrate complexes will form.

ResultsPlus
Examiner Comments

This answer also gained mp4, but did not attempt to explain the effect of lactase at all.

(iii) Explain the effect of **lactase** on the respiration rate of yeast during the first 400 minutes.

(3)

Lactase hydrolyses the lactose into both galactose and glucose, however only glucose can be respired by yeast so the ~~rate~~ volume rapidly increases in the first 100 minutes due to an high rate of anaerobic respiration. After the first 100 minutes, the volume levels off and no more CO_2 is produced as galactose cannot be respired and the glucose has been used up (already respired)

ResultsPlus
Examiner Comments

This answer achieved mp1, 2 and 4, gaining full marks.

Question 10 (b)

Q10(b) was about the effect of temperature on an enzyme-controlled reaction. Candidates were told that the experiment with sucrose was repeated at a temperature 10°C lower, and that all other variables remained the same. They were asked to explain the effect of this temperature change on the respiration rate in yeast.

It was clear that most candidates felt more comfortable with this question and many were able to achieve mp1 – that the rate of respiration would be lower because there was less kinetic energy.

Mp2 proved more challenging, because most referred to fewer enzyme-substrate collisions or E-S complexes formed without linking this to time or frequency. Some wrote that there would be less frequent collisions, but did not say what was colliding, so did not gain credit. A surprising number wrote that enzymes would be denatured at lower temperatures.

Mp3 and 4 were hardly ever seen.

Some wrote vague answers about enzymes working faster at their optimum temperature without any explanation.

(b) The experiment with sucrose was repeated at a temperature 10°C lower.

All other variables remained the same.

Explain the effect of this temperature change on the rate of respiration of yeast.

(3)

The rate of respiration would decrease because the yeast cells have less kinetic energy which means that less enzyme substrate complexes will form so less sucrose is broken down which means that yeast will have less energy to respire.

ResultsPlus
Examiner Comments

This answer achieved mp1 only. Not mp2 as they did not state that it would be less enzyme substrate complexes formed per unit time.

(3)

The rate of respiration of yeast will drastically decrease as there is less energy available for the yeast to work as it is not working at its optimum temperature and so less respiration occurs due to lower collisions between the yeast and substrates.

ResultsPlus
Examiner Comments

This answer came close to 2 marking points, but in the end scored zero.

Not mp1 because it did not specify kinetic energy.

Not mp2 because it refers to yeast and substrates, not enzymes and substrates, and because it says lower collisions without referring to time or rate.

(b) The experiment with sucrose was repeated at a temperature 10°C lower.

All other variables remained the same.

Explain the effect of this temperature change on the rate of respiration of yeast.

(3)

This temperature change would decrease the rate of respiration of yeast. This is because molecules have less kinetic energy so there are less frequent successful collisions between enzyme active site and substrate so less enzyme-substrate complexes form. This means sucrose is broken down into glucose and fructose at a slower rate so rate of respiration is lower. The overall volume of CO_2 produced is the same as there is still the same amount of substrate.

ResultsPlus
Examiner Comments

This answer is a rare example of one which achieved mp4, scoring full marks.

It gained mp1, mp2 (for less frequent successful collisions between enzyme and substrate) and mp4 (for the overall volume of carbon dioxide produced is the same).

Question 10 (c)(i)

Question 10(c)(i) was about the effect of enzyme concentration on an enzyme-controlled reaction. Candidates were given a graph showing the volume of carbon dioxide produced over time when 7g of yeast was used and the substrate was 20g sucrose.

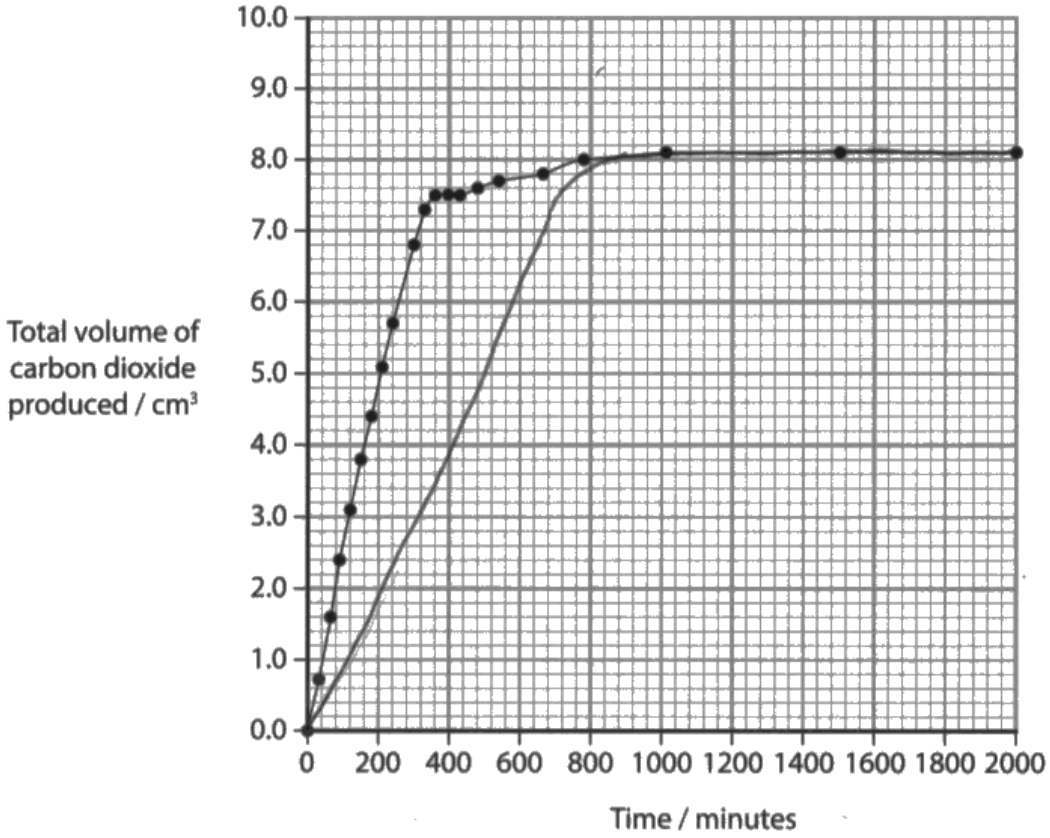
They were asked to sketch a line onto the graph to show the expected results if the experiment was repeated with 3.5g yeast.

Around 20% of candidates correctly worked out that the final volume of carbon dioxide produced would be the same (but that it would be produced more slowly), and gained the mark.

(c) The effect of changing the concentration of yeast on the rate of respiration was also investigated.

Two yeast suspensions were made by adding different masses of yeast to 100 cm^3 of water containing 20 g of sucrose.

The graph shows the results for a suspension containing 7.0 g of yeast.



(i) Sketch a line on this graph to show the expected results for a suspension containing 3.5 g of yeast.

(1)

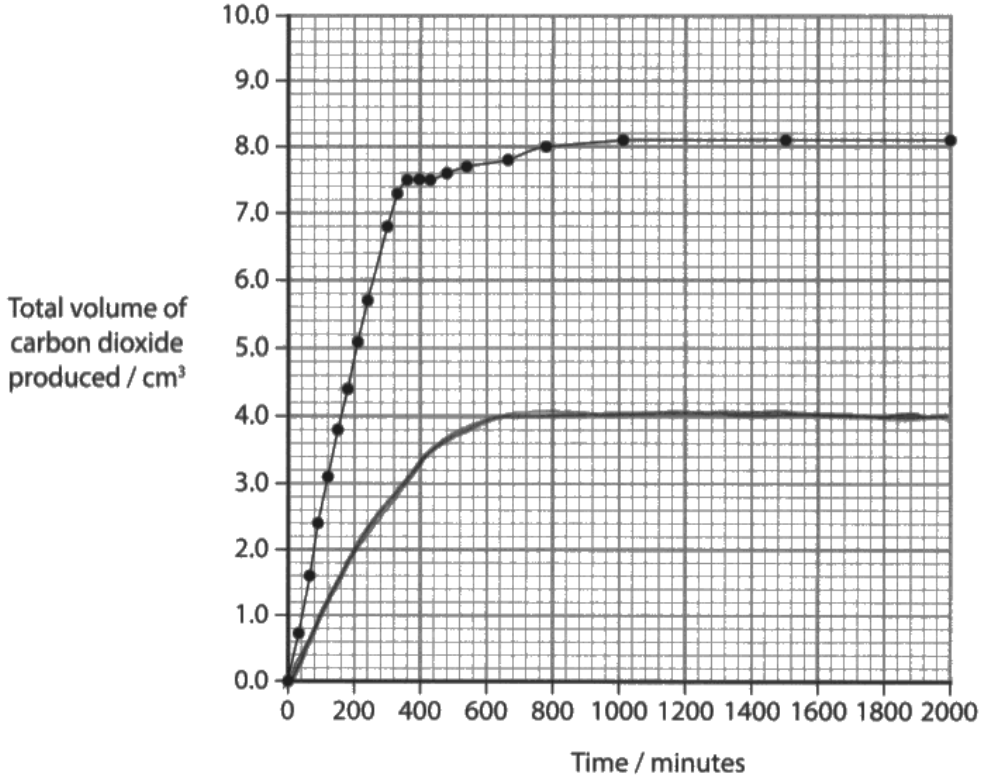
ResultsPlus
Examiner Comments

This is the correct answer showing the carbon dioxide being produced more slowly, but reaching the same final volume.

(c) The effect of changing the concentration of yeast on the rate of respiration was also investigated.

Two yeast suspensions were made by adding different masses of yeast to 100 cm^3 of water containing 20 g of sucrose.

The graph shows the results for a suspension containing 7.0 g of yeast.



(i) Sketch a line on this graph to show the expected results for a suspension containing 3.5 g of yeast.

(1)

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Around 80% of candidates drew a graph like this, with the final volume of carbon dioxide at half the volume produced by 7g of yeast.

Question 10 (c)(ii)

Question 10(c)(ii) asked candidates to explain the effect of changing the concentration of yeast on the volume of carbon dioxide produced. There were six marking points for three available marks, reflecting the number of ways the explanation could be developed, and the answer could be given in the context of comparing 7g to 3.5g (ie there would be a faster initial reaction) or comparing 3.5g to 7g (ie there would be a slower initial reaction).

Generally, candidates found this very difficult and only a minority scored highly. Many were able to get mp1 for the idea that with more yeast cells present more carbon dioxide would be produced (at the start), and some could explain this in terms of the enzymes present in yeast which were hydrolysing sucrose or carrying out respiration, which gained mp2.

However, most did not realise that with the same mass of sucrose present, the volume of carbon dioxide produced would eventually be the same for both concentrations of yeast – these were mp3 and 4. Although some candidates realised that the volume of carbon dioxide would plateau sooner for 7g of yeast, they did not link this to the substrate being used up more quickly, so were unable to get mp5.

Only a minority realised that with half the concentration of yeast, there would be half the rate of reaction or that it would take twice as long for the volume of carbon dioxide to plateau – this was mp6.

We ignored reference to limiting factors if they were unqualified.

This was a complex concept and those who did work their way through it and explain correctly are to be commended. The most common single error was to write that the final volume of carbon dioxide for 3.5g of yeast would be half the volume produced by 7g of yeast.

The most frustrating errors were those made by candidates who understood the complex biology being tested here, but lost mp3 and 4 because they wrote about amount of sucrose (rather than mass or concentration) and amount of carbon dioxide, rather than volume.

(ii) Explain the effect of the concentration of yeast on the volume of carbon dioxide produced in this investigation.

(3)

The higher the yeast concentration the more respiration occcurs which means more production of CO_2 as a by-product

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This answer was typical of the many answers which scored mp1 only.

(ii) Explain the effect of the concentration of yeast on the volume of carbon dioxide produced in this investigation.

(3)

> decreased concentration of yeast decreases volume of CO_2 produced as it causes decreased respiration.

> This is due to fewer smaller concentration of enzymes and substrate ∴ fewer enzyme substrate complex formed

> ∴ less respiration occurs as substrate become limiting factor.

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This answer also scored 1 mark, mp1.

They came close to mp2 and stated that with a lower concentration of yeast there was a smaller concentration of enzymes. However, they added **and substrate, therefore fewer E-S complexes formed.**

This was wrong. The mass of substrate (sucrose) had not changed, and therefore mp2 could not be awarded.

(ii) Explain the effect of the concentration of yeast on the volume of carbon dioxide produced in this investigation.

(3)

increased yeast concentration increases CO_2 production (respiration) rate as it is the yeast that are respiring and so the initial rate is higher as more individuals available to produce CO_2. However, at a certain point the sucrose concentration available will become a limiting factor and so the volume of CO_2 produced will end up to be the same as the yeast will respire all of the sucrose.

(Total for Question 10 = 14 marks)

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This answer scored 2 of the available 3 marks for:

mp1 for the idea that the increased yeast concentration had a higher initial rate.

mp3 for the idea that the volume of carbon dioxide produced would end up to be the same.

They came close to mp4 and 5, but did not actually say that the mass of sucrose was the same or that it would be used up more quickly. The phrase "at a certain point..." was too vague and did not help their explanation.

(ii) Explain the effect of the concentration of yeast on the volume of carbon dioxide produced in this investigation.

(3)

A higher concentration of yeast would result in a faster rate of CO_2 production but would not actually effect the overall volume of CO_2 produced because sucrose is the limiting factor in this reaction and therefore no more than $8.1cm^3$ of CO_2 can be produced with 20g of sucrose available for the yeast to break down.

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This was a very clear explanation, gaining mp1, mp3 (would not affect the overall volume of CO_2 produced) and mp4 (no more than $8.1cm^3$ of CO_2 can be produced with 20g of sucrose).

Paper Summary

Based on their performance in this paper, candidates should:

- Make sure that you are familiar with all of the core practicals, and understand the reasons for carrying out the different steps of the method.
- Get into the habit of considering the effects of errors made during practical work, and understanding how these change the results obtained.
- Become familiar with which stats tests should be chosen to analyse different types of data, and be able to explain the reason for your choice.
- Make sure that you can write a null hypothesis, and that you can analyse the results of a stats test, as well as carrying out the calculation of the test statistic.
- Practise analysing data presented in graph form, and be able to draw conclusions from graphs.
- Take account of command words and make sure your answer reflects the information required; some candidates had problems with separating describe and explain.
- Be able to carry out the mathematical procedures outlined in the specification including reducing a ratio to its simplest form, calculating initial rate and carrying out a dilution from a stock solution.

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