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Examiners' report

A LEVEL

BIOLOGY A

OCR Level 3 Advanced GCE in Biology A

H420

For first teaching in 2023

H420/01 Summer 2025 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate responses is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from Teach Cambridge.

Paper 1 series overview

Candidates attempted all multiple-choice questions and many used additional pages to complete their answers. There was no indication that candidates did not have enough time to attempt all questions.

The approach to the Level of Response questions was systematic and most candidates got marks. Most candidates could construct a null hypothesis but could not correctly identify the *t*-test and the degrees of freedom required to find the critical value.

The practical based calculations were well-answered, but many candidates could not adapt their practical knowledge to unfamiliar contexts, particularly with the use of a hydrogen carbonate indicator to study the rate of photosynthesis.

Most candidates could recognise and identify structures, e.g. in chloroplasts or fish gills, but lacked clarity in relating structures to their function.

Candidates showed a good understanding of different types of enzyme inhibition even with an unfamiliar reaction.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• could clearly and concisely relate the coordination of the electrical activity of the heart to the ECG provided • were confident in discussing statistical data and the validity of a method to evaluate a given conclusion • were able to relate the relevance of a double circulatory system to blood flow and pressure • could relate the structure to function of identified chloroplast components • discuss the role of gibberellins solely in terms of seed germination with a clear chronology of steps • were able to suggest how to utilise Q_{10} to compare temperature and carbon dioxide increases on the rate of photosynthesis.	• were able to suggest a null hypothesis but incorrectly interpreted statistical data and did not evaluate the validity of a method • could not relate the structure of identified components of chloroplasts to their exact function • were able to identify gibberellins as a requirement for seed germination but did not discuss details of their role in seed germination • could not match the ECG components to a correct description of the electrical activity of the heart • did not calculate a mean and relative intensity to be consistent with the data given • could not discuss the structure of haemoglobin in relation to its ability to carry oxygen, often discussing red blood cell structure and function instead.

Section A overview

All multiple-choice questions were answered, although candidates struggled with some of the questions, with option choices written then crossed out and written again. This resulted in some hybrid letters. Candidates should remember to clearly cross out an answer in the answer box and write the new answer next to the answer box. Many candidates had written notes and indicators next to the options to help eliminate or verify the correct option. This is good practice and aids in removing the cognitive load as deciding between the two remaining options is easier than deciding between four. Candidates performed well on graph interpretation questions. Many were able to visually compare rates from the graph related to Questions 7 and 8, doing well on Question 8 but struggled to convert log values into absolute numbers for Question 7. Most candidates were able to identify the correct correlation from the graph in Question 9. Recall questions were well-answered, e.g. Question 2.

Question 1

1 Which option describes a function of inorganic ions?

A Ca^{2+} is pumped across the membrane of a neurone to establish the resting potential.

B Cl^{-} and HCO_3^{-} are involved in transport of oxygen in the blood.

C Plants need NO_3^{-} for synthesis of amino acids.

D PO_4^{3-} is a component of triglycerides.

Your answer ☐ **[1]**

This was generally well-answered, but all options were seen with the most common incorrect answer being A.

Assessment for learning

To promote deeper understanding, candidates can be asked to justify why incorrect options are unsuitable, in addition to identifying the correct answer, e.g., 'Option A is incorrect because it refers to sodium or potassium ions.

Question 2

2 Which option describes a conjugated protein?

A A globular protein with a prosthetic group

B A protein with an inorganic ion

C A protein with more than one polypeptide chain

D An enzyme with an inorganic ion

Your answer ☐ **[1]**

Many candidates got this mark. Candidates could have eliminated all other options by recalling that many conjugated proteins are globular.

Question 3

3 Which statement about the function of enzymes is **not** correct?

A Enzymes affect the structure of whole organisms.

B Enzymes build larger molecules from smaller molecules.

C Enzymes carry signals from one part of the body to another.

D Enzymes catalyse reactions that affect cellular metabolism.

Your answer ☐ **[1]**

This question was generally well-answered. Candidates showed an understanding that 'affect' is a broad term that can refer to any change in rate. As a result, references to rate and specific reactions could be correctly associated with enzyme activity, leaving only C as the correct answer.

Question 4

4 Which option describes the structure of biological molecules?

A Carbohydrates contain only C, H and O, usually with an H to O ratio of 2 : 1.

B Nucleic acids contain only C, H, O, N, P and S in variable ratios.

C Proteins contain only C, H, O and N in variable ratios.

D Triglycerides contain only C, H and O, usually with an H to O ratio of 2 : 1.

Your answer ☐ **[1]**

This was generally well-answered. Candidates could recall that carbohydrates have the general formula $C_nH_{2n}O_n$ or think of glucose formula ($C_6H_{12}O_6$) to recall this general formula.

Question 5

5 Which option describes endocrine communication?

A Endocrine glands release hormones into ducts such as the pancreatic duct.

B Hormones are all lipid soluble and bind to receptors in the cytoplasm.

C Hormones are released from exocrine glands and taken by the blood to specific target cells.

D Target cells have specific receptors for the hormones that act upon them.

Your answer ☐ **[1]**

This question explores the meaning of the term endocrine. This was generally well-answered, with candidates often indicating the inaccuracies next to the incorrect options. Candidates had a clear understanding of the difference between exocrine and endocrine function and also recognised the subtlety of 'all' hormones being lipid soluble as an incorrect statement.

Assessment for learning

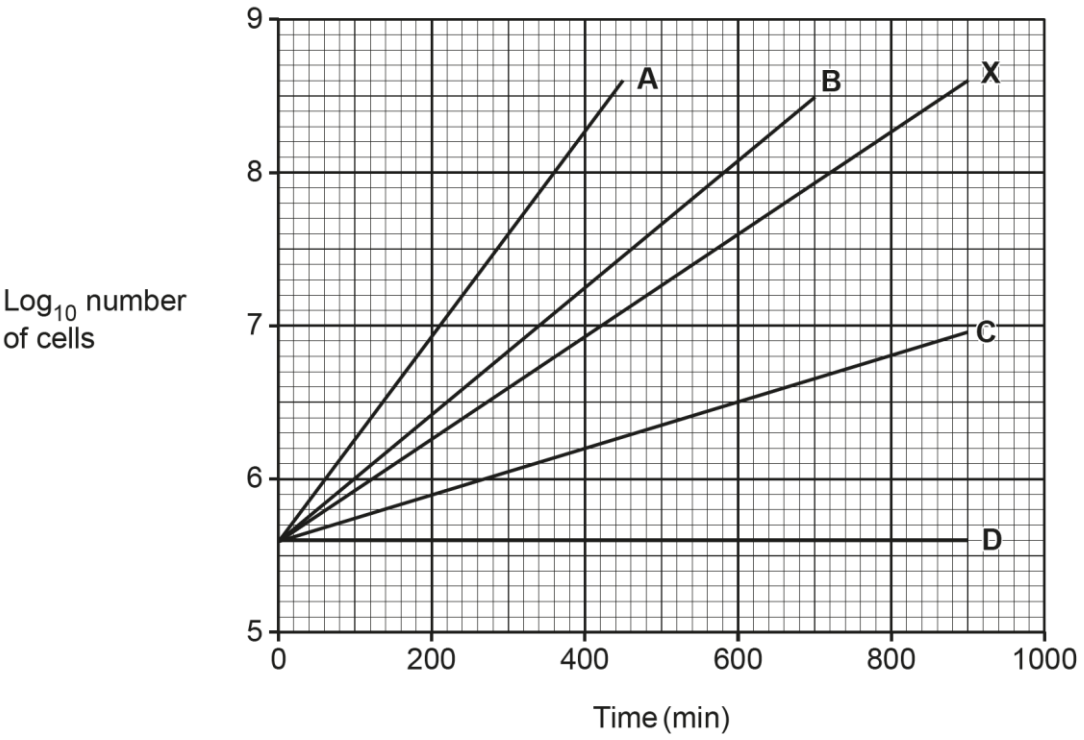
These terms can be cemented in their meaning when examples are used. The most appropriate example being the pancreas with reference to both its endocrine and exocrine function.

Questions 7 and 8

A student investigates the growth of yeast cells in culture under different conditions.

In experiment one they grow yeast cells with glucose at 25 °C. The results are shown as line **X** on the graph.

In experiment two they grow yeast cells under different conditions. The results are shown as lines **A** to **D** on the graph.



Use the information to answer questions **7** and **8**.

7 In experiment one, what is the number of cells in the culture after 10 hours?

A 0.9×10^7

B 4.0×10^7

C 7.6

D 7.6×10^7

Your answer [ ] **[1]**

8 Which line, **A** to **D**, in experiment two represents a culture where the growth rate is approximately double that in experiment one?

Your answer ☐ **[1]**

Successful answers showed workings next to the graph. The value on the y axis at 600 minutes is 7.6. $\log_{10}$ (number of cells) =7.6. This is the same as $10^{7.6}$ which can be rounded to give the answer B.

Calculation:

At 600 minutes Log_{10} (number of cells) =7.6

Number of cells = $10^{7.6}$ ~ 39,810,717

In standard form = 3.981 x 10^7 ~ 4.0 x 10^7

For Question 8, most candidates got the mark. Candidates should be able to immediately eliminate C and D as the gradient would have to be greater than X for there to be an increase.

Question 9

9 A scientist measures the oxygen uptake and carbon dioxide output of an athlete on an exercise bike at increasing work rates.

The results are shown in the graph.

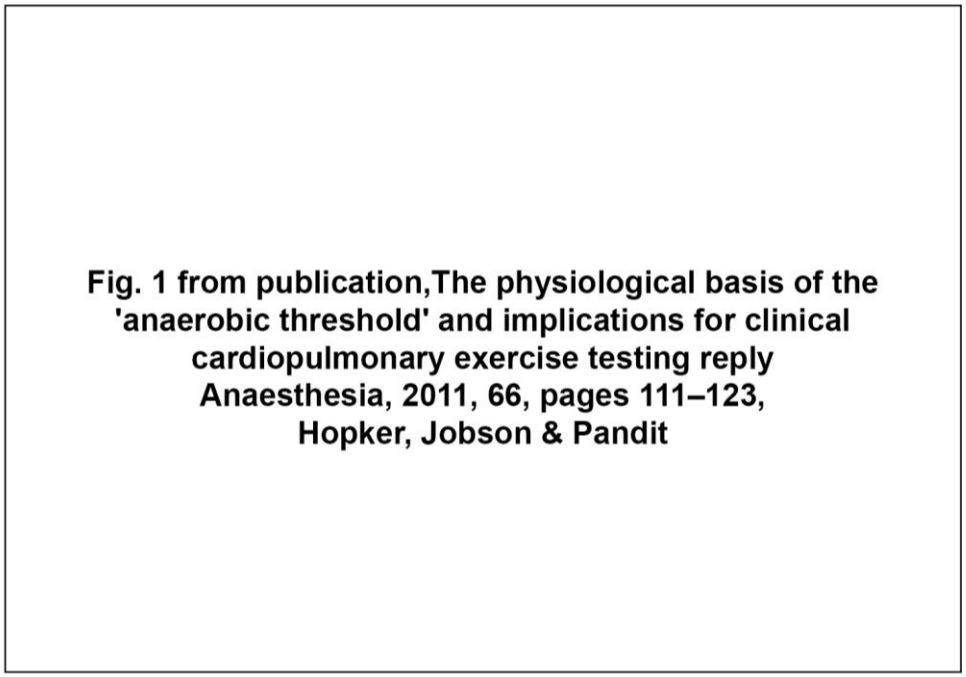


Fig. 1 from publication,The physiological basis of the 'anaerobic threshold' and implications for clinical cardiopulmonary exercise testing reply Anaesthesia, 2011, 66, pages 111–123, Hopker, Jobson & Pandit

What are the results shown in the graph?

A There is a negative correlation between oxygen uptake and work rate.

B There is a positive correlation between carbon dioxide output and work rate up to 300 W after which the correlation becomes negative.

C There is a positive correlation between oxygen uptake and work rate.

D There is no correlation between carbon dioxide output and work rate.

Your answer [ ] **[1]**

This was well-answered, with a lot of candidates showing a clear understanding of correlation.

Question 11

11 A student completes a series of experiments to investigate the role of auxin in apical dominance.

The experimental procedures are shown in the table.

Experiment	Procedure
1	Control: apical bud left on plant.
2	Apical bud removed.
3	Apical bud removed and replaced with agar block.
4	Apical bud removed and replaced with agar block containing auxin.

What are the expected results of the investigation?

A Lateral buds will grow in all the experiments.

B Lateral buds will grow in experiments 2 and 3.

C Lateral buds will grow in experiments 2, 3 and 4.

D Lateral buds will not grow in any of the experiments.

Your answer ☐ **[1]**

This was generally well-answered, with a lot of candidates appreciating the opposing nature of the growth of apical and lateral buds.

Question 13

13 Which statement does **not** describe the Krebs cycle?

A It combines an acetyl group with citrate to form oxaloacetate.

B It is a source of ATP produced by substrate level phosphorylation.

C It is a source of reduced NAD and reduced FAD that are re-oxidised in oxidative phosphorylation.

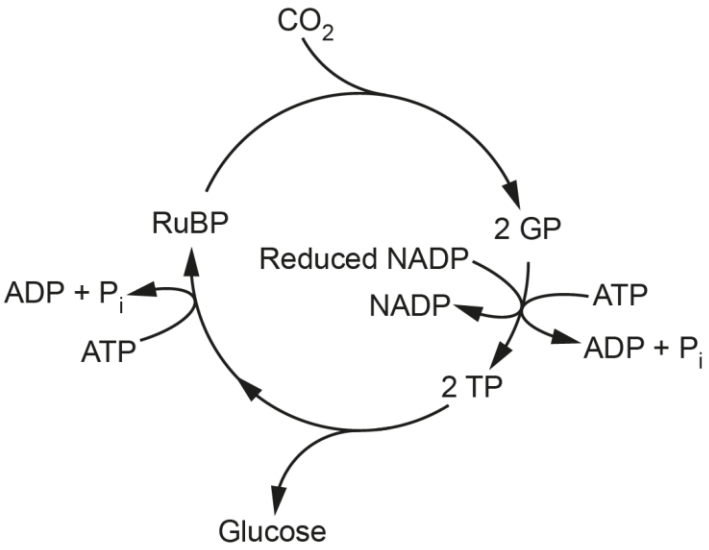
D It releases coenzyme A for reuse in the link reaction.

Your answer ☐ **[1]**

This was well-answered, with many candidates embracing the negative format and correctly answering the question. Many correct responses included a sketch of the Krebs cycle alongside the question. This proved to be an effective strategy for recalling key information and applying it to identify the correct answer (Option A) by recognising that citrate and oxaloacetate were given in the wrong order.

Question 14

The diagram shows the process of carbon dioxide fixation in the light independent stage of photosynthesis (Calvin cycle).



Use the diagram to answer questions **14** and **15**.

14 Which of the statements about the effect of reducing light intensity is/are correct?

1 The amount of glucose produced will be reduced.
2 The concentration of GP will increase.
3 More ATP and reduced NADP will be available from the light dependent reaction.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer [ ] **[1]**

Many candidates were unable to use the information provided to select the correct statements for this question, with just over half of candidates answering correctly. There were varied responses to this question, which required understanding of both stages of photosynthesis to determine that option B is the only correct choice.

Question 15

15 Which of the statements about the effect of reducing carbon dioxide concentration is/are correct?

1 The amount of glucose produced will be increased.
2 The concentration of RuBP will increase.
3 The concentrations of GP and TP will both decrease.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer [ ] **[1]**

This was well-answered, with most candidates correctly stating option C. Candidates found Question 15 easier to follow as it purely focused on the Calvin cycle diagram provided.

Section B overview

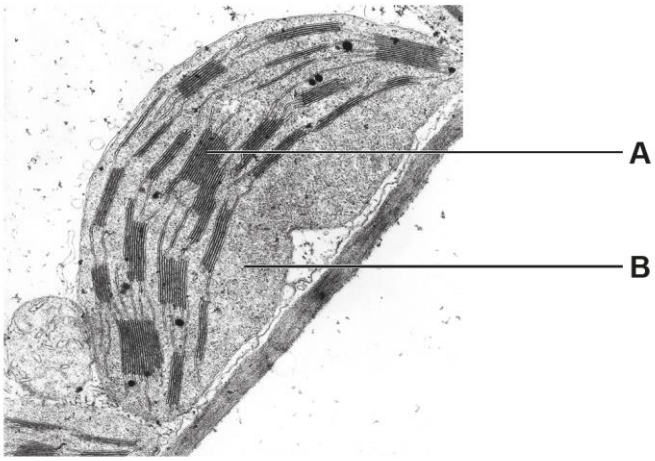
Candidates attempted most question parts, although some omitted Question 19. Identification of components from micrographs and pictures were well-answered, but many candidates were not precise when describing adaptations of certain structures. This was the case for Question 16 (a) and later in Questions 21 (a) (i) and 21 (a) (ii). Numerical questions were well-answered, often with clear workings shown, although some candidates did not display their final answer in the same consistent manner as given data for Question 19 (a) (ii) or did not pay attention to the units already on the answer line for Question 16 (b) (i), writing their answer in cm. The Level of Response questions were well-answered, with a clear reference to the different components of the question. For Question 18 (b), most candidates could write a null hypothesis and explain the relevance of the *t*-test, but very few candidates could accurately state the degrees of freedom to the correct critical value. For Question 20 (d), many candidates described a clearly the events for the cardiac muscle contraction, in the correct order and were able to relate these events to the ECG.

Some candidates confused biological terms and features. This was apparent for Questions 16 (a) (i) and 16 (a) (ii), where reference was often made to plasma membranes, cytoplasm and mitochondria being present in chloroplasts, as well as writing cisternae instead of cristae. This confusion was also seen in Question 21 (b), where some candidates confused haemoglobin with red blood cells and described the structural adaptations of red blood cells instead of the pigment. Candidates struggled with the unusual context of Question 19, especially for Questions 19 (b) (i) and 19 (c) (ii). The subtle differences between questions asking for improvements to a method versus modifications often led candidates to repeat the same answers. Additionally, most candidates were unable to explain the relevance or limitations of the indicator used in the experiment, frequently misidentifying it as a source of carbon dioxide.

Question 16 (a) (i)

16

(a) This is a transmission electron micrograph of a chloroplast.



(i) Identify the components labelled **A** and **B and** describe how they are adapted for their function.

Component **A** .....

Adaptation .....

.....

.....

Component **B** .....

Adaptation .....

.....

.....

[4]

Components were identified correctly in most responses, with a few errors when the chloroplast was confused with a cell and plasma membranes or cytoplasm was stated as a component.

The adaptations often lacked precision. A lot of answers discussed the adaptation but related it to the function of photosynthesis instead of a precise stage in photosynthesis.

Exemplar 1

Component A ..... thylakoid .....

Adaptation ..... the thylakoid membrane is embedded with photosystems (including PSII and PSI) to carry out light-dependent photophosphorylation in photosynthesis .....

Component B ..... Stroma .....

Adaptation ..... contains ribosomes to synthesise the enzymes required for the Calvin cycle, such as rubisco enzyme, to catalyse the reaction of RuBP and CO_2 .....

[4]

The adaptation response in this exemplar relates precisely to the function in the various stages of photosynthesis.

Question 16 (a) (ii)

(ii) Identify **one** similarity and **one** difference between the structures of chloroplasts and the structures of mitochondria.

Similarity .....

.....

.....

Difference .....

.....

.....

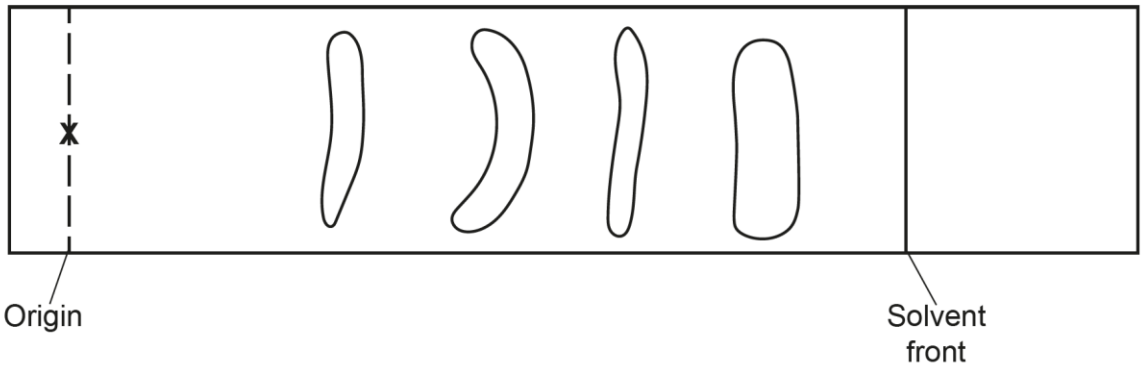
[2]

Some responses confused the organelles with cells and referenced membranes as plasma membranes. A few candidates stated that chloroplasts do not have their own DNA. Starch was referred to occasionally as a difference, but this is not a structure of chloroplasts but a product from its reactions. For similarities, a few responses referred to ATP synthase but added that this was required for oxidative phosphorylation, which is not relevant to chloroplasts.

Question 16 (b) (i)

(b) A student used thin layer chromatography (TLC) to separate the photosynthetic pigments in a chloroplast extract.

This is the result of the TLC.



(i) Calculate the R_f for the most soluble pigment.

Give your answer to **2** significant figures.

Distance travelled = ... mm

R_f = ...

[3]

Candidates scored well on this question, with many correctly identifying the most soluble pigment as the one nearest the solvent front. However, there were variations from candidates in measuring the large component illustrated. Measurements should have been to the middle of the component, but values to the top line of the component or to the bottom line of the component were accepted. Most candidates correctly measured the solvent front although errors were seen with measurements to the end of the TLC paper. Many candidates measured in cm rather than mm and some wrote their answer on the answer line in cm even though the 'mm' unit was already stated. Candidates should always pay attention to the presence of units on an answer line, so their answer reflects the units stated. Most answers, where the component distance was divided by the solvent front distance, were given to 2 significant figures.

OCR support

Chromatography is one of the practical activities that candidates will have an opportunity to complete during their practical endorsement. Past paper questions on chromatography can be found here.

Assessment for learning

In chromatography measurements should have been to the middle of the component Candidates should always measure the middle of the component, which they can always do by measuring the top and bottom of the illustrated component and dividing by 2 if it appears difficult to judge this accurately.

Question 16 (b) (ii)

(ii) The student noticed that the spots were very faint and thought that there might be other pigments present in the mixture that were too faint to be seen.

Describe how the student could increase the intensity of the spots using the same chloroplast extract.

.....

.....

.....

.....

..... **[2]**

Responses to this question lacked clarity. For example, candidates often referred to adding more spots without clarifying if their spots referred to the chloroplast extract, or where the spots/extract should be placed. Some responses referred to adding a greater volume, which was not credited. Adding more volume would just spread out the extract and not intensify the separated pigments unless it was allowed to dry in between additions. References were also made to using a stronger solvent which again was not credited. Solvents separate the pigments they wouldn't increase the intensity of the spots.

Some responses referred to adding different stains or colours. Adding more colours would lead to additional spots on the TLC as they would probably have a different affinity to the TLC and potentially interfere with the results. These responses also referred to ninhydrin, which is required for chromatography of amino acids rather than chloroplast extract.

A few responses referred to grinding the chloroplasts to a greater degree or adding in different components to release the pigments. This was irrelevant as the question asks how the same chloroplast **extract** could be used.

Assessment for learning

When answering method questions, it is useful to visualise the steps in the method to help make statements explicit. Additional pages can be used to sketch the steps or to think through the procedure step by step to help focus on possible improvements or sources of error.

Question 16 (b) (iii)

(iii) Describe how the student could use the same equipment but increase the accuracy of the calculated R_f value.

.....

..... **[1]**

Most responses focused on repeating the TLC and calculating a mean. There were a few responses that used the term average and not mean. Candidates should look at data and mode/median/mean to make sure they are clear why the term mean is used and not average.

OCR support

Details of mean/mode/median can be found in the mathematical skills handbook.

Maths for Biology resources can support candidates as they include tutorials and quizzes for each mathematical skill assessed in the specification.

Question 16 (b) (iv)

(iv) The student was not able to identify any of the pigments using R_f values from a data book.

Suggest an explanation for this.

.....

..... **[1]**

This part of the question was a good differentiator, with stronger responses referring to variables such as a different solvent, temperature, or plant species.

Question 16 (b) (v)

(v) Describe how the student could use TLC to identify the pigments present in the mixture without calculating R_f values.

.....

.....

.....

.....

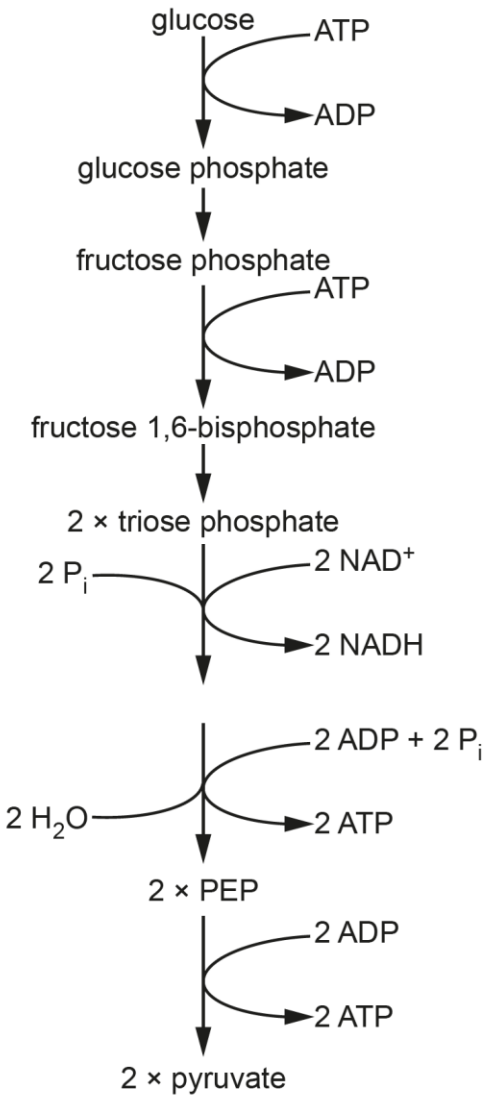
..... **[2]**

Many responses recognised the colour of the pigments as a tool for comparison, but sometimes did not state what the colours would be compared to.

Question 17 (a) (i)

17

(a) The diagram shows some of the steps in glycolysis.



The enzyme phosphofructokinase (PFK) catalyses the conversion of fructose phosphate to fructose 1,6-bisphosphate (hexose bisphosphate).

(i) State the type of reaction that is catalysed by PFK.

..... **[1]**

This was generally well-answered, with most answers recognising that a phosphorylation reaction occurs to make fructose 1,6-bisphosphate. However, many answers referred to this phosphorylation as substrate level.

Misconception

Substrate-level phosphorylation is not the same as the phosphorylation of fructose phosphate. Substrate-level phosphorylation refers to the direct transfer of a phosphate group from a substrate to ADP, forming ATP. In contrast, the phosphorylation of fructose phosphate involves the use of ATP, where a phosphate group is removed from ATP (forming ADP) and added to the sugar molecule. Candidates should focus on whether ATP is being formed (as in substrate-level phosphorylation) or consumed (as in other phosphorylation reactions) to help distinguish between the two.

Question 17 (a) (ii)

(ii) The intermediate compound PEP is a reversible non-competitive inhibitor of PFK.

Explain how PEP inhibits PFK.

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.....

.....

..... **[3]**

This was well-answered by most candidates. A few responses referred to the allosteric site as a second active site. Candidates should be reminded that active site refers to the part of an enzyme where substrate binds and a second active site would suggest more than one substrate and not the binding of an inhibitor. A few candidates confused non-competitive inhibition with competitive inhibition. It is useful to compare and contrast these when teaching this topic so the differences can be clearly defined. A few candidates confused the different terms and referred to PFK as the inhibitor.

Assessment for learning

A good practice when answering questions with unknown context is to annotate the stem of the question. In this case it can help candidates to identify which molecules are enzymes and which are substrates.

Question 17 (a) (iii)

(iii) ATP is also an inhibitor of PFK.

Suggest **and** explain why ATP cannot be a competitive inhibitor of PFK.

.....

.....

.....

.....

..... **[2]**

Many candidates gained one mark for correctly suggesting that ATP does not have a similar shape to fructose phosphate. Some extended this reasoning by explaining that ATP would therefore not be complementary to the active site. However, a number of responses focused on stating that ATP was a non-competitive inhibitor, rather than explaining why it is *not* a competitive one. It's important to note that the question asked for reasoning behind why ATP is not a competitive inhibitor, not to identify the type of inhibition.

Question 17 (a) (iv)

(iv) Inhibition of PFK by ATP and PEP is an example of a negative feedback control mechanism.

State the name of this type of inhibition in metabolic pathways such as glycolysis.

..... **[1]**

Many candidates could correctly recall this type of inhibition. Some answers referred to end point inhibition with others stating homeostasis or negative feedback.

Assessment for learning

When using terms like this (i.e. end product inhibition) it is good to emphasise the logic in the keywords. This key term refers to the product at the end of the metabolic pathway inhibiting a stage in the pathway- hence the term end product inhibition.

Question 17 (a) (v)

(v) ATP is converted to ADP and then AMP (adenosine monophosphate) when ATP provides energy for processes in the cell.

AMP reverses the inhibition of PFK by ATP.

Use this information to suggest how PFK acts as a key enzyme in the regulation of the rate of glycolysis.

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.....

.....

.....

..... **[2]**

Many candidates found it difficult to formulate a response and referred to a need for ATP for energy driven reactions rather than focusing on the rate of glycolysis as stated in the question stem.

Question 17 (b)

(b) Complete the following sentence.

Some inhibitors form strong covalent bonds with enzymes and are known as

..... inhibitors.

[1]

Candidates who did well in the exam recognised the relevance of the strong covalent bond statement and correctly identified non-reversible inhibitors. Many answers referred to non-competitive inhibitors even though the previous question parts had focused on reversible non-competitive inhibitors. This suggests that candidates had either not realised the relevance of the covalent bond or did not connect the previous question parts to this question part.

Assessment for learning

Candidates should always refer to previous parts of the same question to look for information that may be relevant in the stem of the questions.

Question 17 (c) (i)

(c) The chemical equation for aerobic respiration with glucose as substrate is:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

(i) State the name of the type of reaction in aerobic respiration that produces CO_2.

..... **[1]**

This was well-answered, with most candidates stating decarboxylation. Hydrolysis was a common incorrect answer.

Some incorrect answers referred to the stages where this decarboxylation occurs.

Assessment for learning

Candidates should underline or annotate key parts of the question stem to focus their answers. They should also use all the question parts to help inform their answers.

Question 17 (c) (ii)

(ii) State the names of the **two** stages in respiration where CO_2 production occurs.

1 .....

2 .....

[2]

This was well-answered, with most candidates getting at least 1 mark, and many getting both. Some answers referred to oxidative phosphorylation or glycolysis.

Question 17 (c) (iii)

(iii) Respiration of glucose involves a series of oxidation reactions.

Explain how oxidation occurs in glycolysis.

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.....

.....

..... **[2]**

Many candidates got 1 mark for NAD becoming reduced. However, many candidates struggled to answer *how* this reduction occurs. A common misconception was to focus on the loss of electrons, which does not fully explain the formation of NADH. In the case of NAD, it becomes reduced by gaining both electrons and a hydrogen ion to form NADH

Misconception

Candidates should be reminded that oxidation and reduction can be understood in terms of three key principles: oxidation involves loss of electrons, gain of oxygen or loss of hydrogen, while reduction is the opposite.

Question 18 (a)

18

(a) Describe the role of plant hormones in the control of seed germination.

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.....

..... **[4]**

Most responses recognised gibberellin as the key hormone in this process with many stating ABA as an antagonist. Candidates who were confident with the general structure of a seed, answered this question with a clear chronological flow. Some responses that identified gibberellins discussed all functions of gibberellins and did not apply their response to seeds. There were often references to 'the plant' or stem elongation suggesting a lack of precision with language and/or appreciation of the components of a seed.

Question 18 (b)*

(b)* Scientists investigate the effect of gibberellin on stem length in young soybean plants.

This is the method they use:

- Select young plants with 4 pairs of leaves.
- Apply gibberellin solution to the leaves of 8 young plants.
- Select 8 more young plants as a control group.
- Allow young plants to grow until they develop 7 pairs of leaves.
- Measure the distance between the fifth and sixth pairs of leaves in each young plant. This is called the internode distance.
- Calculate the mean and standard deviation of the internode distance for each group.

Their results are shown in the table.

Group	Mean internode distance (cm)	Standard deviation
Gibberellin treated	6.33	1.44
Control	3.58	1.27

Here are the critical values for *t*.

Degrees of freedom (df)	Probability (%)	
	5.0	1.0
6	2.45	3.71
7	2.36	3.50
8	2.31	3.36
10	2.23	3.17
12	2.18	3.05
14	2.15	2.98
16	2.12	2.92

The scientists used Student's *t*-test to compare the mean internode distances in the treated and control groups.

Their calculated value for *t* was 4.05.

The scientists concluded that gibberellin caused a significant increase in stem length in young soybean plants.

Suggest a null hypothesis for the investigation **and** evaluate this conclusion.

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.....

.....

..... **[6]**

Most candidates successfully stated a null hypothesis and interpreted the statistical test correctly by rejecting it. However, few calculated the degrees of freedom accurately, with many basing their conclusions on incorrect probability values. Candidates should remember that this was an unpaired *t*-test, as it involved two independent groups. Therefore, the degrees of freedom are calculated as the total sample size minus two. For example, (8 + 8) - 2 = 14.

Very few responses referred to the lack of clarity with the control group. Candidates should realise that a control must have all variables the same as the experimental group except for the active factor. Thus, although gibberellin is left out in the control group, the volume must be the same as the experimental group, e.g. they should be sprayed with the same solution as the experimental group minus the gibberellin.

OCR support

The mathematical skills statistics booklets cover the different statistics in the A Level specification, as well as providing a useful flow chart to know what test is suitable for any particular data set.

There are also resources on the Maths for Biology which can be used to support students with statistics.

Exemplar 2

• null hypothesis → There will be no significance on the effect of gibberellins on stem length in young soy bean plants

Evaluation:

Calculated value was greater than critical value (4.05 > 2.36) so reject the ~~results~~ null hypothesis as the results are significant. There is a 95% confidence that the increase in stem length of young soy bean plants is due to gibberellins.

Evaluate

• leaves should be same size, age, part of leaf

• same volume and concentration of gibberellins should be used on all leaves

• Larger sample size should be used

• Temperature should be controlled (Thermostatically controlled water bath) [6]

Extra answer space if required.

• Light intensity should be controlled (same distance from light sour/dark)

• mean calculated + stats test ✓

• Gibberellin treated plant had higher mean internode distance than control

↳ However Gibberellin treated plant also had higher standard deviation so results may not be consistent.

In this exemplar, the response is set out as a reflection of the question parts and labelled appropriately, starting with a clear null hypothesis followed by an agreement of the conclusion with reference to the statistical test and then concluded with discussions on the validity of the method. The communication mark was not given, as the degrees of freedom were incorrect so the line of reasoning, although logical, was based on incorrect values. The degrees of freedom were based on n-1 for one group, only suggesting confusion with a one sample t-test.

Question 18 (c)

(c) Soybeans are important food crops.

Farmers often grow soybeans with the plants close together but this causes the stems to grow too long so that the plants fall over, which reduces the crop yield.

A scientist suggested that spraying soybean plants with a chemical that inhibits gibberellin production could increase yields.

Explain the scientist's suggestion.

.....

.....

.....

.....

.....

..... **[3]**

Most responses appreciated that inhibiting gibberellin would lead to shorter stems that would not fall over. Few responses provided reasons why not falling over would increase yield, merely stating that yields increase, which could already be inferred from the stem of the question.

Very few candidates appreciated the relevance of the inhibition of gibberellin production rather than release, and so few responses discussed the decrease in gibberellin concentration as a result of this inhibition.

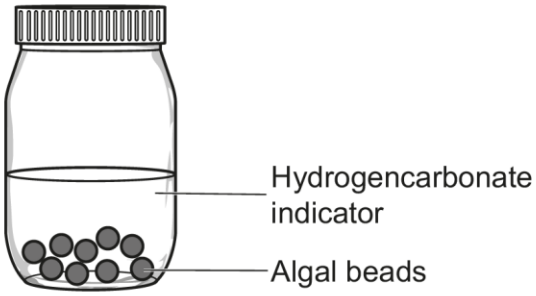
Question 19 (a) (i)

19

(a) A student investigates the effect of light intensity on the rate of photosynthesis in algae that had been immobilised in calcium alginate to make algal beads.

The student places the algal beads in small screw-cap bottles containing hydrogencarbonate indicator.

The indicator turns from orange to red and then purple as CO_2 is removed from the solution.



The student uses the time taken for the indicator to turn purple as a measure of the rate of photosynthesis.

(i) State **two** variables that the student should keep constant during this experiment.

1 .....

.....

2 .....

.....

[2]

This was well-answered, with most candidates referring to the algal beads or the hydrogen carbonate indicator, probably using the diagram as a prompt. A few answers referred to the independent or dependent variables.

Question 19 (a) (ii)

(ii) The student places the bottles at different distances from a light source.

There are four replicates at each distance.

The student's results are shown in the table.

Distance (D) from light source (cm)	**Relative light intensity ($1/D^2$)**	**Time taken for indicator to turn purple (min)**				
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean
250	1.60×10^{-5}	65	63	66	67	65.3
375		77	80	82	78	
500	4.00×10^{-6}	103	99	101	95	99.5
1000	1.00×10^{-6}	185	190	130	195	190.0

The student calculates relative light intensity using the following formula:

$$\text{Relative light intensity} = \frac{1}{\text{distance}^2}$$

Calculate the relative light intensity and mean for the 375 cm distance.

Relative light intensity = ...

Mean = ... min

[2]

Most candidates completed the calculations correctly, with the relative light intensity being $1 \div (375)^2$ and $(77 + 80 + 82 + 78) \div 4$. However, many candidates did not express their answers to be consistent with the equivalent calculations and answers in the table. Common inconsistent answers were 7.10×10^{-6} or 7.1×10^{-6} and 79.25 for the mean.

OCR support

The mathematical skills handbook gives examples of correct rounding, significant figures and standard form.

The practical skills handbook also provides guidance on how to complete data in a table.

Question 19 (a) (iii)

(iii) Outline an improvement to the method that the student could use to get a more accurate measure of the rate of photosynthesis.

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.....

..... **[2]**

Many candidates identified a colorimeter as a suitable piece of equipment to improve the accuracy of the measurement but did not follow through with how this would relate to the photosynthetic rate. Some responses discussed a different method, e.g. measuring oxygen production. This was not appreciated as the question referred to an improvement of the method used, not a new method.

Question 19 (b) (i)

(b) The student wants to use the algal beads method to investigate the effect of CO_2 concentration on the rate of photosynthesis.

(i) Explain why it would **not** be possible to use the hydrogencarbonate indicator method to investigate the effect of CO_2 concentration.

.....

.....

.....

.....

..... **[2]**

This question was a good discriminator. Successful responses used the information in the stem of the question to reflect the changes in colour that would occur with adding external carbon dioxide concentrations and the consequent difficulty in using colour change as a dependent variable. Many responses confused the hydrogen carbonate indicator with sodium hydrogen carbonate as a carbon dioxide source.

Misconception

Hydrogen carbonate indicator is different from sodium hydrogen carbonate added to a solution as a source of carbon dioxide. Candidates should appreciate that an indicator is a substance that changes colour with pH.

Question 19 (b) (ii)

(ii) Suggest how the student could modify the method so the effect of CO_2 concentration on the rate of photosynthesis could be measured.

.....

.....

.....

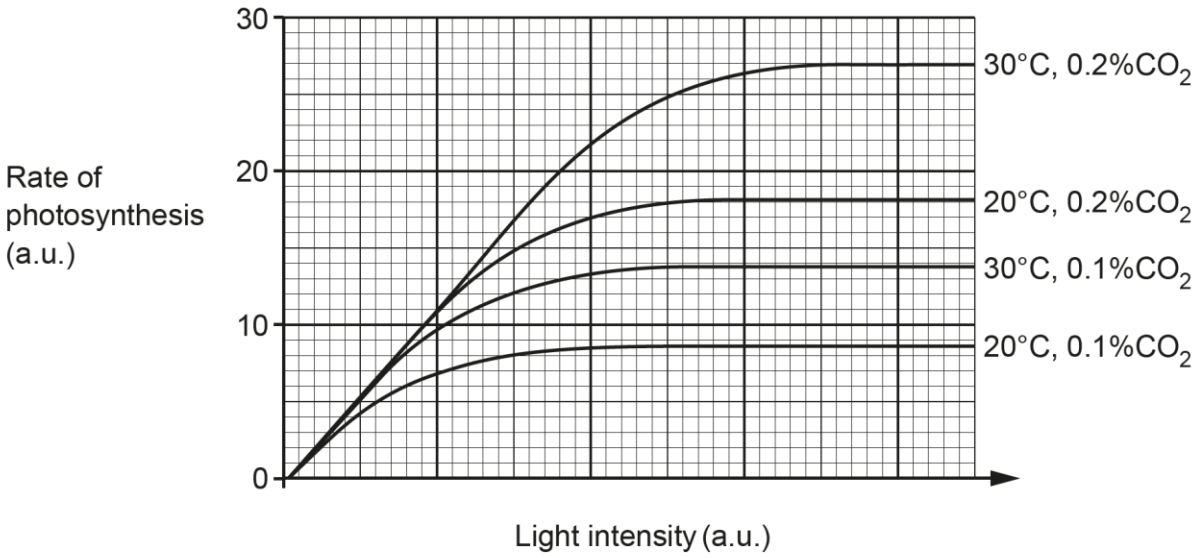
.....

..... **[2]**

Many candidates referred to measuring the oxygen produced as a modification. However, apparatus was often quoted that were not associated with photosynthesis, e.g. potometers and respirometers.

Question 19 (c) (i)

(c) The graph shows the effect of light intensity on the rate of photosynthesis at two temperatures and two CO_2 concentrations.



(i) Explain the evidence from the graph that shows that CO_2 concentration is a limiting factor in these experiments.

.....

.....

.....

.....

..... **[2]**

Most candidates successfully compared the rate of photosynthesis with different carbon dioxide concentrations at the same temperature. Few candidates related their answer to light intensity. Most responses focused on the plateau components of the graph and did not discuss the increasing light intensity as well.

Question 19 (c) (ii)

(ii) A student looked at the graph and concluded that CO_2 concentration has a greater effect on the rate of photosynthesis than temperature.

Use your knowledge of Q_{10} and a calculation to support the student's conclusion.

.....

.....

.....

.....

..... **[2]**

Successful responses quoted the meaning of Q_{10} in order to express their answer clearly. Calculations required the rate at the higher value relative to the rate at the lower value for temperature and carbon dioxide concentrations. Many candidates quoted the a.u. values from the graph without carrying out a calculation using those values. Responses tended to support the student's conclusion but not using the doubling aspect of the Q_{10} definition.

Question 20 (a)

20

(a) The table compares features of different types of blood vessel in mammals.

Feature	Blood vessel type			
	E	**F**	**G**	**H**
Diameter of lumen	largest	large	small	smallest
Thickness of wall	thin	thickest	thick	thinnest
Proportion of smooth muscle and elastic fibres in wall	more smooth muscle than elastic fibres	more elastic fibres than smooth muscle	similar proportions of both	none present

Use the letters **E** to **H** to complete the following table.

Each letter may be used once, more than once, or not at all.

Description	Blood vessel type
This blood vessel type transports deoxygenated blood to the lungs.	.....
This blood vessel type is the site of exchange of gases and nutrients.	.....
This blood vessel type is involved in regulation of blood flow near the surface of the skin.	.....

[3]

Few candidates could match all three descriptions to the blood vessel type. Most candidates recognised H as the site of exchange of gases, followed by the blood vessel type near the surface of the skin. Many answers identified the different blood vessel types by writing them underneath the first table but did not match this correctly with the descriptions provided.

Question 20 (b)

(b) Unlike most other veins, pulmonary veins do not have valves.

Suggest why valves are **not** needed in pulmonary veins.

.....

..... **[1]**

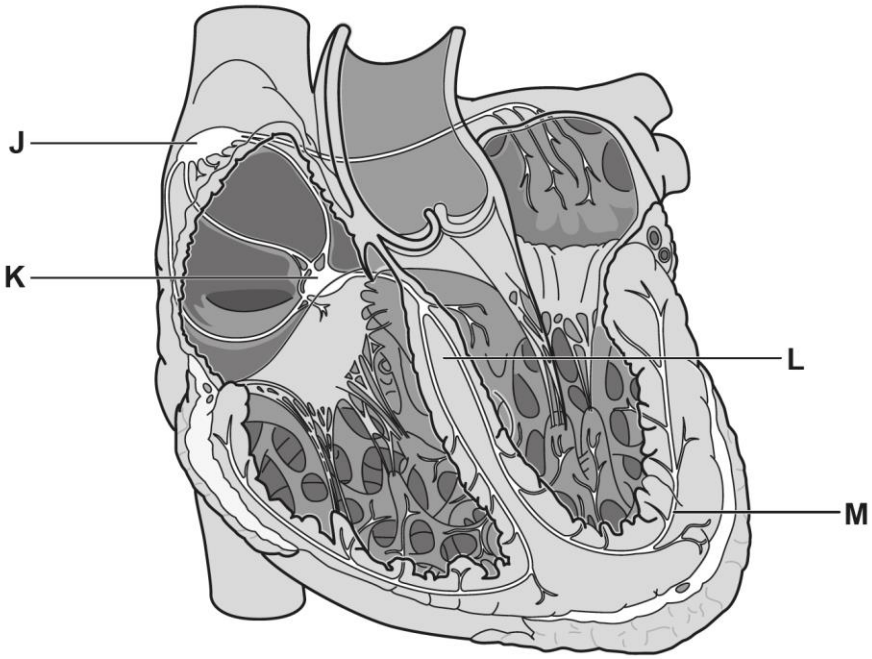
This was well-answered by most candidates. Most responses included reference to no backflow occurring showing a clear knowledge of the role of valves and suggested that higher pressure prevented the back flow. Many responses also related the flow as not going against gravity. Some answers referred to the flow being downwards only.

Misconception

Candidates visualise the pulmonary vein as situated downwards from the lungs to the heart. This misconception occurs as the structure of the heart and its associated vessels are often discussed in isolation to their relative position to other organs. Candidates would benefit from seeing diagrams that show the pulmonary veins in relation to the lungs as well as the heart.

Question 20 (c)

(c) This is a drawing of a dissected human heart.



Identify the structures labelled **J** to **M**.

J .....

K .....

L .....

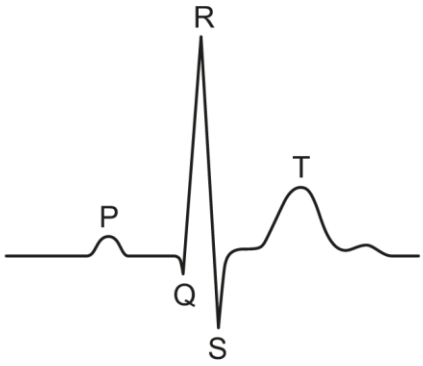
M .....

[4]

This was well-answered, with many candidates identifying all four structures. Some candidates confused L and M.

Question 20 (d)*

(d)* This is an electrocardiogram (ECG) trace of a single heartbeat.



Describe how contraction of the heart muscle at rest is initiated and relate this process to the electrical activity recorded by the ECG.

.....

.....

.....

.....

.....

..... **[6]**

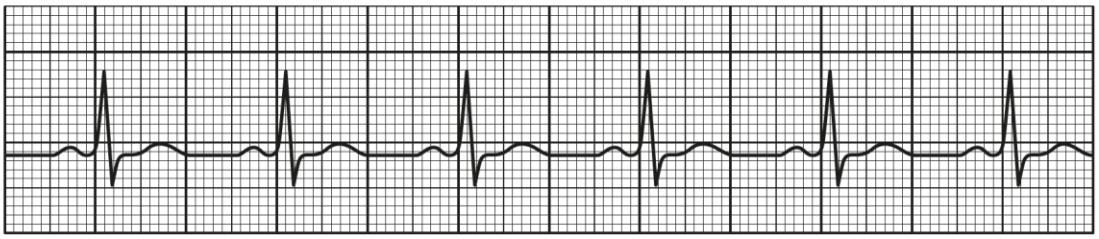
Responses that could clearly describe the coordination of the electrical activity of the heart usually related it correctly to the ECG peaks. Some responses confused the ECG peaks with the pressure changes in the heart rather than the electrical activity despite the information in the stem of the question. Some responses referred to signals passed from atria to ventricles instead of the A Level term of *impulse* or *wave of excitation*. This part of the specification could be revisited when the nervous system is taught to emphasise use of the correct terminology.

Few candidates appreciated the relevance of the 'at rest' aspect of the question and did not mention the myogenic nature of cardiac muscle. Indeed, some responses discussed the role of the medulla oblongata and sympathetic nervous system in slowing or raising the heart rate.

Question 20 (e) (i)

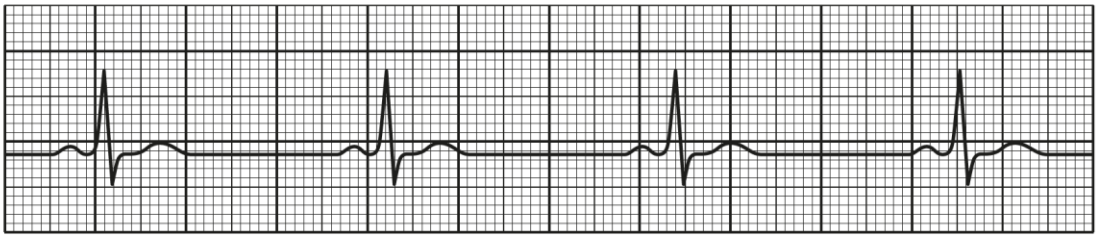
(e) **Fig. 20.1** shows a normal ECG trace.

Fig. 20.1



(i) **Fig. 20.2** shows an ECG trace from a patient with abnormal heart activity.

Fig. 20.2



Identify this abnormality.

Give a reason for your identification.

Abnormality .....

Reason .....

.....

[1]

This was generally well-answered, with most candidates interpreting the trace correctly as a slowed heart rate. However, the abnormality was often misspelt as brachycardia. Candidates would benefit from a discussion of certain biological prefixes, e.g. in Greek *brachy* meaning 'short' whereas *brady* means 'slow'.

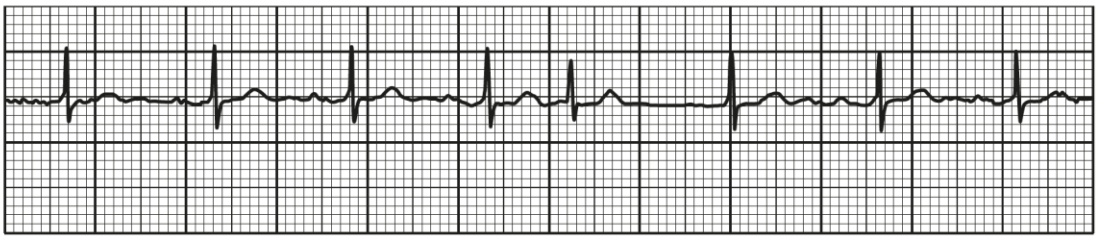
Assessment for learning

Emphasising prefixes for particular medical terms is useful to relate the term to their relevance, brachy and brady being a good example of this as well as 'ectopic' which refers to being out of place.

Question 20 (e) (ii)

(ii) **Fig. 20.3** shows an ECG trace from another patient with abnormal heart activity.

Fig. 20.3



Identify this abnormality.

Give a reason for your identification.

Abnormality .....

Reason .....

.....

[1]

Many candidates could identify the abnormality but could not give a correct reason. Many responses referred to too many heart beats or the absence of the T wave. Candidates should make sure they look at the overall pattern of all the components of the trace to draw conclusions and not just one part that looks different.

Question 21 (a) (i)

21
(a)
(i) Describe **three** ways fish gills are adapted for efficient gas exchange.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

Most candidates were able to identify relevant features of the fish gills, in particular lamellae and counter current flow. Lamellae adaptation was correctly identified as increasing surface area, but other adaptations were less well-described.

Question 21 (a) (ii)

(ii) Explain why insects can function with open circulatory systems.

.....

.....

.....

.....

.....

..... **[3]**

Candidates noted that insects are small with a high surface area to volume ratio, enabling diffusion alone to meet their respiratory requirements. However, many candidates did not appreciate that oxygen transport in insects occurs using the tracheal system and is independent of the circulatory system which explains why an open circulatory system is sufficient.

Many responses discussed the insects as not having a high metabolic rate. This is misleading, as insects, particularly during flight, can exhibit metabolic rates to 100 times higher than at rest. Candidates should not regard insects as sedentary organisms with consistently low levels of aerobic respiration.

Question 21 (a) (iii)

(iii) The largest fish is the whale shark. Whale sharks have an average mass of 20 tonnes.

The largest marine mammal is the blue whale. Blue whales have an average mass of 150 tonnes.

Use your knowledge of gas exchange and circulatory systems to suggest why marine mammals can grow to a much larger size than fish.

.....

.....

.....

.....

..... **[2]**

Most candidates identified the mammals as having a double circulatory system. However, many explanations focused on increased oxygen uptake due to a more efficient gas exchange system leading to more aerobic respiration, rather than focusing on the advantage of the circulatory system itself. Candidates that discussed the rate of flow or blood pressure often began with the definition of a double circulation, which helped inform the relevance of blood going through the heart twice in one complete circuit.

A few responses incorrectly stated that the fish heart allows mixing of deoxygenated and oxygenated blood. Fish have a single circulatory system with a heart consisting of one atrium and one ventricle, through which only deoxygenated blood flows. It is amphibians and reptiles, which have three chambered hearts, which can experience mixing of deoxygenated and oxygenated blood.

Misconception

Fish do not have an inferior gas exchange system to mammals, quite the opposite. Fish have access to less oxygen in water and so need a more efficient gas exchange system, with a counter current flow and large surface area. The exchange surface of gill filaments is much greater in surface area compared to mammals, relative to their body size.

Question 21 (b)

(b) Explain how the structure of haemoglobin allows it to transport oxygen from the lungs to the tissues.

.....

.....

.....

.....

.....

..... **[4]**

Candidates were able to identify key aspects of the structure of haemoglobin, but responses varied when adapting this information to their role in oxygen transport. Most responses were able to describe the binding of oxygen at the lungs and release at respiring tissues and often described or quoted cooperative binding. Some responses described haem groups containing iron but did not describe the iron as an ion.

Some responses confused haemoglobin with red blood cells. These responses discussed how the large surface area and absence of nucleus, increased space for oxygen transport.

Misconception

Some responses incorrectly suggested that oxygen binds to iron in the same way as iron rusts. It is important to remind students that in haemoglobin, oxygen binds reversibly to iron ion within the haem group. This is not the same as the reaction between elemental iron and oxygen in air, which forms rust (iron oxides).

A few responses also incorrectly stated that oxygen binds via hydrogen bonding. Oxygen binds to iron ion via a coordinate bond. Hydrogen bonds form between hydrogen and highly electronegative atoms like nitrogen or oxygen (or fluorine), which are not involved in this reaction.

Exemplar 3

Haemoglobin is a globular protein, and is soluble in blood plasma, so it can travel from the lungs to the tissues in the blood. Haemoglobic is a conjugated protein that has 4 prosthetic 'haem' groups. Each haem group has an iron ion (Fe^{2+}) centre in its porphyrin ring, which helps bind 1 O_2 molecule to the prosthetic group. Each haemoglobin can carry 4 O_2 molecules, as it is now fully saturated. O_2 molecules bind to ~~the~~ the haemoglobin by cooperative binding. Once 1 ~~O~~ O_2 has binded, the shape of haemoglobin changes ~~slightly~~ slightly to make it easier for other O_2 molecules to bind. Haemoglobin picks up O_2 at high pO_2 ie. the lungs and releases the O_2 molecules at low partial pressures of O_2, ie. the tissues. **[4]**

This response logically moves from the overall structure of the protein to its individual components and how oxygen attaches to them with a good description of cooperative binding. The response then discusses the movement of haemoglobin from and to the relevant parts of the body.

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