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VCE Biology ¾
AOS 2 Revision & Experimental Design [0.11]
Workshop

Error Logbook:

New Ideas/Concepts	Didn't Read Question
Pg / Q #: _____ Notes:	Pg / Q #: _____ Notes:
Algebraic/Arithmetic/ Calculator Input Mistake	**Working Out Not Detailed Enough**
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Section A: Recap

Active Recall: What is Validity?

_____

_____

Active Recall: What is the purpose of a control group?

_____

_____

Active Recall: What is the difference between accuracy and precision?

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Active Recall: What is the difference between repeatability and reproducibility?

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Active Recall: What is meant by limitations in experiments?

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Section B: Multiple Choice Questions (10 Marks)

Question 1 (1 mark)

An experiment was conducted that investigated the effect of temperature on the function of amylase. Amylase catalyses the breakdown of starch and this can be measured by using an iodine solution. Iodine is a chemical that stains dark in the presence of starch. The procedure is summarised in point form below.

- Five Petri dishes were prepared with a 2% starch and gelatin (solid at temperatures below 60°C) solution.
- A small hole was made in the middle of the Petri dish in which a solution of amylase was added.
- The resulting Petri dishes were exposed to a variety of temperatures (10°C, 20°C, 30°C, 40°C, 50°C).
- After a 24-hour incubation period, the Petri dishes were washed in a weak solution of iodine to test for the presence of starch. The results are illustrated below.

10°C	20°C	30°C	40°C	50°C
				

The independent variable in this experiment would be the:

A. Diameter of the circle where there is no evidence of starch.

B. Temperature.

C. Area within the Petri dish where starch is present.

D. Size of the Petri dishes.

Space for Personal Notes

Question 2 (1 mark)

Students completed their investigation and analysed their results. They suggested their results were affected by systematic errors.

Systematic errors:

A. Result in a spread of readings.

B. Affect the precision of a measurement.

C. Are easy to identify and eliminate.

D. Cause readings to differ from the true value by a consistent amount each time.

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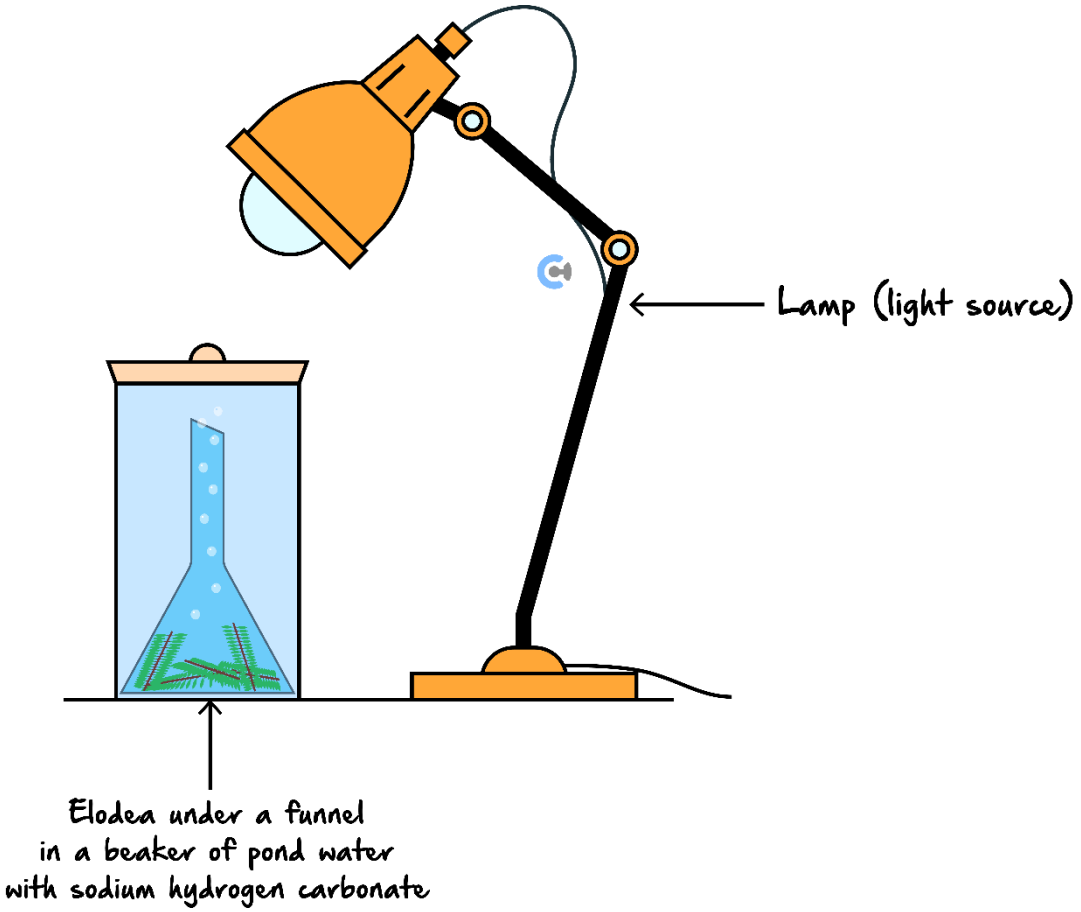
Question 3 (1 mark)

The apparatus shown below was set up in a Biology laboratory.



Sodium hydrogen carbonate (a source of carbon dioxide) was added to pond water in a beaker. A piece of an aquatic plant called *Elodea* was added and placed under a funnel in the beaker. A lamp was placed 5 *cm* away from the beaker and switched on. The number of bubbles produced by the *Elodea* was recorded for one minute. The experiment was repeated with the lamp placed 10 *cm*, 15 *cm*, 20 *cm* and 25 *cm* away from the beaker. The entire experiment was repeated three times and an average result at each distance was calculated.

The dependent variable in this experiment is the:

A. Amount of sodium hydrogen carbonate added to the beaker.

B. Number of bubbles produced in one minute.

C. Time taken to count the bubbles produced.

D. Distance of the lamp from the beaker.

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Question 4 (1 mark)

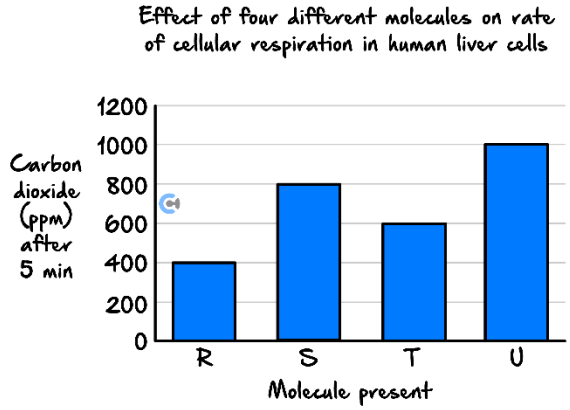
A student investigated the effect of the presence of four different molecules, R, S, T, and U, on the rate of cellular respiration in human liver cells. The production of carbon dioxide by the cells was recorded over a five-minute interval. The final concentration of carbon dioxide was recorded. The data collected is shown below.

Molecule present	Concentration of carbon dioxide (ppm) after five minutes
R	400
S	800
T	600
U	1000

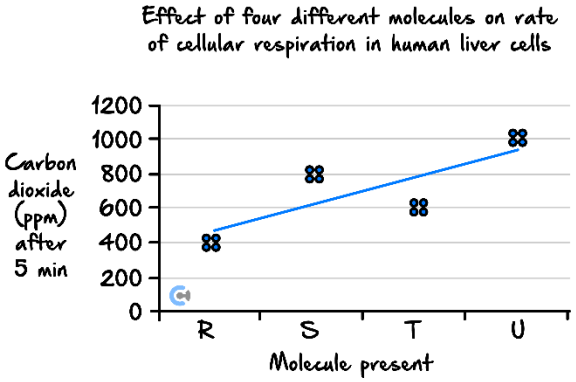
The student presented the results as a graph.

Which one of the following graphs is the best representation of the results?

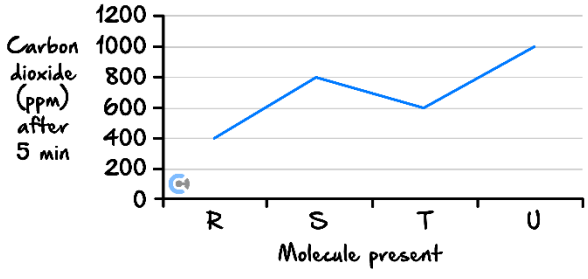
A.



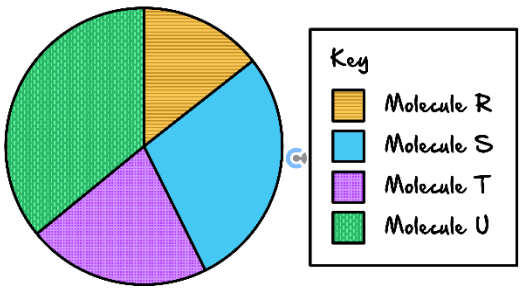
B.



C.

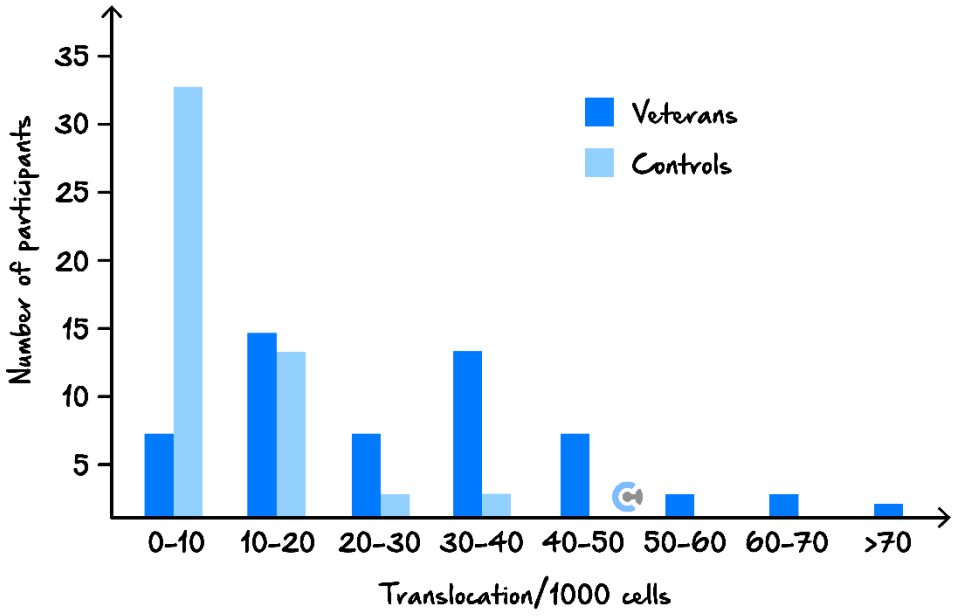


D.



Question 5 (1 mark)

In 1957-58 the British government conducted a series of nuclear tests in the mid-Pacific (code-named Operation Grapple). This involved 551 personnel onboard naval vessels that were stationed at various distances between 20 and 150 nautical miles from ground zero. Recently, a biotechnological technique called mFISH was carried out with many of the surviving personnel to investigate a potential link between chromosomal translocations and nuclear radiation exposure. The results are shown in the graph below.



Based on the results of these tests, it can be said that:

A. The nuclear radiation caused the translocations.

B. There are more 10-20 or greater translocations per 1000 cells in the veterans compared to the control group.

C. The control group would have been the same age as the 551 personnel were in 1957-58.

D. There were over 200 participants involved in the testing.

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Question 6 (1 mark)

In a photosynthesis experiment, the number of oxygen bubbles produced by a plant is counted under different light wavelengths. The light intensity is controlled, but the experiment consistently measures more bubbles than expected. What would improve the accuracy of the measurements?

A. Reducing the sample size to avoid interference.

B. Using a more sensitive bubble counter that can detect smaller bubbles.

C. Recalibrating the light source to ensure it provides the correct wavelength.

D. Increasing the exposure time to allow more bubbles to accumulate.

Question 7 (1 mark)

An experiment is set up to investigate the effect of different sugar concentrations on the rate of fermentation in yeast. The researcher measures the volume of CO_2 gas produced. Which of the following actions would improve the validity of the experiment?

A. Using yeast from different batches to see how it influences fermentation.

B. Keeping the temperature constant while varying the sugar concentrations.

C. Measuring CO_2 production at different time intervals but not controlling for other variables.

D. Changing both the sugar concentration and the temperature at the same time.

Question 8 (1 mark)

In an experiment to investigate the effect of light intensity on the rate of photosynthesis, the plant is exposed to different light intensities at varying distances from the light source. The oxygen production is measured by counting the number of bubbles released. However, the light source's power fluctuates, and a mechanical error causes the timer to start a few seconds late. How do these issues affect the results?

A. The fluctuation in light power introduces random error, while the delay in starting the timer introduces systematic error.

B. Both light power fluctuations and the delayed start introduce systematic errors, causing a constant bias in the results.

C. The mechanical error introduces random error, while the fluctuating light intensity introduces systematic error.

D. Both errors introduce random errors, affecting the consistency of the results but not the accuracy.

Question 9 (1 mark)

In an experiment investigating the effect of light intensity on the rate of photosynthesis, an aquatic plant is exposed to varying light intensities. The oxygen production is measured by collecting the gas over a set period. A systematic error occurs in the apparatus, where the oxygen collection chamber leaks slightly, causing the measured volume to be consistently 5% lower than expected. How does this error affect the experiment?

A. The error introduces random fluctuations in the measurements, making the results less precise but not affecting their accuracy.

B. The error introduces both random and systematic errors, making the results both inconsistent and inaccurate.

C. The error introduces systematic error, consistently reducing the volume of oxygen collected, which affects the accuracy of the results.

D. The error introduces random error, but the volume reduction does not affect the overall accuracy of the results.

Question 10 (1 mark)

In an experiment investigating the effect of light intensity on the rate of photosynthesis, an aquatic plant is exposed to different light intensities. The oxygen production is measured over a fixed period. A control group is included in the experiment, where the plant is kept in complete darkness. What is the role of the control group in this experiment, and how does it contribute to the validity of the results?

A. The control group is used to ensure that the oxygen production measured is only due to the light intensity, confirming the effect of the experimental variable.

B. The control group is used to measure the baseline rate of photosynthesis, which is not affected by light intensity, to compare the plant's growth with and without light.

C. The control group is used to measure the plant's oxygen production in the absence of light, but it is not needed to assess the effect of light intensity.

D. The control group helps to eliminate any random errors by ensuring that all plants are treated the same.

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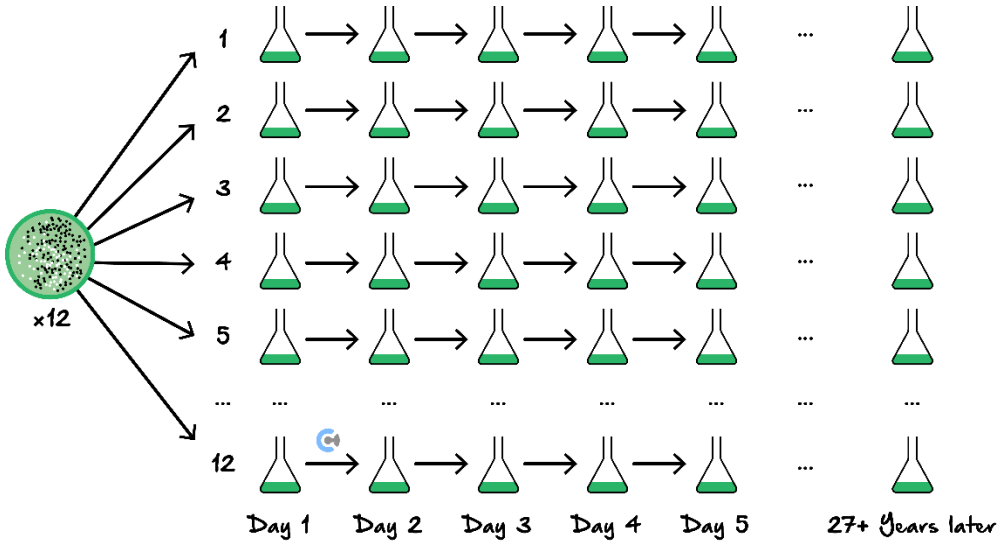
Section C: Short Answer Questions (61 Marks)

Question 11 (5 marks)

In 1988 a scientist called Richard Lenski and his group used a single ancestral genome of *Escherichia coli* to put 12 genetically identical populations in 12 identical environments. Each environment consisted of a flask filled with 10 mL of bacterial growth medium, and a nutrient broth containing glucose and citrate. Citrate is a potential food source that *E. coli* cannot use.

The group was interested in observing the evolution of diversification and adaptation as they happened in the laboratory.

The method of their experiment involves a simple serial transfer protocol: As the populations grow over the course of every 24 hours, they use up the resources in their flasks, so every day a 0.1 mL sample of each population is transferred to a flask of 9.9 mL of fresh growth medium and thus allowed to keep reproducing. The method is shown in the diagram below.



Source: E Parke, 'Experiments, Simulations, and Lessons from Experimental Evolution', Publicly Accessible Penn Dissertations, 1114, 2015, <https://repository.upenn.edu/edissertations/1114>

The experiment had been running for 27 years at the time the results were shown. This was equivalent to 65000 generations of bacteria. A generation is the time between when an organism is formed and when it reproduces.

a. State **two** factors that were controlled in this experiment. (2 marks)

b. Assume that you are a scientist looking to further this research and you have access to the bacteria from a generation after 30000.

Describe how you would conduct an experiment to investigate the effect of different glucose concentrations on the frequency of the mutant citrate phenotype. (3 marks)

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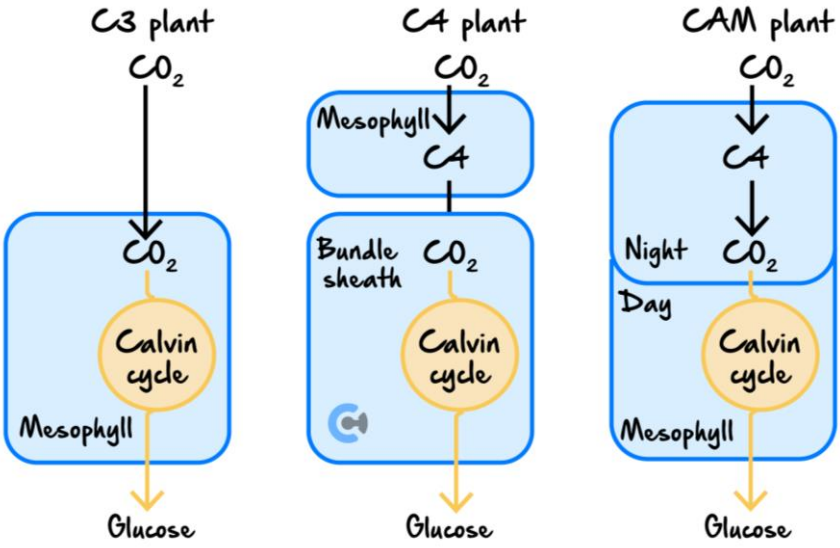
Question 12 (8 marks)

Plants have the unique ability to photosynthesise and utilise sunlight. They are able to produce high-energy-containing molecules that fix carbon dioxide (CO_2) into forms of carbohydrates that can be stored or used by plant cells. Most plants use the C3 pathway to fix CO_2 and some use the C4 pathway. A small group of plants use a combination of both pathways. This smaller number of plants is called the CAM plants.



Source: Adapted from H kheyrodin and S Kheyrodin, 'CO_2 gas exchange in Crassulacean acid metabolism and C3 and C4 plants', International Journal of Advanced Research in Biological Sciences, vol. 4, issue 10, 2017, <http://dx.doi.org/10.22192/ijarbs.2017.04.10.007>

As part of their VCE Biology practical investigation, a group of students collected plant samples from their school grounds. While the students were able to identify most of the plants they collected, there was one they had not seen before. They performed a series of experiments with this plant in the laboratory. The observations they made, as well as documented information for C3, C4, and CAM plants are shown in the table below.

Plant Characteristic	Unknown Plant	C3 Plant	C4 Plant	CAM Plant
The ideal temperature for photosynthesis.	25 - 35°C	15 - 25°C	30 - 40°C	> 40°C
Pathway to fix CO_2.	C4 pathway and Calvin cycle.	Only Calvin cycle.	C4 pathway and Calvin cycle.	C4 pathway and Calvin cycle.
Stomata open during the day.	Yes	Yes	Yes	No
Photorespiration occurring.	Moderate to low	High	Low	Only observed in the middle of the day.
Water loss during the day.	Moderate	High	Moderate	Low
Plant growth rate.	Moderate	Moderate	Fast	Very slow

a. Based on the information provided, state whether the unknown plant is a C3, C4, or CAM plant. Justify your response. (5 marks)

b. Outline three additional steps that could be carried out to extend the investigation and assist with identifying the unknown plant. (3 marks)

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Question 13 (8 marks)

A local middle school undertakes a study to explore the effects of varying carbon dioxide levels on the rate of photosynthesis in aquatic plants.

The experiment involves placing samples of *Elodea* (an aquatic plant) in different concentrations of carbonated water, which is achieved by dissolving varying amounts of baking soda in the water. Each sample is then exposed to the same intensity of light from a grow lamp.

The number of oxygen bubbles produced by each plant sample over a set period is counted as they rise to the surface of the water, providing a measure of the photosynthetic activity of the plants.

a. What is the independent variable in this experiment? Theoretically, explain how this factor could influence the rate of photosynthesis. You may draw a graph. (2 marks)

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b. What is the dependent variable in this experiment? Justify why this method of measuring the rate of photosynthesis is scientifically sound. (2 marks)

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Angad wanted to expand the results of the experiment to a greenhouse where the *Elodea* could be produced in large quantities. Vishal told him that he must keep the temperature tightly controlled.

c. Explain why Angad must keep the temperature tightly controlled for photosynthesis. (2 marks)

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d. Scientists are developing a new material to cover greenhouses which can split incoming light and convert rays from green wavelengths to red wavelengths.

Explain how this new material increases crop yields. (2 marks)

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Question 14 (9 marks)

Calandrinia balonensis is an Australian flowering plant found in arid regions west of the Great Diving Range and throughout central Australia. It is well-adapted to its warm climate and is usually found growing in red sandy soils and spinifex zones. Like many plants that adapted to a hot, dry climate, *C. balonensis* utilises the CAM pathways of photosynthesis.

a. Describe how the adaptations of *C. balonensis* maximise the efficiency of photosynthesis in a warm, arid environment. (2 marks)

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b. Briefly describe the role of RubisCO in synthesising glucose in photosynthesis and outline how coenzymes are involved in this process. (2 marks)

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c. Referring to the role of RubisCO, explain why photorespiration is more likely to occur at higher temperatures. (2 marks)

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d. Like CAM plants, C4 plants are adapted to hot climates. Compare the process of photosynthesis in C4 and CAM plants. (3 marks)

Space for Personal Notes

Question 15 (11 marks)

Anaerobic Respiration is one mechanism by which glucose can be metabolised in animals, plants and bacteria.

a. What is meant by the phrase 'anaerobic'? (1 mark)

_____

_____

b. Other than ethanol, what is the product of this process (anaerobic respiration)? (1 mark)

_____

_____

A limitation of using this process to manufacture bioethanol is the toxicity of ethanol to the cell – which causes death in most cases. A proposed method to solve this limitation is to increase the activity of alcohol dehydrogenase (which metabolises ethanol) by genetic editing via CRISPR-Cas9.

c. Describe the process by which the scientist can edit the gene coding for alcohol dehydrogenase using CRISPR-Cas9. (3 marks)

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d. Evaluate the suitability of using this method for optimising bioethanol production. (2 marks)

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Another method proposed by which ethanol production can be optimised is by introducing a gene coding for a synthetic cellulase into either sugarcane or yeast cells and causing the gene to be expressed in large quantities. Cellulase breaks down cellulose, a major component of plant cell walls into glucose.

e. Explain, with reference to cellulase's function, how the overexpression of the cellulase gene would lead to increased rates of bioethanol production. (2 marks)

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f. Explain whether it is more suitable to introduce the cellulase transgene into sugarcane cells or yeast cells in aiming to optimise bioethanol production. (2 marks)

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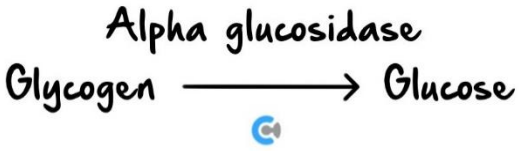
Question 16 (10 marks)

Infantile-onset Pompe disease (IOPD) is an inherited metabolic disorder that results from a mutation in the GAA gene. Symptoms include an accumulation of glycogen in the heart, liver and skeletal muscles of the body. This can cause damage to the cells in the heart and liver, muscle weakness and death. A functioning form of this gene produces the enzyme acid alpha-glucosidase (GAA), an enzyme responsible for the breakdown of glycogen in the body.



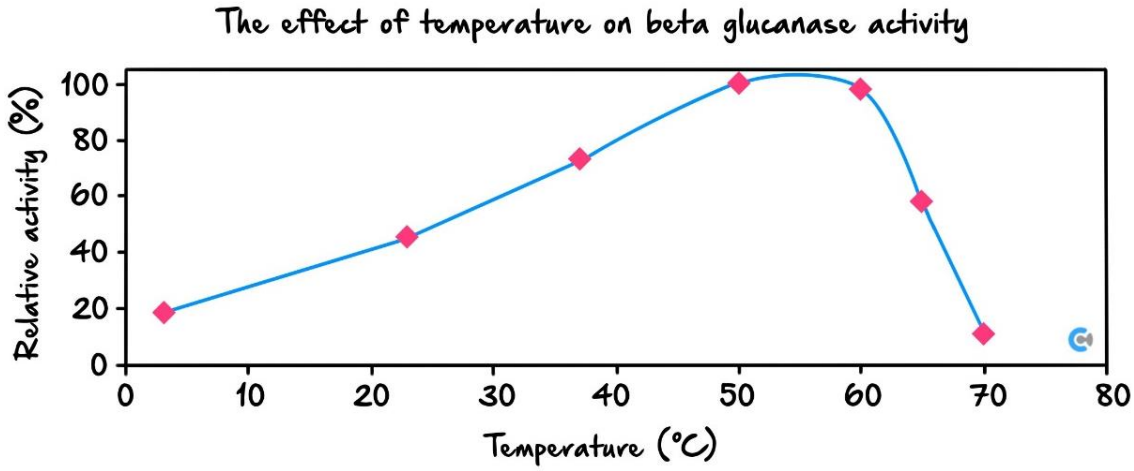
There are a number of mutations in the GAA gene that can result in a non-functioning enzyme.

Normal	Gly	Pro	Arg	Asn	Ala	Gln
	GGG	CCC	CGG	GAT	GCC	CAG

Mutation	Gly	Pro	Arg	Asn	Ala	Gln
	GGG	CCC	CGG	GAT	GCC	CAG

a. Explain why the inability to break down glycogen can cause damage to heart and liver cells. (4 marks)

To ensure that the enzyme is able to work effectively, it is important that the temperature of *Saccharomyces cerevisiae* is kept at a constant level.



b. Use the graph above to identify the optimum temperature for *Saccharomyces cerevisiae* in the brewing process. (1 mark)

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c. Explain why a temperature of 10°C is not used in the brewing process. (2 marks)

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At the end of fermentation, portions of the yeast can be removed from the solution for the next brew. The top part of the solution will contain younger yeast, while the lower part of the solution will contain ‘aged' yeast. Brewers claim that aged yeast cultures produce a 'better' beer with an increased ability to use the sugars to produce a high yield of ethanol and other flavours, as well as an increased flocculation potential (frothing when poured).

d. Identify the inputs and outputs of the fermentation process. (2 marks)

Inputs	Outputs

e. Identify a coenzyme that is part of the process of fermentation. (1 mark)

_____

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Question 17 (4 marks)

The emerging Australian biofuels industry hopes to use farming waste such as plant stubble for profit within the next decade. Bioethanol is a liquid fuel that is chemically derived from cellulose-rich plant stubble, making it economically attractive. Bioethanol burns much more cleanly than fossil fuels, which reduces pollution and originates from renewable resources, which is a crucial factor for a sustainable future.

a. Bioethanol is one example of a biofuel. Identify **one** other example of a biofuel. (1 mark)

_____

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b. How is bioethanol produced from cellulose-rich plant stubble? (2 marks)

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c. Explain why biofuels are regarded as renewable energy resources. (1 mark)

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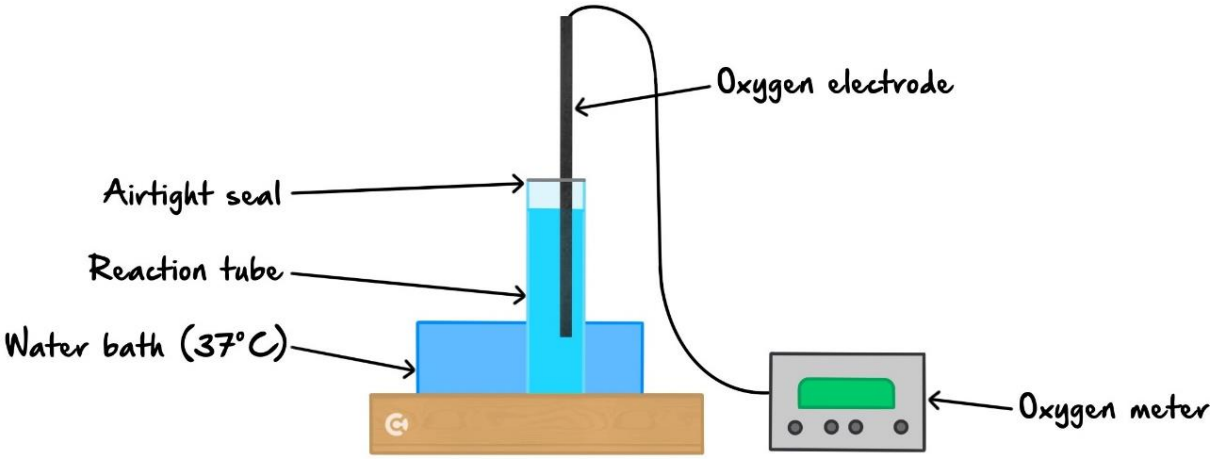
Space for Personal Notes

Question 18 (6 marks)

The apparatus shown below was used in a series of experiments to study aerobic respiration.



In three different experiments, the reaction tube initially contained the following:

a. Suspension of mitochondria.

b. Cytosol of cells from which the mitochondria had been removed.

c. Suspension of mitochondria and cytosol of cells.

The temperatures and pH of the mixtures within the reaction tubes were carefully controlled so as not to damage the mitochondrial structure or any of the enzymes.

In each experiment, a solution containing glucose was first added to the mixture in the reaction tube and the oxygen concentration was measured for three minutes. Then, a pyruvate solution was added and the oxygen concentration was measured again for three minutes.

Using your knowledge and understanding of aerobic respiration and mitochondria, complete the tables below with your prediction of the change in oxygen concentration of the mixture in the reaction tube after the addition of each substance and give a reason for your prediction.

Experiment 1 - Suspension of mitochondria

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
Glucose		
Pyruvate		

Experiment 2 - Cytosol of cells from which the mitochondria had been removed

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
Glucose		
Pyruvate		

Experiment 3 - Suspension of mitochondria and cytosol of cells

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
Glucose		
Pyruvate		

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