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Examiners' Report
June 2023

GCE Biology B 9BI0 01

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Introduction

This paper was fairly typical of a 9BI0_01 paper, covering a range of both AS and paper 1 A2 topics using a range of different command words and including the statutory number of multiple choice questions and maths marks.

The multiple choice questions were quite well answered and the calculations performed better than in previous years. It was also evident that centres are more familiar with the requirements of the levels-based questions and are preparing their candidates for these more effectively.

Question 1 (a)(i)

The majority of candidates wrote the correct answer with many qualifying it with middle lamella, which was unnecessary. The commonest incorrect answer given was cellulose.

1 Plants take up inorganic ions from the soil.

These ions include calcium, phosphate and potassium.

(a) (i) Name the molecule that contains calcium ions in the cell walls of a plant. (1)

Calcium pectate for the middle lamella ~~calcium pectate~~

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Examiner Comments

This example is typical of ones that we frequently saw.

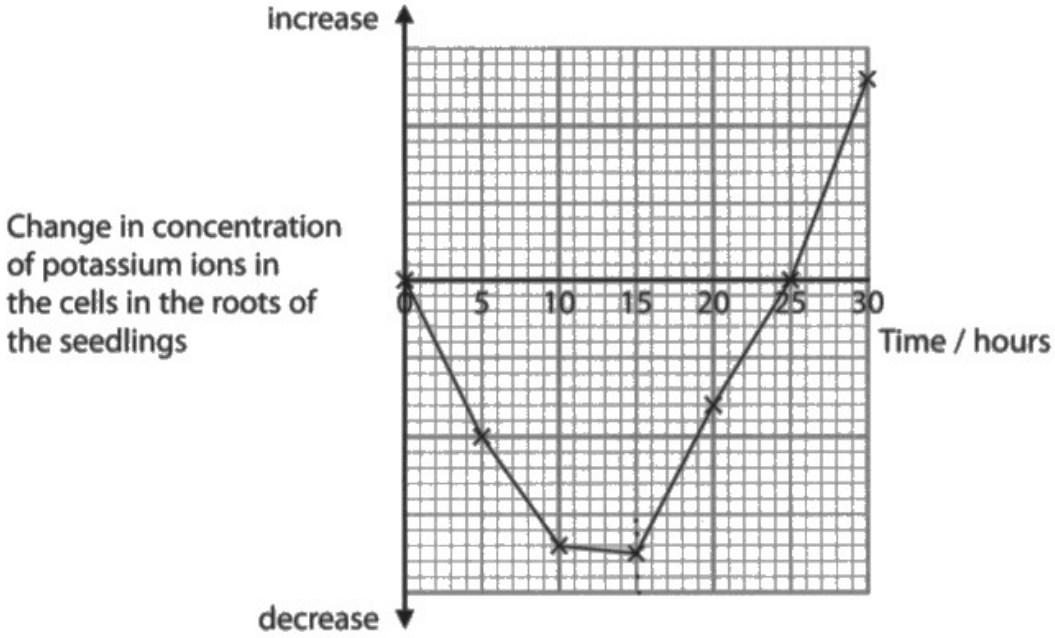
Question 1 (b)

A range of responses were seen with the majority of candidates focusing on describing the data before starting to explain the data. Those candidates who did attempt to explain the data tended to explain the increase in the ion concentration, ignoring the decrease. Few candidates made reference to aerobic respiration, just referring to the aerobic conditions.

(b) The uptake of potassium ions by plant seedlings in anaerobic and aerobic conditions was investigated.

The seedlings were grown in a mineral ion solution containing a low concentration of potassium ions for 30 hours. The conditions were anaerobic for the first 15 hours and aerobic for the second 15 hours.

The graph shows the results of this investigation.



Explain the changes in the concentration of potassium ions in the cells in the roots of the seedlings during this investigation.

(4)

potassium ions are used to create chloroplyll in plants. Before 15 hours, the potassium ions in the cell roots decrease as it is transported into the cell via active transport and during anaerobic respiration there is not enough ATP to allow for active transport and thus it diffuses out down the concentration gradient. The rate of decrease decreases as the concentration gradients gets smaller. During aerobic respiration, after 15 hrs, there is an increase in ATP and thus active transport happens and at 25 hours there is a net positive amount of potassium pumped into the cell.

(Total for Question 1 = 6 marks)

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Examiner Comments

This response illustrates all of our mark points except the fourth one.

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Examiner Tip

A question that starts with the command word 'explain' requires you to say why something is happening; your response should be using terms like because, therefore, as a result if you have completed it correctly.

Question 2 (a)

This question was answered well by many candidates. Those candidates who did not score, either simply repeated the information in the table without actually using it to answer the question or else mis-read the information and wrote about membrane-bound organelles. The other errors were to roll all of the information together and not specify whether they were referring to the Bacteria or the Eukaryote or to refer to the Bacteria as prokaryotes.

2 Living organisms are divided into three domains: Archaea, Bacteria and Eukaryota.

(a) The table shows some characteristics of organisms in the domain Archaea.

Characteristic	Organisms in the domain Archaea
membrane-enclosed nucleus	absent
peptidoglycan in cell wall	absent
ribosomes	70S

Explain why these organisms have **not** been classified in either of the other two domains.

(2)

Because eukaryotes have 80S ribosomes not 70S unlike archea and because eukaryotes have a membrane bound nucleus and only bacteria have peptidoglycan cell walls. So an organism without 80S ribosomes and a peptidoglycan cell wall and no membrane bound nucleus must be in archea.

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Examiner Comments

This response illustrates both our mark points.

Question 2 (b)(i)

Some candidates found this question quite challenging and simply repeated the information in the table and did not use it to actually answer the question. The most frequently awarded mark was the first one, although the more able candidates would score this and then usually the third mark point as well.

(b) Some Archaea have the enzyme adenylate kinase (AK).

This enzyme is similar to AK enzymes found in humans.

There are two types of this enzyme in humans, AK1 and AK3.

The table gives some information about these two enzymes.

Enzyme	Location in the cell	Substrate	Role of enzyme
AK1	cytoplasm	adenosine triphosphate (ATP)	transfers phosphate
AK3	mitochondria	guanosine triphosphate (GTP)	transfers phosphate

R groups

(i) The tertiary structures of AK1 and AK3 are very similar but not identical.

Analyse the information to deduce why there are two AK enzymes.

(3)

These enzymes are found in different locations in the cell and break down different substrates

- This means that the shape of their active site will be different as it is specific to the substrate.
- Their active site may be different because of different R groups causing ionic, disulfide and hydrogen bonds to form in different places, leading to a slightly different tertiary structure.

Mark points 1 and 3 in the very first sentence. The response was then awarded the fourth mark point.

Use the number of marks allocated to a question to help you deduce how many points you should be making.

Question 2 (b)(ii)

A range of responses were seen to this question but very few candidates wrote more than one reason so limited themselves to one mark. Many candidates did discuss the need for a different tertiary structure but did not link it into what we required for our fourth mark point.

(ii) Some types of Archaea have only one type of AK enzyme.

This enzyme can catalyse both the reactions shown in the table.

The tertiary structure of this enzyme is different from AK1 and AK3.

Explain why Archaea have a different type of AK enzyme.

(2)

Archea ~~they~~ don't have mitochondrea so both ATP and GTP will ~~be~~ need to be acted on in the cytoplasm, and it is more efficient to have one enzyme to catalyse both. The active site of that enzyme will need to be able to bind to ATP and GTP to form enzyme-substrate complexes with both, so will have a different shaped active site.

(Total for Question 2 = 7 marks)

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Examiner Comments

This is an example of one of the stronger responses that we saw.

Question 3 (a)

A very straightforward definition was required to start this question but not all candidates could give it.

3 Xylem and phloem tissues transport molecules and ions through plants.

(a) Give the meaning of the term **tissue**.

(1)

A group of cells, working together to carry out a particular function in the body.

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Examiner Comments

A clear definition. Just what we were looking for.

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Examiner Tip

We can ask you to define any biological term present in the specification, so make sure you have compiled a glossary of terms as you work your way through the course.

Question 3 (b)

A range of combinations were given in this question, which is effectively just three multiple choice questions. Most candidates knew that the phloem had sieve plates but fewer were confident about the presence of cellulose in the cell walls of cells from both tissues and the presence or absence of mitochondria in the two tissues.

(b) The table gives some information about the structures of xylem and phloem tissues.

For each statement, put **one** cross ☒ in the appropriate box, in each row, to show whether these statements are true for both types of tissue, xylem tissue only, phloem tissue only or neither type of tissue.

(3)

Statement	Type of tissue			
	both xylem and phloem	xylem only	phloem only	neither xylem nor phloem
Contain sieve plates	☒	☒	☒	☒
Have cellulose in the cell walls	☒	☒	☒	☒
Have mitochondria	☒	☒	☒	☒

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Examiner Comments

This candidate knew the structure of xylem and phloem.

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Examiner Tip

If you make a mistake, make sure that it is clear what is crossed out and what is your answer.

Question 3 (c)(ii)

A fairly straightforward calculation that the majority of candidates could do correctly and express to an appropriate number of decimal places.

(ii) In an experiment, the time between radioactivity appearing in aphid A and aphid D was 210 minutes.

The distance between these two aphids was 50 cm.

Calculate the rate of flow of phloem contents between these two aphids, in cm hour^{-1}.

210 mins = 3·5 hrs = 14·285714 29 (1)

50 cm

$\frac{50}{3·5} = \frac{100}{7}$

Answer 14·29 cm hour^{-1}

ResultsPlus
Examiner Comments

A clearly laid out calculation with a sensible choice for the number of decimal places given.

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Examiner Tip

Always check to see if we have given instructions on how to express your answer. If we have not, then you must decide what is appropriate for yourself.

Question 3 (c)(iii)

We saw lengthy responses to this question but few candidates actually gained all three marks despite the question being straight from the specification. Mark point 1 was scored often except by candidates who undermined themselves by naming other transport methods as well. Mark point 2 was probably the mark point most frequently awarded but there were candidates who wrote about glucose being transported. There was confusion as to how sucrose left the phloem. Candidates made attempts at scoring mark points 4 and 5 but the commonest error was to only give half the mark point; they would explain how water either entered or left the phloem but not both and they would mention the hydrostatic pressure at either the source or the sink without referring to both.

(iii) Describe how sugars are transported through the phloem.

(3)

- Sucrose is dissolved in H_2O to form sucrose solution and is transported in translocation, from the source [shoots] to the sink [roots]

- Sugars are transported in both directions down a pressure gradient
- At the leaf / source, sucrose is actively pumped from companion cell into sieve tube element, lowering water potential, so water moves in via osmosis from nearby xylem vessels increasing hydrostatic pressure
- At sink, sucrose is converted to starch, ~~lowering~~ increasing water potential so H_2O moves out and into xylem vessels, decreasing hydrostatic pressure
- Sugars move down a pressure gradient
- Bi-directional flow of sugars in phloem from source to sink

(Total for Question 3 = 9 marks)

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Examiner Comments

This is a high quality response, illustrating all our mark points.

Question 4 (c)

It is clear from candidate responses that they have used past mark schemes to learn the events that take place from the virus attaching to the host cell until it is assembled. However, few candidates appreciated that it takes more than one host cell to be destroyed for symptoms to occur and that there will be a delay for enough virus particles to be produced and host cells destroyed. There are still candidates that think that all RNA viruses are retro viruses and describe latency.

(c) Symptoms of influenza appear some time after a person is infected with the virus.

Explain why there is a time delay between infection and the symptoms appearing.

(3)

The virus ~~to~~ must enter the cell ~~before~~ ~~to~~ ~~atta~~ and its RNA must be used to synthesise new viral particles. ~~These mu~~ using the host's ribosomes. ~~These must be~~ ~~modi~~ The protein capsid must be synthesised and the virus must be assembled and lyse or bud from the cell. The virus must replicate many times before symptoms appear which will take time.

ResultsPlus
Examiner Comments

This candidate clearly knows what events must take place following attachment of the virus to its host cell and they appreciate that a high number of virus particles are necessary before symptoms will occur.

Question 4 (d)(i)

Candidates still find ratios difficult. Marks were lost because candidates did not express their answer as 'something to one' or 'one to something' or because they used an inappropriate number of decimal places.

(d) In some countries, people take antibiotics without a prescription.

In a survey, 77% of people who had taken antibiotics had taken them without a prescription.

Some of the people who took antibiotics without a prescription had influenza.

(i) Calculate the ratio of the number of people who took antibiotics without a prescription to the number of people who took antibiotics with a prescription.

Give your answer to two decimal places.

(1)

77 : 23 = 100 people

77 : 23

÷5 ÷5

15.4 : 4.6

÷2

7.7 : 2.3

7.7 : 2.3

3.85 : 1.15

Answer 0.77:0.23

This answer was seen on several occasions.

A ratio must be expressed as 'something to one' or 'one to something'.

Question 4 (d)(ii)

Most candidates knew that antibiotics are not effective on viruses but tended to say that the reason was because they did not have a peptidoglycan cell wall. Very few candidates scored mark point 2 despite lots of references to selection pressures in Q7(b)(iv), with these responses demonstrating a good understanding of this.

(ii) Explain why antibiotics should not be taken by people with viral infections.

(2)

Antibiotics ~~do~~ are not effective against viruses as ~~the~~ viruses are non-living. Antibiotics are ~~not~~ a selective pressure for bacteria so more resistant bacteria emerge.

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Examiner Comments

We felt that 'selective pressure' was close enough to 'selection pressure', particularly as it was used in the right context.

(ii) Explain why antibiotics should not be taken by people with viral infections.

(2)

- Antibiotics are not effective against viruses since viruses are not living cells so don't have ribosomes or cell walls
- An increased / over-use of antibiotics leads to antibiotic-resistant strains of bacteria spreading as the antibiotic acts as selection pressure / gives selective advantage to resistant strains so resistant strains of bacteria are more likely to survive and reproduce

(Total for Question 4 = 8 marks)

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Examiner Comments

A very good response that does give more details than we actually needed for the two marks.

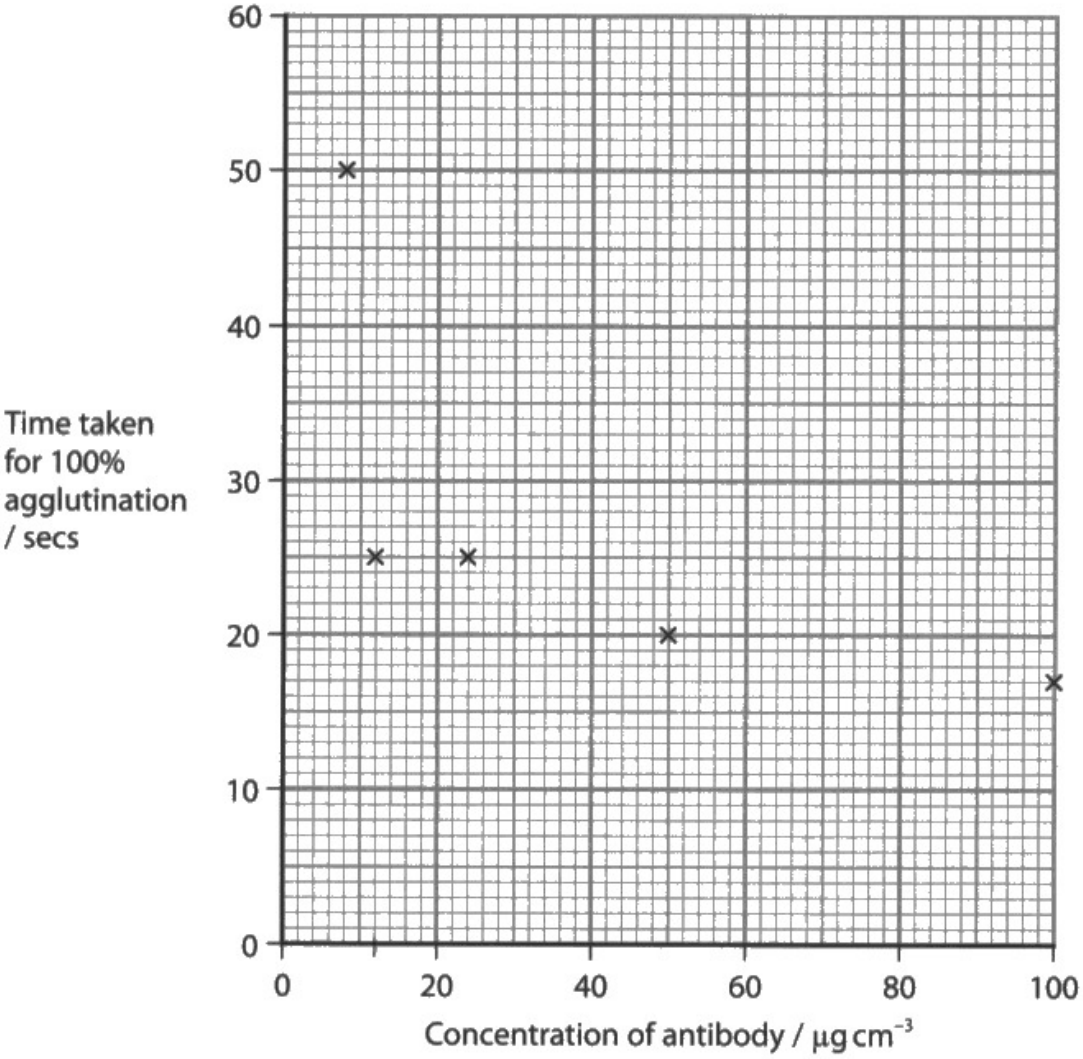
Question 5 (b)(i)

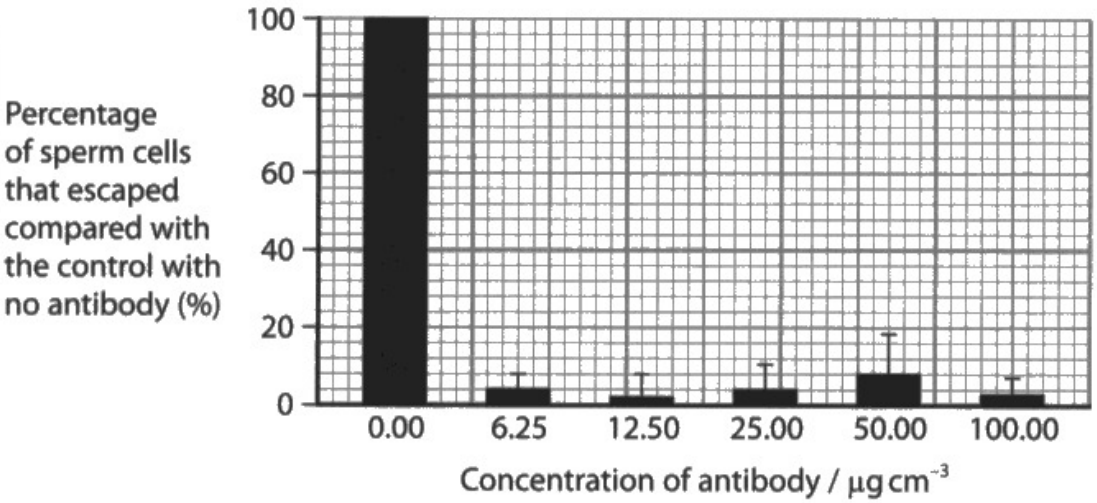
A reasonable number of candidates did this calculation correctly with the vast majority of these candidates expressing their answer as 6 000 and not in standard form.

Question 5 (b)(ii)

Candidates find commenting on data quite difficult, and this was no exception. Mark point 1 was frequently scored but barely any responses commented on the lack of error bars on the graph. The vast majority of candidates expect to find a pattern in data and the comments on graph 2 were no exception. There were comments about the error bars but usually in relation to the reliability of the data whereas we required comments on significance or validity.

(ii) The graphs show the results of this assay.





Analyse the data to comment on these results.

(3)

- As concentration of antibodies increase, time taken for agglutination decrease.
- Difference in the changes noted when concentration is increased from 8 to 12 $mg\ cm^{-3}$, 25 seconds greater.
- The percentage of sperm cells that escapes has no correlation with the concentration of ~~cells~~ antibody, as long as more than 6.25 $mg\ cm^{-3}$ is used. Presence of antibody decreases the percentage of escaped sperm cells greatly.

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Examiner Comments

This candidate could comment on what the data showed but did not comment on the error bars, or lack of them in graph 1.

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Examiner Tip

If a question starts with the command word 'comment on' and it is referring to data then you must comment on any error bars or lack of them. Do not refer to 'reliability' but to significance or validity.

Question 5 (b)(iii)

This question scored very poorly. Despite us telling the candidates in the question that the sperm were agglutinated by the antibodies, the vast majority of candidates ignored this and did not write anything approaching what was on our mark scheme. There were lots of comments about sperm swimming in different directions and therefore getting joined together in different orientations. Sadly, a number of candidates who had got the gist of the question forgot their biology lessons and talked about antibodies with binding sites to two different types of antigens.

Explain these observations.

(3)

Antibodies cause agglutination by binding to multiple antibodies on the foreign body, holding them together. Antibodies are specific to ~~extra~~ a ~~an~~ certain antigen. If they are able to bind to a to sperm head and flagellum, this means the same antigens are found throughout the sperm. Antibodies can bind multiple objects together because they have two binding sites.

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Examiner Comments

This was such a good response that we felt we could ignore the reference to antibodies at the end of the first line as it was clearly a slip.

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Examiner Tip

Always read through your answer to make sure that you have written what you mean and have not made any careless errors due to the pressures of exams.

Question 5 (c)

In the responses to this question the first mark point was most frequently awarded but for mark point 2 candidates essentially repeated the stem of the question without referring to the lack of antibodies.

(c) In the development of these contraceptives, the effect of the concentration of sperm cells on the time taken to agglutinate was also investigated.

Explain why agglutination could take longer at low and at high concentrations of sperm cells.

(2)

At low concentration it takes longer for antibody to collide with sperm so less likely to bind to antibody / more time needed, and around antibodies need to collide into each other for agglutination. At high conc, there are many sperm cells to be captured so it takes more time to capture them all as ~~not~~ ~~less~~ lower antibody : sperm concentration ratio

(Total for Question 5 = 10 marks)

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Examiner Comments

Although we did not really like the reference to 'capture', this candidate clearly knew the answer to the question and this poorly worded explanation did not contradict our mark point.

(c) In the development of these contraceptives, the effect of the concentration of sperm cells on the time taken to agglutinate was also investigated.

Explain why agglutination could take longer at low and at high concentrations of sperm cells.

(2)

At low concentrations of sperm cells, there will be less frequent collisions between sperm cells and antibodies, so fewer antibody-sperm complexes form over time, decreasing agglutination rate. At high sperm cell concentrations, the antibodies will become the limiting factor because they will be saturated with sperm cells, ~~so agglutination rate will decrease~~ and relative concentration of antibodies is lower.

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Examiner Comments

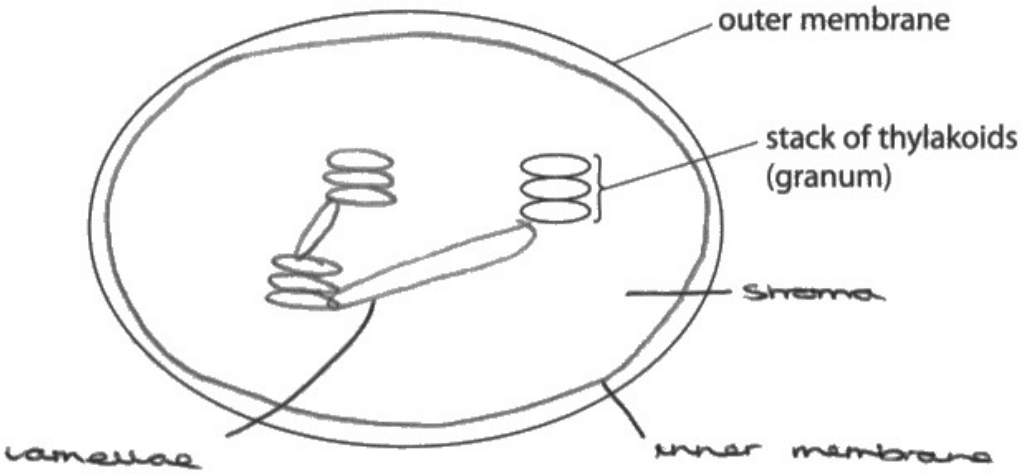
This was another way of phrasing the answer to get two marks. As a reference to 'limiting factor' was not the most appropriate, we did require some sort of qualification in the response to show that the candidate understood what was happening.

Question 6 (a)(i)

We have asked candidates to draw organelles such as chloroplasts in previous series and we saw a typical range of responses. The more able candidates had no problems with correctly drawing and labelling three structures, scoring full marks. In the diagrams from the less able candidates we saw mitochondria drawn and the stroma labelled as cytoplasm. Another common error was to draw the DNA as a linear structure.

6 Scientists have removed thylakoids from chloroplasts to make artificial chloroplasts.

(a) The diagram shows part of a chloroplast.



(i) Draw and label **three** other structures found in a chloroplast.

(3)

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Examiner Comments

This is an example of the type of diagram we were looking for.

Question 6 (a)(ii)

Candidates found converting the units straightforward for mark point 1. Surprisingly few candidates however expressed their answer to two significant figures as instructed.

(ii) Chloroplasts can be 3 µm in length.

Calculate the magnification of this diagram for a chloroplast that is 3 µm in length.

Give your answer to two significant figures.

(2)

8.2cm

= 82 mm

= 82 000 µm

$\frac{82\,000}{3} = 27333.33...$

Answer 27 000

ResultsPlus Examiner Comments

A clearly laid out calculation with the correct number of significant figures.

ResultsPlus Examiner Tip

Always show your working for a calculation worth more than one mark; if you arrive at the wrong answer, you may still pick up a method mark.

In addition, check the question to see if we require you to express your answer in a particular way.

Question 6 (b)

Candidates have clearly been prepared for their exam using past mark schemes as there were some excellent accounts of the light-dependent reactions. Unfortunately, a number of candidates did not link their answer to the thylakoid membranes as required, not gaining the marks. Other common errors were to not use the term 'absorb' so missing out on mark point 1, referring to reduced NAD and not reduced NADP so missing out on mark point 2 and not actually stating that the processes like photolysis and chemiosmosis were sited on the thylakoid membranes and missing out on mark point 5.

(b) Explain the importance of the thylakoid membranes in the light-dependent stage of photosynthesis.

(4)

- Thylakoid membranes contain ATP Synthase channel to allow Hydrogen ions to move down H^+ conc gradient (Chemiosmosis) and provide energy for photophosphorylation of ADP to ATP. Thylakoid membranes also have chlorophyll (electrons) in photosyste I these absorb light energy and get excited. ~~and as a result~~ There are electron carrier proteins in ETC of thylakoid membranes so that electrons can be transported through membrane providing energy for H^+ ions to move from Stroma to accumulate in thylakoid space. Compartmentalisation from the Stroma.

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Examiner Comments

This response illustrates all our mark points; we just would have preferred a more categoric statement for mark point 5.

Question 6 (c)(i)

The majority of candidates could correctly name the enzyme as RUBISCO. A variety of combinations of capital and lowercase letters were used but we ignored this.

Question 6 (c)(ii)

This question was not answered well as few candidates realised that we were really asking them about the products of the light-dependent reactions being needed in the light-independent reactions, which involves enzymes.

(ii) Explain why it is necessary to keep the thylakoids and enzymes together within droplets.

(2)

Because the products from the light-dependant stage move out of the thylakoid into the stroma, the enzymes involved in the light-independant stage must have access to the products of the light-dependant stage including NADPH and ATP.

Furthermore, the enzymes and substrate must be in same aqueous as water as metabolic reactions can occur in water but not in oil and ~~reactants~~ reactants would be unable to dissolve or move towards each other in oil.

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Examiner Comments

This is one of the better responses that we saw; we rarely saw the third mark point.

Question 7 (a)

Many candidates scored the mark for this calculation. The main reason for not scoring was for incorrectly expressing the answer in standard form.

Question 7 (b)(i)

Candidates are familiar with the rules of complementary base pairing so were able to score both marks for what is a relatively straightforward calculation.

(b) Analysis of the genome of the Yap hadal snailfish and the Mariana hadal snailfish showed that they were closely related.

(i) The DNA from the Yap hadal snailfish contained 725 608 564 bases and 204 202 736 of these bases were adenines.

Calculate the number of guanine bases in the DNA of this fish.

(2)

C&G = 725 608 564 - 2x 204 202 736 = 317 203 092

G = 317 203 092 ÷ 2 = 158 601 546

Answer 158 601 546

ResultsPlus Examiner Comments

This is an example of a well-thought out calculation.

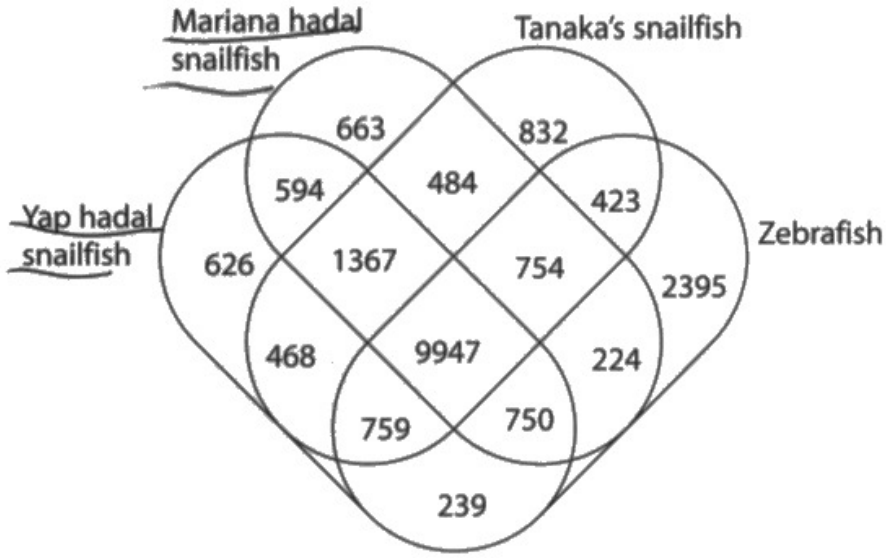
ResultsPlus Examiner Tip

Show your working to all calculations that are worth more than one mark.

Question 7 (b)(ii)

Candidates coped well with this calculation despite it requiring them to select numbers from an unfamiliar diagram, unless they had seen the SAMS questions that were produced for the launch of this specification. Marks that were lost were generally by those candidates who did not express their answer to one decimal place, as instructed.

(ii) The Venn diagram shows unique and shared gene families in the genomes of three species of snailfish and a zebrafish.



Calculate the percentage of gene families in the Yap hadal snailfish that are shared with the Mariana hadal snailfish.

Give your answer to one decimal place.

(2)

594+1367+9947+750 = shared

= 12658

Yap hadal is 12658 + 626 + 468 + 759 + 239

= 14750

Answer 85.8 %

$\frac{12658}{14750} \times 100 = 85.8$ (1dp) %

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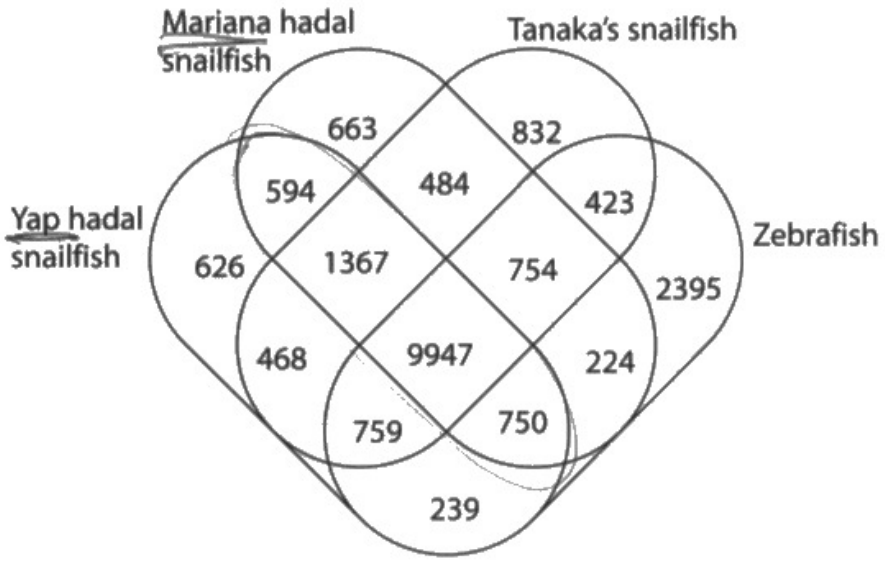
Examiner Comments

We felt that there were two ways of interpreting this question which is why there are two possible methods and answers on the mark scheme. This demonstrates the first alternative.

(ii) The Venn diagram shows unique and shared gene families in the genomes of three species of snailfish and a zebrafish.



Calculate the percentage of gene families in the Yap hadal snailfish that are shared with the Mariana hadal snailfish.

Give your answer to one decimal place.

(2)

594 + 1367 + 9947 + 750 = 12658

663 + 484 + 754 + 224 + 12658 = 14783

14783 / 12658 = 1.1679 x 100 = 116.8

12658 / 14783 = 0.8562 5 x 100 = 85.6%

Answer 85.6 %

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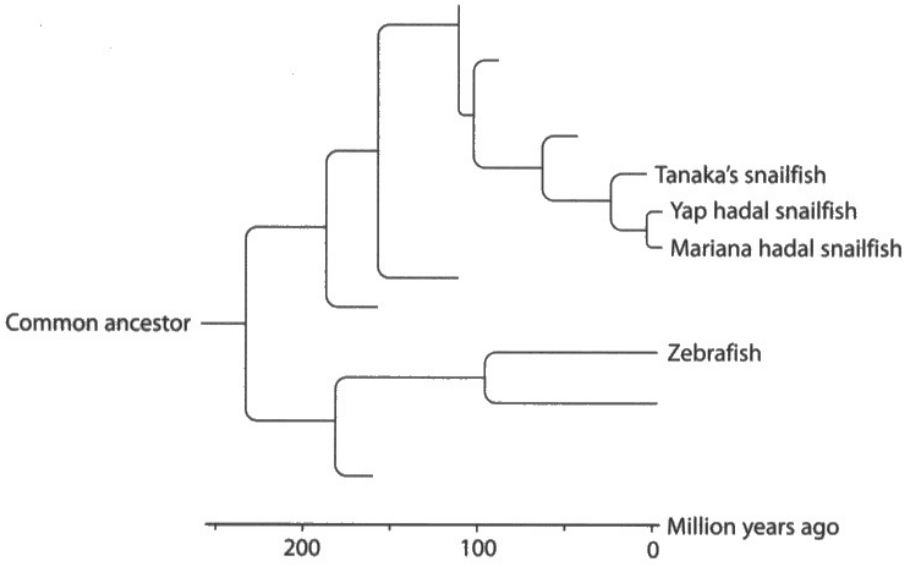
This demonstrates the second way of approaching this calculation.

Question 7 (b)(iii)

This question was also relatively high-scoring. The less able candidates described the relationships in terms of the branching or thought that each branch point represented a generation. There were some candidates who tried to apply the classification of organisms into kingdoms, phyla, classes, orders, families, genera and species to the fish.

(iii) The diagram shows the evolutionary relationship between three species of snailfish and a zebrafish.



Analyse the diagram to describe the evolutionary relationship between these four species of fish.

(3)

- Yap hadal snailfish + mariana hadal snailfish most closely related evolving from same common ancestor
- zebra fish most distantly related to other three
- all evolve from same common ancestor
- Tanaka's snailfish not as closely related to yap hadal + mariana hadal but are closer than zebrafish (the three evolve from same common ancestor).

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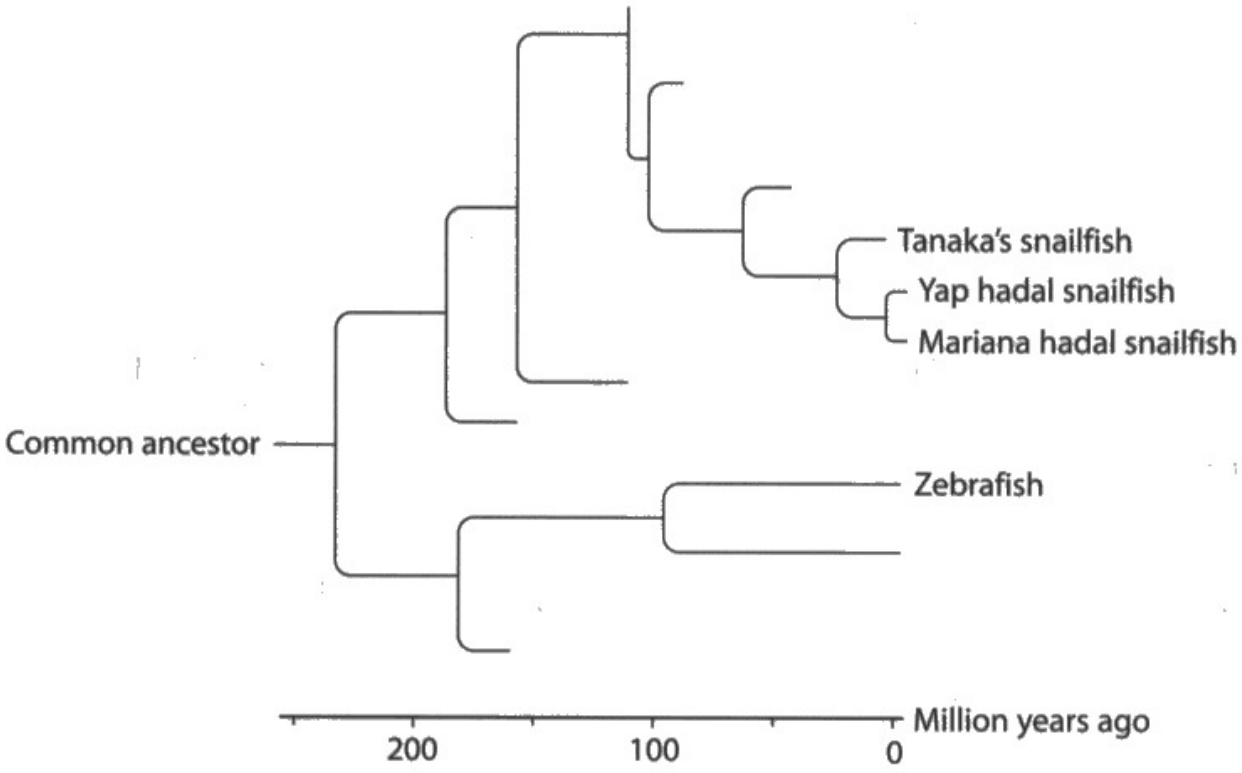
Examiner Comments

Mark points 2, 3 and 1 are illustrated in bullet points 1 and 3.

(iii) The diagram shows the evolutionary relationship between three species of snailfish and a zebrafish.



Analyse the diagram to describe the evolutionary relationship between these four species of fish.

(3)

- Yap hadal snailfish and Mariana hadal snailfish share the most recent common ancestor. Yap hadal snailfish and Mariana hadal snailfish's ancestor shares the same ancestor to Tanaka's snailfish.
- Zebrafish were the first to diverge from the earliest common ancestor so are the least similar to the other three species.

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Examiner Comments

Mark points 3, 4 and 5 are illustrated here.

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Examiner Tip

This is another example where the number of marks allocated to a question will help guide you to how many descriptions you should be making to access full marks.

Question 7 (b)(iv)

The first of our two levels-based questions saw a wide range of responses, with a number of candidates scoring the Level 3 marks. It was, on average, a higher-scoring question than the second question of this style, Q09(c).

There was some confusion between allopatric and sympatric speciation, which we tried to ignore where possible and there were candidates who thought that the selection pressures caused the mutations, which is a misconception we have seen before. The section that candidates performed best on was the natural selection section but there were some weak descriptions that were barely above GCSE level and there was the usual confusion between genes and alleles. Very few candidates made any reference to epigenetics. This did not surprise us but we felt that they should be credited if they did. We designed the level descriptors in such a way that this was not required to access the Level 3 marks.

*(iv) The Mariana hadal snailfish and the Yap hadal snailfish were caught in separate trenches hundreds of kilometres apart.

Explain how these fish evolved to become separate species.

(6)

Via the process of speciation and in this case allopatric speciation as there has been a physical barrier which seperates these species and prevents them from interbreeding and so no gene flow in the population. As they were caught in 2 seperate trenches. they experienced different selection pressures acting upon them. these could be biotic or abiotic factors such as predation, light intensity, food availability. This lead to frequent and random mutations in the DNA base sequence and led to the development of a beneficial allele. the individual with this beneficial allele was able to breed and pass this on increasing the allele frequency. This led to a change in the allele frequency of the 2 population due to distruptive ~~stabilising~~ selection. This meant that the 2 species were no longer the same species but 2 distinct seperate species which could no longer interbreed to produce fertile offspring.

ResultsPlus
Examiner Comments

This is a Level 3 response which demonstrates particularly good understanding of allopatric speciation and selection pressures. This candidate does imply that the different environments cause the mutations but we ignored this as much as possible as it did not contradict anything they had said. It is quite a short response but it is clear that this candidate understands speciation.

*(iv) The Mariana hadal ~~snailfish and the Yap hadal~~ snailfish were caught in separate trenches hundreds of kilometres apart.

Explain how these fish evolved to become separate species.

(6)

Allopatric speciation.
Parent population migrated which established a geographical isolation. The original gene pool had ~~some~~ ~~little~~ genetic ~~variety~~ variation due to random mutations in the genome (DNA.
~~to~~ Because of the geographical isolation, gene flow stopped. They ~~or~~ then encounter ~~diffent~~ different selection pressures and ~~environment~~ ~~environment~~ ~~environment~~ changes ~~so~~ some alleles will be more advantageous. the individuals with these alleles are more likely to survive and breed (natural selection) as they are better adapted to their niche (environment). the advantageous allele frequency increases and the alleles eventually gets fixed. By this point, ~~th~~ as this happens in both populations, ~~their~~ their gene pools become distinct and interbreeding has stopped (reproductive isolation) ~~so~~ so they've eventually different species.

ResultsPlus
Examiner Comments

This is another Level 3 response that demonstrates a good understanding of natural selection and the fact that it will occur in both trenches but leading to different phenotypes.

Question 8 (a)

Candidates know the macrophage antigen-presentation to T helper cells story but only the more able candidates realised that in a mRNA vaccine, the macrophages synthesised the actual antigen themselves. This resulted in our first two mark points being less frequently awarded. Quite a few candidates thought that the mRNA was presented by the macrophage but we ensured that this was only penalised once. Vague responses did not specify that the population of T cells that were presented the antigen were the T helper cells.

8 Vaccines are being developed to stimulate the immune response to destroy cancer cells.

Some of these vaccines contain mRNA that codes for specific antigens found on cancer cells.

(a) These vaccines deliver the mRNA into antigen presenting cells, such as macrophages.

protein synthesis

Describe how the delivery of mRNA into macrophages results in antigen presentation by these cells.

(4)

*mRNA strand is taken in by macrophage via endocytosis

*Using macrophage ribosomes mRNA is translated for protein synthesis to produce cancer cell antigen protein.

*Cancer cell antigen proteins are presented on macrophage cell surface membrane on MHC protein as an antigen presenting cell from macrophage that presents cancer cell antigen

*T-helper cell can and will bind to cancer cell antigen using its CD4 receptor, activating it and causing it to divide and specialise into T-memory and helper cells.

ResultsPlus
Examiner Comments

This response illustrates all our mark points except mark point 2, which tended to be seen the least frequently.

ResultsPlus
Examiner Tip

Read the question carefully and work out where your answer should begin and finish. In this question your answer needs to start with the introduction of mRNA and end with the actual presentation to the T helper cells. The number of marks allocated to the question will then give you an idea of how many steps you need to include.

Question 8 (b)

Candidates made a really good attempt at this compare and contrast question with very few blank responses seen. However, the responses highlighted just how much confusion there is between the two types of immune responses. Some of the more frequently seen misconceptions were that the HIR had two stages and the CMI only one, T helper cells were only involved in the HIR and not the CMI, that macrophages presented the antigen in the HIR and infected host cells in the CMI, the HIR was faster than the CMI and that antibodies killed the pathogens in the HIR.

(b) Antigen presentation results in the stimulation of both the humoral immune response and the cell-mediated immune response.

Compare and contrast the humoral immune response with the cell-mediated immune response.

(4)

- The humoral response ~~is~~ involves 2 stages, T helper activation and the B effect stage whereas the humoral response is just one stage
- The ~~humoral response~~ cell-mediated is activated when ~~there~~ pathogen has invaded host cells and T killer cells ~~re~~ bind to the antigen presenting cells whereas the humoral response is for lose pathogens and the T helper cells bind to phagocytes that have engulfed the pathogen and are presenting MHC-antigen complexes on their surface.
- The humoral response ~~does~~ produces ~~both~~ T helper memory cells and B ~~effector~~ memory cells whereas the cell mediated response produces T killer memory cells
- ~~The humoral response uses~~ Both the humoral and cell mediated responses use cytokines to activate ~~ly~~ lymphocytes (T killer activated in ~~h~~ cell mediated & B effector activated in humoral)
- The cell mediated kills the pathogen using enzymes that causes the cells they have invaded to lyse whereas the humoral uses antibodies to agglutinate and ~~opsonin~~ cause opsonisation of pathogen.
- Both ~~invo~~ lymphocytes (humoral T helper and B effector and cell mediated T killer)

ResultsPlus
Examiner Comments

This response illustrates some of the misconceptions but nevertheless illustrates some good understanding of the two types of immune response. We awarded mark points 8, 4, 3, 6 and 7.

ResultsPlus
Examiner Tip

Compare and contrast means that you must give similarities and differences to access full marks. The points you are making should be in pairs for each aspect you are comparing or contrasting. Do not write two separate descriptions because we cannot piece your answer together with this command word.

(b) Antigen presentation results in the stimulation of both the humoral immune response and the cell-mediated immune response.

Compare and contrast the humoral immune response with the cell-mediated immune response.

(4)

- Both the humoral and cell-mediated ~~Humoral~~ immune responses are specific immune responses.
- Both humoral and cell-mediated immune responses use ~~bbbbb~~ and activate T-helper cells - Both responses produce memory cells
- Humoral response releases antibodies whereas the cell-mediated does not
- Cell mediated immune response uses T-killer cells whereas humoral does not
- ~~Cell-mediated response used~~ more for virus and cancer whereas humoral ~~used~~ more for bacterial infection.

ResultsPlus
Examiner Comments

This response illustrates good exam technique for this type of question; the different aspects have been paired together and both similarities and differences are given. We awarded mark points 2, 4, 7 and 6.

Question 8 (c)

Unfortunately, many candidates wasted time writing about the development of the immune response and did not start their story with the actual products. Mark point 2 was lost by some candidates who thought that the antibodies themselves destroyed the cancer cells. It was also very obvious that many candidates do not know the differences between an antibody's role in agglutination, opsonisation and as an antitoxin; many candidates just wrote down all three roles.

(c) These vaccines stimulate both the humoral immune response and the cell-mediated immune response.

Explain how the products of these responses result in the destruction of cancer cells.

perforin

(4)

The cell mediated immune response produces T-killer cells which secrete perforin which makes holes in the cancer cells resulting in their death. They also secrete chemicals which cause apoptosis of cancer cells. The humoral response produces plasma cells which secrete antibodies. These agglutinate the cancer cells so neutrophils or macrophages can engulf and digest them. Also [redacted] ataxation occurs, which kills cancer cells.

ResultsPlus
Examiner Comments

This response was awarded full marks for scoring mark points 1, 3 and 4.

(c) These vaccines stimulate both the humoral immune response and the cell-mediated immune response.

Explain how the products of these responses result in the destruction of cancer cells.

(4)

The humoral response produces plasma cells which produce antibodies capable of binding to the antigens on the cancer cells acting as agglutinators or opsonins to make them more easily identified & be engulfed by phagocytes.
The cell mediated response produces T killer cells which release perforins that bind to the cell membrane of the cancer cells to form pores leading to an influx of water & ions causing the cancer cells to lyse & die.

ResultsPlus
Examiner Comments

This response illustrates the lack of clarity that many candidates have between opsonisation and agglutination.

Question 9 (a)(ii)

The responses to this question were encouraging. This is a different context for testing the role of the electron transport chain but many candidates coped well and picked up marks. Mark point 4 should have been one of the most accessible but many responses were too vague, just referring to cell death or that the fish cannot swim.

(ii) Explain why inactivating cytochrome c oxidase could be fatal.

(3)

Inactivating it will mean that the electron cannot be passed down the complexes in the electron transport chain. This means there will be no redox reactions and so no energy to pump H^+ ions into the inter-membrane space. With no hydrogens in the space, none will pass through the ATPase complex and so no ATP will be synthesised (no oxidative phosphorylation) This will mean the fish will have no energy to carry out the metabolic processes needed in the body and will die.

ResultsPlus
Examiner Comments

This is a logically thought out response demonstrating the majority of our mark points.

Question 9 (b)(i)

Definitions of epigenetic modification were disappointing with very few candidates giving us both halves of the definition.

(b) The adaptation of these fish to H_2S in their environment is thought to be due to epigenetic modification by DNA methylation.

(i) State the meaning of the term epigenetic modification.

(1)

a change to gene expression, without changing the base sequence of DNA

ResultsPlus
Examiner Comments

This candidate clearly knew the meaning of epigenetic modification.

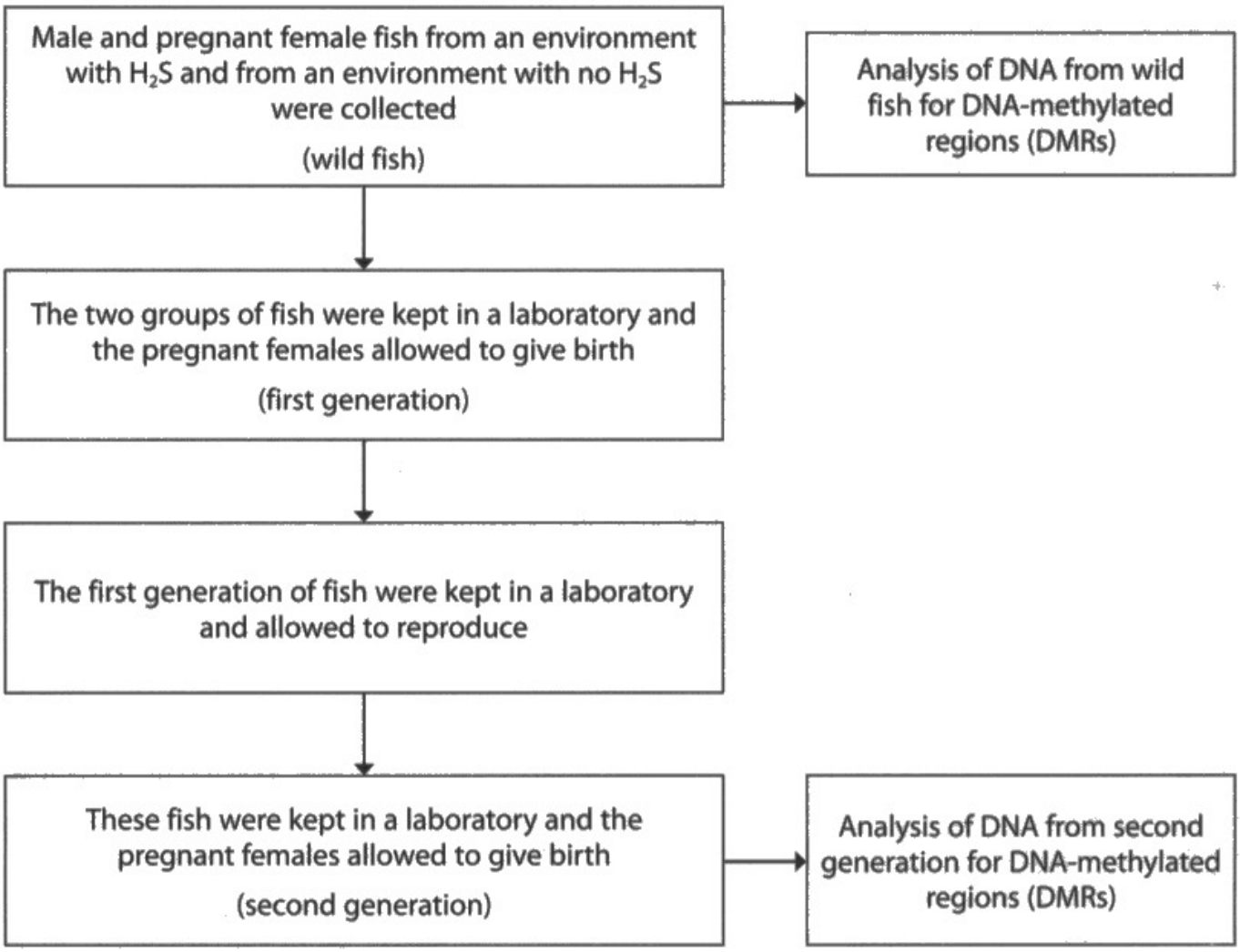
Question 9 (c)

This levels-based question was not answered as well as the one in Q07, despite our massive hint in the previous part to this question that this was all about epigenetic modification. We read lots of responses that simply described the data being shown in the graph. The candidates who had realised that they were expected to discuss the data in terms of epigenetic modification were quite often limited to a Level 2 response as they did not apply their knowledge to the fish in the H_2S environment.

*(c) The effect of hydrogen sulfide (H_2S) on DNA methylation in these fish was investigated.

The flow diagram shows part of the method used in this investigation.

All the fish kept in the laboratory were in water with no H_2S.

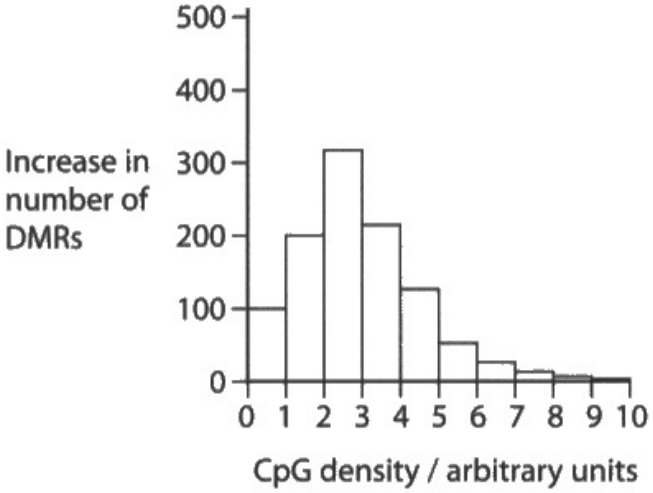


A CpG site is a region of DNA where a cytosine nucleotide is followed by a guanine nucleotide on the sense strand.

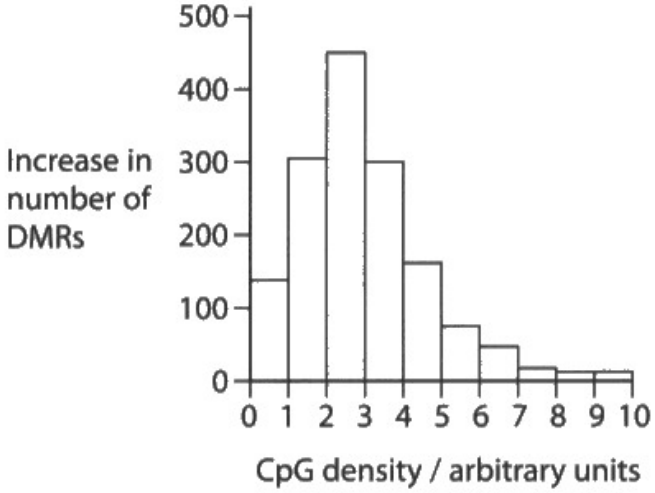
The DNA was analysed for the number of DNA-methylated regions (DMRs) at areas of DNA with different CpG densities. The numbers of DMRs for each group of fish were then compared.

The graphs show the increase in the number of DNA-methylated regions (DMRs) in each group of fish.

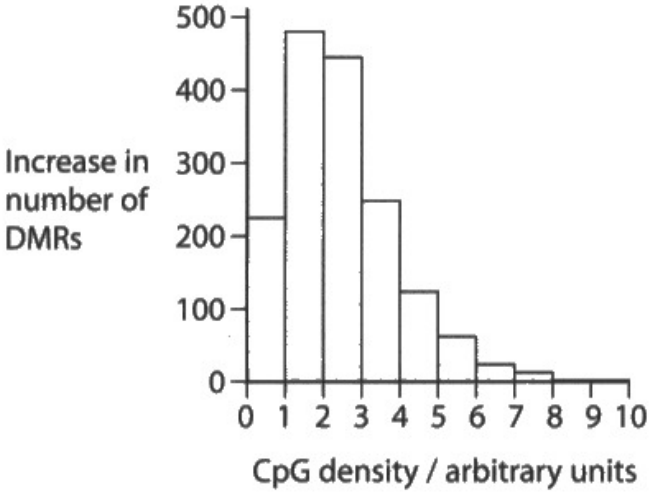
Graph 1: Wild male fish
fish from environment with H_2S compared with fish from environment with no H_2S



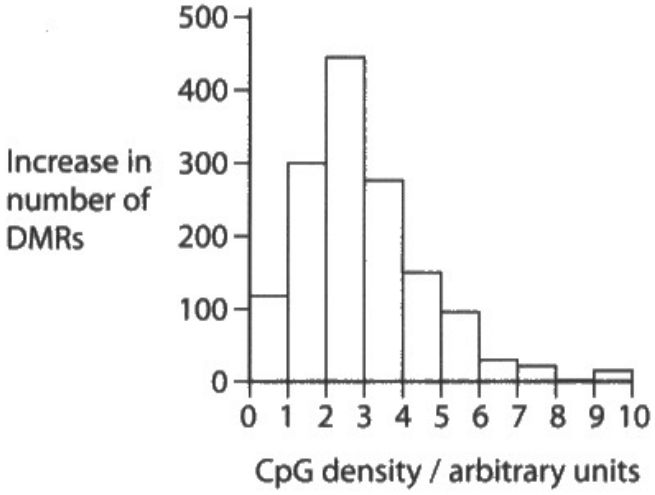
Graph 2: Wild female fish
fish from environment with H_2S compared with fish from environment with no H_2S



Graph 3: Second generation male fish
fish from environment with H_2S compared with fish from environment with no H_2S



Graph 4: Second generation female fish
fish from environment with H_2S compared with fish from environment with no H_2S



Discuss the results of this investigation.

(6)

DNA methylation occurs when a ~~ca~~ methyl group attaches to a cytosine which is next to a guanine. This can either tighten or relax the DNA to change the rate of transcription. The results from graph one and two roughly follow the same trends, but DMRs are at a higher number in female fish than male. Graph 4 (second generation females) present the same trend apart from no DMR increase in 8-9 CpG density region. As H_2S interupts respiration, DNA methylation occurs to enhance ~~ca~~ cytochrome c oxidase production or switch the genes for that protein off and enhancing the protein production of others in the ETC that aren't affected by H_2S. This is done by changes in the DNA structure to vary rate of transcription. Due to graph 3, male fish genes appear to be more effected by H_2S on DMR than female fish.

ResultsPlus
Examiner Comments

This is an example of one of the stronger responses that we saw. This candidate has identified that epigenetic modification is involved so has given some facts about that first. They then have looked at the information that we gave them about H_2S and cytochrome c oxidase and put it all together to discuss the data.

ResultsPlus
Examiner Tip

Always look at the information that we have given you and then try to incorporate it into your answer; information is there for you to use.

*(c) The effect of hydrogen sulfide (H_2S) on DNA methylation in these fish was investigated.

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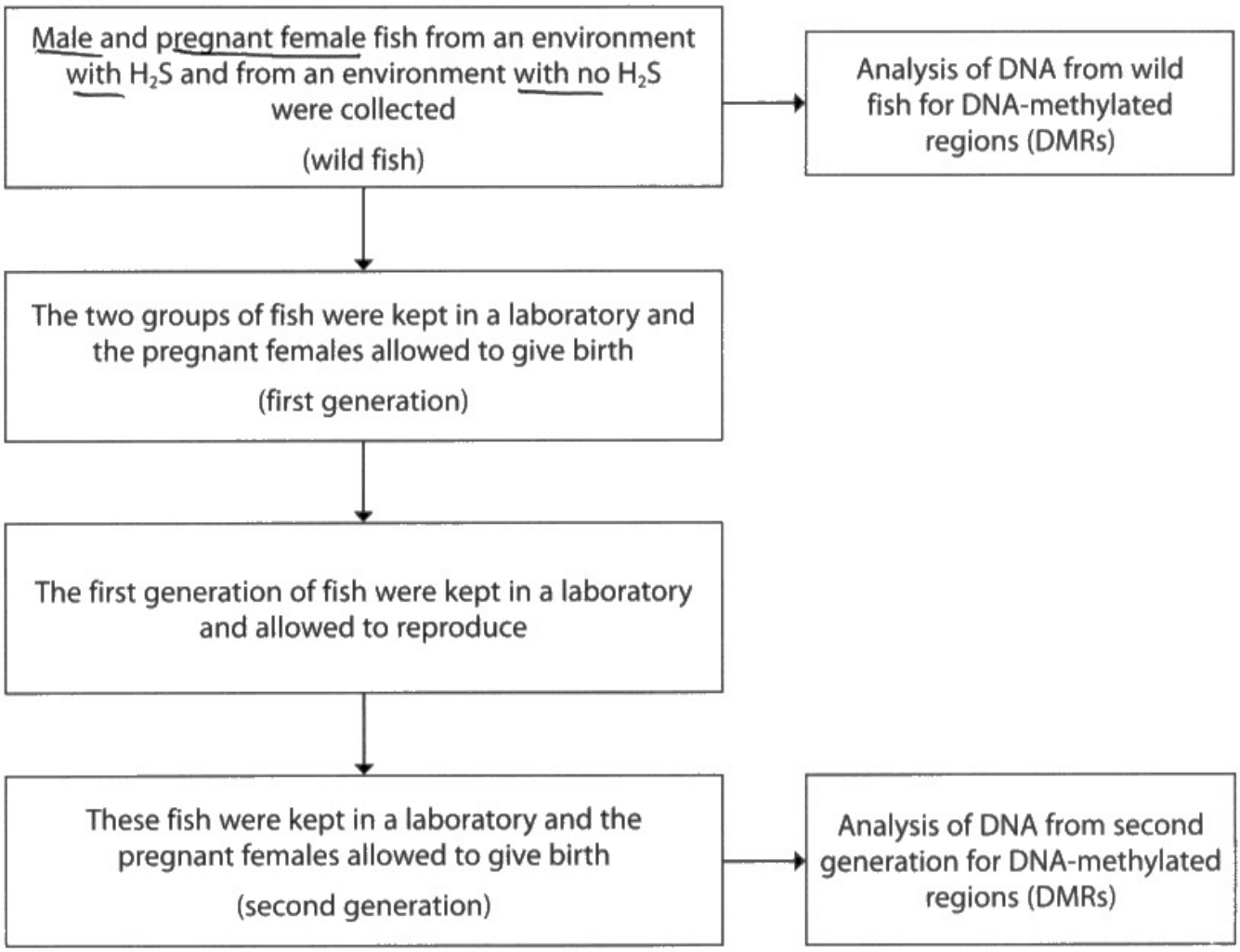

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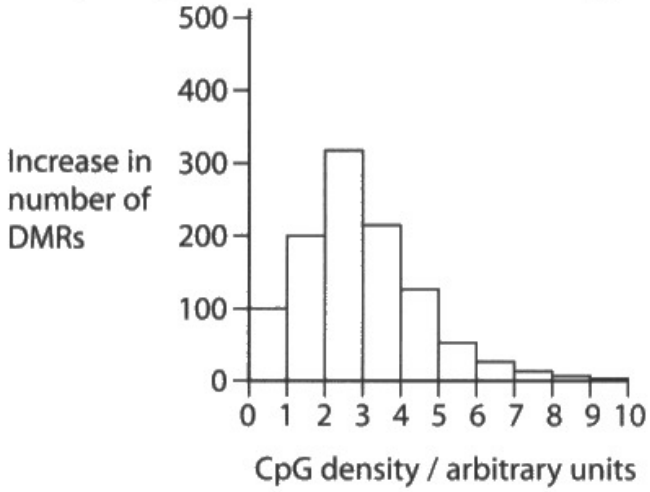
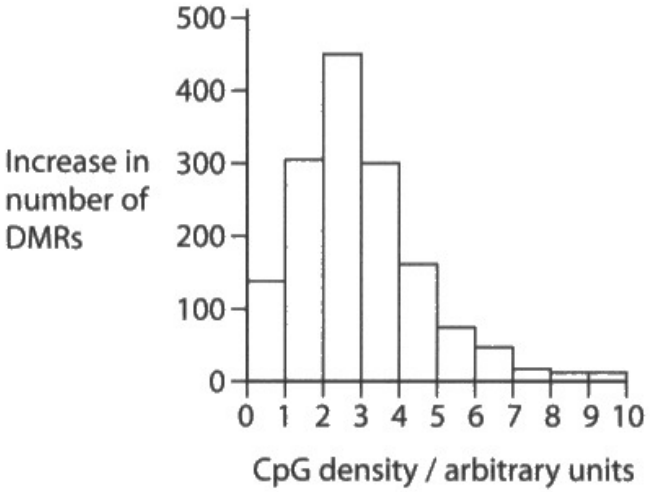
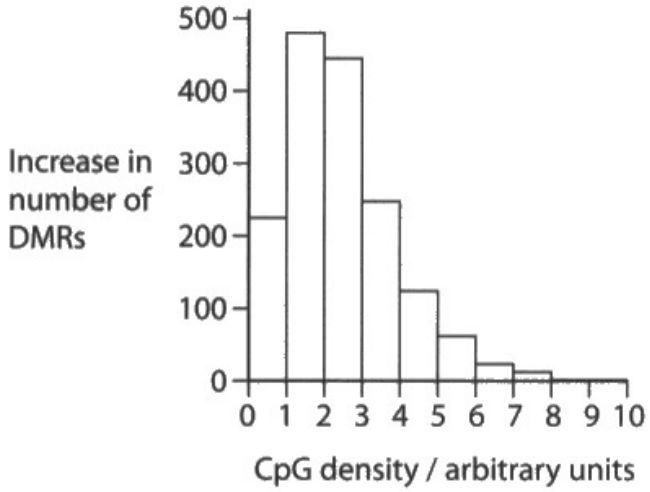


Graph 2: Wild female fish
fish from environment with H_2S compared with fish from environment with no H_2S



Graph 3: Second generation male fish
fish from environment with H_2S compared with fish from environment with no H_2S



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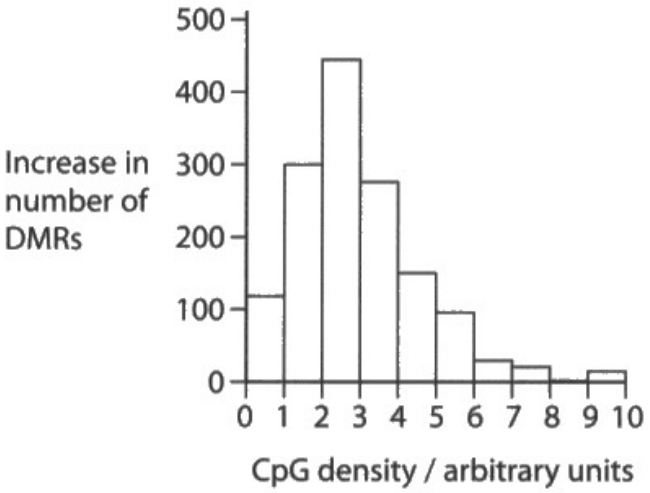
fish from environment with H_2S compared with fish from environment with no H_2S



Discuss the results of this investigation.

(6)

The ~~wild~~ wild male and wild female fish in environments with H_2S all had higher numbers of DMRs at each CpG density compared to the fish from an environment with no H_2S. This suggests they have an increased amount of DNA methylation, which may explain why as genes are switched on/off they can survive in the H_2S environment. In the second generation, the male fish had a much larger number of DMRs at CpG densities of 0-3. This suggests that being in water with no H_2S increased the methylation of areas with lower CpG densities. This may be due to the fact that epigenetic modification would take place in order for the fish to adapt to their new environment. However, the female fishes' DMR numbers increased about the same amount as in the second generation as the wild generation - DNA methylation about the same. For all the groups, the highest increases in DMRs were at 2-3 CpG density, with the second generation of male fish having theirs at 1-2. ~~All~~ for all the groups, the increase in number of DMRs decreased with an increase in CpG density - ~~getting~~ more similar to the no H_2S fish. This was only done with one group of one species of fish, and they did not test for any other epigenetic modifications - limitations to the investigation

(Total for Question 9 = 12 marks)

TOTAL FOR PAPER = 90 MARKS

ResultsPlus
Examiner Comments

This candidate has taken a slightly different approach by looking at each graph and discussing the data in terms of epigenetic modification. Another example of a good Level 3 response.

Paper Summary

Based on their performance on this paper, candidates should:

- Read the whole question carefully, including the introduction, to help relate your answer to the context asked. Quite often, early parts of the question will be designed to give clues to latter components which might appear more obscure due to an unfamiliar context.
- Use all of the information provided in the question to help you with your answer, eg graphs and tables of data including the labelling; this is particularly important in the levels-based questions.
- Make sure when asked to explain your answer that you have effectively included terms such as because, so, therefore, as a result, in your response. Make sure that you do not simply describe the data or repeat the information in the question that we have given you.
- Set out calculations carefully showing each stage of your working in case a mistake is made at the final step. Also check that the magnitude of the answer and the units makes sense in the context of the question and consider how you should express your answer if we have not given you instructions on how to do so.
- Be specific in your vocabulary avoiding vague terms such as amount and use something measurable such as volume or mass. Avoid using the term reproducible and refer to significance or valid, whichever is more appropriate.
- Ensure diagrams accurately represent exactly what is being drawn and that the label lines are touching the structures that they are pointing to.
- Attempt all questions and avoid leaving blanks, as blank answers are guaranteed zero marks.
- Look at appendix 6 and 7 of the specification to familiarise yourself with the command words and the examples of the mathematical calculations you are expected to be able to perform.

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