Name: _____

Biology

Question and Answer Book

Unit 3, Area of Study 2 - Comparison and evaluation of biological concepts, methodologies and methods, and findings from three student practical activities

- Reading time is **5 minutes**
- Writing time is **55 minutes**

Materials supplied

- Question and Answer Book of 12 pages

Instructions

- Follow the instructions outlined at the beginning of Section A.

Students are not permitted to bring mobile phones and/or any unauthorised electronic devices into the examination room.

Contents pages

Section A

Instructions

- Answer all questions in the space provided.
- Write your responses in English.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Experiment 1

Does photosynthesis need light to proceed?

Background information: This investigation uses Hydrogen carbonate indicator to measure the rate of photosynthesis. Hydrogen carbonate indicator is a pH indicator that can be used to determine the presence of carbon dioxide. As the concentration of carbon dioxide in a solution increases, the acidity increases (pH decreases), and the indicator turns yellow. At lower carbon dioxide concentrations, the acidity decreases (pH increases), and the indicator turns purple/blue.

Materials:

Calcium chloride solution	Flat bottom test tubes
Plastic sieve	Syringe
Small beakers (100 ml) x 2	Black paper and sticky tape
Pipettes-disposable	Distilled water
Green algal suspension (Chlorella)	Hydrogen carbonate indicator
10 ml measuring cylinder	Retort stand, boss head and clamp
Sodium alginate solution	Spatula

Method:

1. Place 10 algal balls (rinsed with distilled water) into two of the flat bottom test tubes.
2. Using a 10 ml measuring cylinder measure out 10 ml of hydrogen carbonate pH indicator and add to all 4 flat bottom test tubes and replace the lid.
3. Wrap black paper around one of the flat bottom test tubes containing algal balls and indicator, and wrap another lacking algal balls. Tape this firmly into place so that no light can get into the bottle.
4. Place all 4 flat bottom test tubes at equal distances from the light source. Leave for half an hour.
5. Record colour of each tube on the results table.

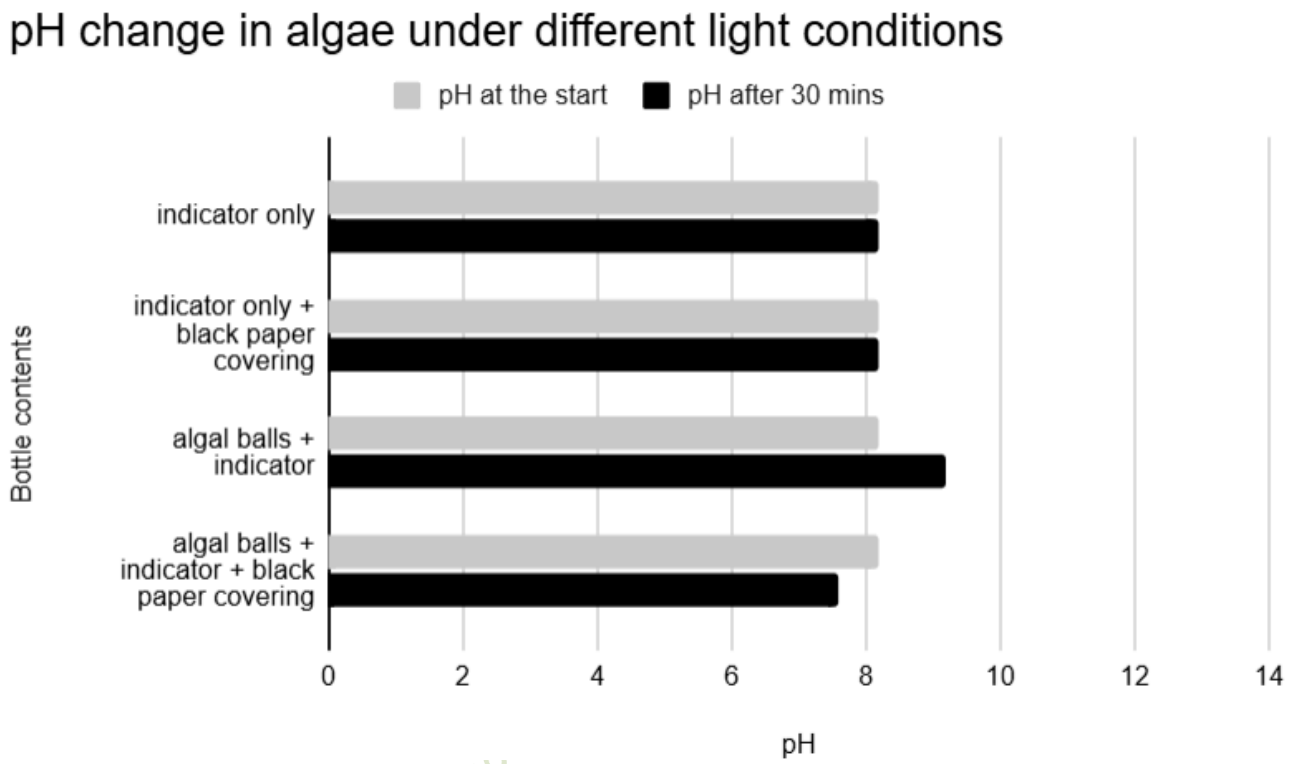
Results:

	Bottle contents	Indicator colour at the start	Indicator colour after 30 mins
1	indicator only	red	red
2	indicator only + black paper covering	red	red
3	algal balls + indicator	red	purple
4	algal balls + indicator + black paper covering	red	orange

Table 1: Colour change of pH indicator under different light conditions

	Bottle contents	pH at the start	pH after 30 mins
1	indicator only	8.2	8.2
2	indicator only + black paper covering	8.2	8.2
3	algal balls + indicator	8.2	9.2
4	algal balls + indicator + black paper covering	8.2	7.6

Table 2: pH change under different light conditions, based on comparison of colour to standards



Question 1 (10 marks)

a. Analyse the results seen in Test Tube 4 of Experiment 1. 3 marks

b. How does exposing algal balls to light affect the pH level of the solution? Justify your answer. 3 marks

c. What type of data was collected in Table 1 of Experiment 1? 1 mark

d. Outline a limitation of the method, above, and explain how it could be overcome in future trials.

3 marks

Experiment 2

Investigation of Cellular Respiration in Plants

Background information: Plants undergo both photosynthesis and cellular respiration to maintain energy balance. The light compensation point is the light intensity at which the rate of photosynthesis equals the rate of respiration, resulting in no net exchange of carbon dioxide. This experiment uses bromothymol blue, a pH indicator that changes color based on CO_2 levels, to observe how different light intensities affect CO_2 production in germinating seeds. By measuring the color change in the indicator solution, we can identify the light intensity where CO_2 consumption by photosynthesis balances its release through respiration, determining the plant's light compensation point.

Materials:

1 x growth container with germinating seeds (grown in dark conditions) 3 test tubes 2 x 50mL syringes with plastic tube attached White paper Plastic straw	10 mL measuring cylinder Test tube rack Bromothymol blue Distilled Water Foil Lights (at various intensity)

Method:

1. Add 5 mL of distilled water and 1 drop of bromothymol blue to 4 test tubes.
2. Place an equal number of germinating seeds into 4 sealed containers (e.g., small jars).
3. Each container represents a different light intensity:
    a. 0 lux (completely dark, wrapped in foil).
    b. 1000 lux (dim light, ~1m from a lamp).
    c. 5000 lux (moderate light, directly under a weak lamp).
    d. 10,000 lux (bright light, strong LED or sunlight).
4. Let the seeds sit under the specified light intensities for 1 hour.
5. After 1 hour, use a syringe to draw gas from each jar.
6. Bubble the gas through the bromothymol blue in separate test tubes.
7. After 30 seconds, note down the final colour

Results:

Light Intensity (lux)	Starting Colour	Final Colour
0	Blue	Yellow
1,000	Blue	Green
5,000	Blue	Blue
10,000	Blue	Blue

Table 3: Colour change of pH indicator under different light conditions

Question 2 (17 marks)

a. Referring to Table 3, explain why there is no colour change above a light intensity of 5000 lux.

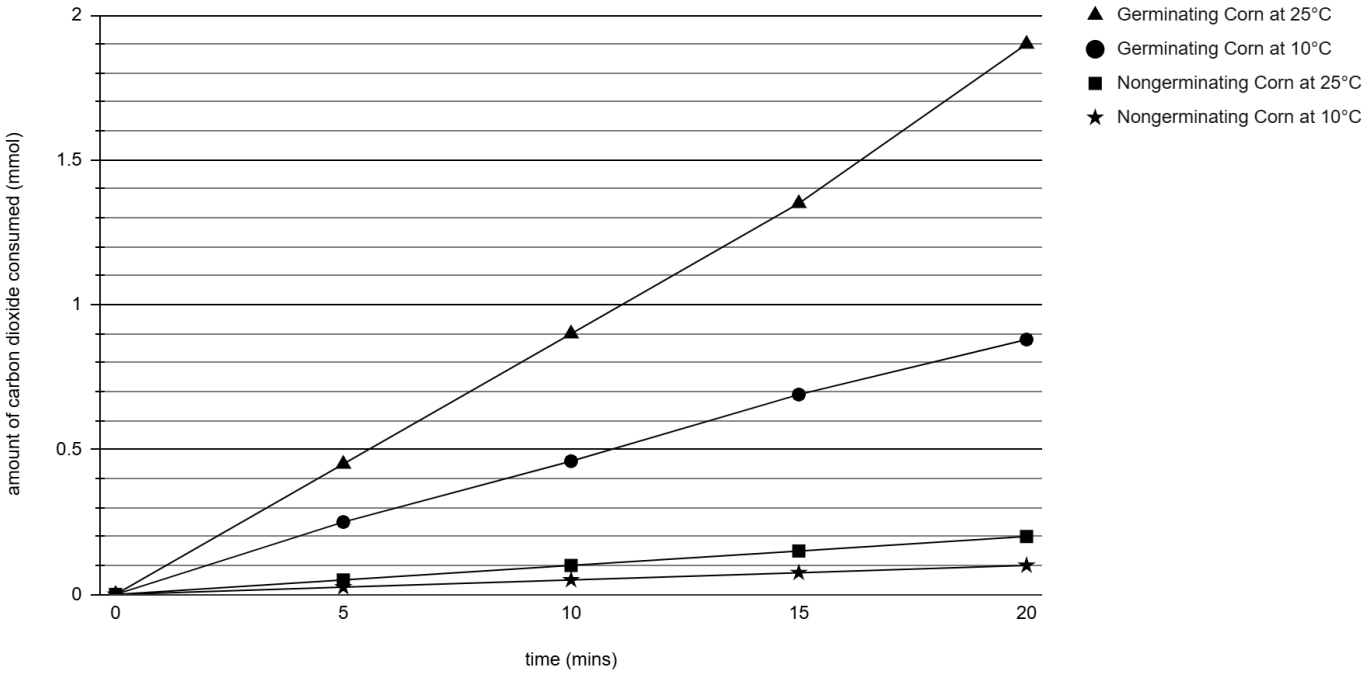
2 marks

b. Define uncertainty, and outline one factor that would **increase** the uncertainty in the results collected. 2 marks

c. Describe **one** reason for the production of coenzymes during cellular respiration. 1 mark

Corn (*Zea mays*) is a widely cultivated crop grown for food, feed, and fuel. Germination is a critical stage in the life cycle of corn, and environmental factors, such as temperature, can significantly affect its success. In an investigation, two students, Archie and Christy examined the impact of temperature on both germinating and non-germinating corn seeds. The study aimed to assess the seeds' metabolic activity under varying temperature conditions. The results, presented in the graph below, show how temperature impacts the rate of carbon dioxide consumption in both germinating and non-germinating seeds.

Carbon dioxide production from corn under different conditions



d. Christy proposed that temperature had a greater impact on the amount of carbon dioxide consumed, whereas Archie proposed that whether the seed was germinating or not had a greater effect.
Which student is correct? Compare their findings to support your conclusion. 3 marks

e. Corn is a type of C4 plant. Rice, tobacco and other agricultural crops are C3 plants.
Explain how C4 plants are better adapted to warmer environments compared to C3 plants. 3 marks

Another student, Buttercup, repeated the experiment, recorded the same results, and then extended the investigation by testing the corn in 5°C temperature intervals.

f. In the space below, predict the **results** for the different trials and describe why.

i. Germinating Corn at 70°C 2 marks

ii. Nongerminating Corn at 0°C 2 marks

g. Comment on the level of validity of the experiment Buttercup completed in comparison to the original experiment performed by Christy and Archie. 2 marks

Experiment 3

Does sucrose concentration change the rate at which organisms undergo cellular respiration?

Background information: The International Energy Agency (IEA) expects biofuel demand to grow from 146 billion litres/year in 2020 to between 186 and 342 billion litres/year in 2026 (an increase of 27%-134%). The magnitude of the increase will depend on whether countries meet their expressed policy goals of increasing biofuel use and the relative price of biofuels compared to oil. The OECD-FAO forecast more modest biofuel consumption growth than the IEA (134 billion litres of biofuel in 2026).

Materials:

Sucrose solutions (1%, 5%, 10%, 20%)	String
Measuring cylinder	5 balloons
Stirring rod	Dry yeast
Marker	37°C water bath
Distilled water	Test tube rack
5 medium test tubes	Ruler
Spatula	Timer / Stopwatch

Method:

1. Label test tubes 1-5.
2. Place 3g of yeast into each test tube.
3. Place 25 ml of distilled water into test tube 1 and stir. Place a balloon tightly over the opening of the test tube.
4. Measure and record the initial circumference of the balloon by wrapping the string around the largest part of the balloon.
5. Place 25 ml of each sucrose solution (1%, 5%, 10%, 20%) into test tubes 2-5 respectively**.**
6. Place 3g of yeast into each test tube and stir.
7. Seal the test tubes immediately by placing a balloon tightly over the opening of the test tubes.
8. Measure and record the initial circumference of each balloon, as per step 4.
9. Place the test tube rack, with all test tubes, into the water bath and start the timer for 30 minutes.
10. After 30 minutes, remove the test tubes from the water bath. Record the circumference of the balloons.. Calculate any difference in the circumference of the balloons.

Results:

Sucrose Concentration	Change in balloon circumference (cm)
0% (distilled water)	0
1%	2
5%	9
10%	17
20%	17

Table 4: Change in balloon circumference under various sucrose concentrations

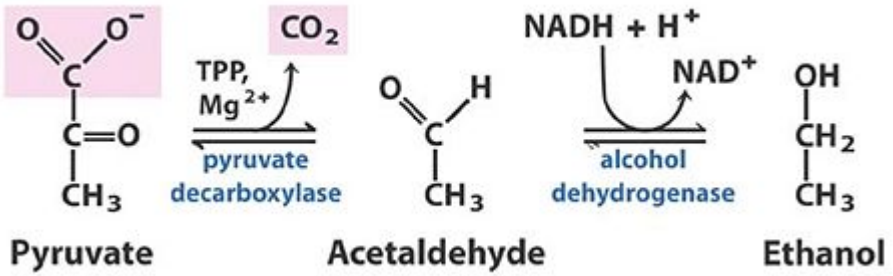
Question 3 (13 marks)

a. Describe how **two** variables can be controlled in this experiment. 2 marks

b. How could a biofuel company use these findings? 2 marks

Starch from the wheat grain can be used to produce bioethanol. In this process, *Saccharomyces cerevisiae* yeast and enzymes that break down starch into monosaccharides are added to the starch. *S. cerevisiae* is a facultative anaerobe.

c. Explain how *S. cerevisiae* is used in the production of bioethanol. 2 mark



Source: Proteopedia 2022, Pyruvate decarboxylase, <https://proteopedia.org/wiki/index.php/Pyruvate_decarboxylase\>

Alcohol dehydrogenase catalyses the reaction of Acetaldehyde to Ethanol.

d. With reference to the diagram above, explain the role of alcohol dehydrogenase in anaerobic fermentation. 3 marks

A researcher was investigating various compounds for their effects on the activity of alcohol dehydrogenase (ADH), an enzyme essential for alcohol fermentation. One of the compounds tested, Compound X, yielded interesting results when the experiment was performed using acetaldehyde as the substrate.

e. Design an experiment to test the effect of Compound X, allowing the researcher to determine whether Compound X is a competitive inhibitor. 4 marks

End of Section A

Extra space for responses

Clearly **number** all responses in this space

Unit 3, Area of Study 2 assessment report

General Comments

Students are reminded that the set of key science skills (refer to pages 7-9 of the study design) are examinable, and school-assessed coursework provides students with firsthand experience that can be applied to examination questions.

Section A

Question 1a

Marks	0	1	2	3	Average
%					

- pH decreased from 8.2 to 7.6 / colour changed from red to orange

Any one of:

- Carbon dioxide was released
- Cellular respiration was occurring

And:

- Photosynthesis was occurring at a low rate / not occuring

Question 1b

Marks	0	1	2	3	Average
%					

- pH level increases as seen in Test Tube 3 (from 8.2 to 9.2 / red to purple)

And:

- Algal exposed to light are able to undergo light dependent reaction

And one of:

- Creating the inputs (NADPH / ATP) for light independent / calvin cycle
- Consumes carbon dioxide

Question 1c

Marks	0	1	Average
%			

- Qualitative

Question 1d

Marks	0	1	2	3	Average
%					

Any one of the following:

- State: Collecting qualitative data / subjective / colour of solution / bias
  Identify: Overcome by using a pH meter to
  Explain: collect higher resolution reading

- State: No repetition / small sample size
  Identify:Repeat the experiment
  Explain: calculate an average to reduce the effect of outliers / random errors

- State: Unable to measure if the number of chloroplast/mitochondria are the same in each algal ball
  Identify: Create a suspension of these organelles
  Explain: ensure consistency across trials

- State: limited range of light intensities
  Identify: have more light intensities
  Explain: allows experimenters to determine to measure the impact of light intensity to a greater extent, increasing validity

Question 2a

Marks	0	1	2	Average
%				

Any one the following:

- The enzymes in photosynthesis are saturated
- Leading to the rate of carbon dioxide production plateauing

- Water / chlorophyll is a limiting factor
- Leading to insufficient number of ATP/NADPH being produced for the light independent reaction

- Colour change is a subjective measure
- Therefore a colour change may occur but it was not recognised by the observer

- Light compensation point
- Where cellular respiration = photosynthesis, therefore no net CO2 release

Exemplar student response: Saturation point occurs between 5000 lux to 10000 lux which all available enzymes bind to a substrate respectively (are saturated). Therefore, further increasing the light intensity won't increase the rate of photosynthesis in which no extra CO2 can be consumed, thus there is no colour change.

Question 2b

Marks	0	1	2	Average
%				

- The lack of exact knowledge of the value of the quantity being measured

And one of:

- Colour change is a subjective / qualitative measure
- Equipment used (using an example) to measure / anything that contributes to random errors
- Not repeating the experiment / small sample size
- Large interval ranges

Exemplar student response: Uncertainty is when the results don't reflect the true value of the quantity being measured. One factor that would increase uncertainty in the results would be the determination of the final pH colour, as colour interpretation is subjective.

Question 2c

Marks	0	1	Average
%			

- NADH / $FADH_2$ function: To provide hydrogens to the electron transport chain
- ATP provides energy

Question 2d

Marks	0	1	2	3	Average
%					

- Archie
- Larger change in carbon dioxide consumed between germinating corn at 25 and nongerminating at 25 (1.7mmol difference)
- Difference between nongerminating corn at 10 and nongerminating corn at 25 is 0.1mmol

Question 2e

Marks	0	1	2	3	Average
%					

- Separating the light independent stage across two different cells/undertake the Calvin cycle in bundle sheath cells / LD stage and LI stage occur in different cells (mesophyll and bundle sheath, respectively)
- Ensures a high concentration of CO2 around RuBisCo
- C3 plants are less adapted as they have no adaptation to combat the binding of oxygen / photorespiration

Question 2f i.

Marks	0	1	2	Average
%				

- Low / no consumption of carbon dioxide (mmol)
- Enzymes involved in photosynthesis will have denatured / lost 3D structure of active site

Question 2f ii.

Marks	0	1	2	Average
%				

- Low / no consumption of carbon dioxide (mmol)
- Enzymes involved in photosynthesis will have less collisions with their substrate / less kinetic energy

Question 2g

Marks	0	1	2	Average
%				

- Buttercups experiment is more valid
- Buttercup has measured a broader range of temperature therefore better measuring the effects of temperature on CO_2 production, which is the aim (description of aim) of the experiment / what it is supposed to measure

Exemplar student response: Validity is higher in Buttercups experiment compared ot the original. This is because more temperatures were tested in the second experiment, allowing for a broader knowledge of the effect of temperature (IV) on CO2 consumption (DV).

Question 3a

Marks	0	1	2	Average
%				

Any 2 of:

- Use the same mass of yeast (g) in each trial
- Use the same volume of distilled water (ml) in each trial
- Use the same volume of sucrose solution (ml) in each trial
- Place in the water bath for the same amount of time (minutes)
- Expose to the same temperature water bath (°C)
- Use the same species of yeast for each trial

Question 3b

Marks	0	1	2	Average
%				

- Don't use beyond 10% sucrose / saturation point / optimal [sucrose]
- Is more economical / cost effective / make more more / don't waste money on sucrose / reduce sucrose waste

Exemplar student response: Biofuel companies can save money and time, by using 10% sucrose concentration to produce the most amount of ethanol during the ethanol fermentation stage as it has reached a saturation point, meaning it would be useless to use 20% sucrose concentration, and they can produce biofuels more efficiently.

Question 3c

Marks	0	1	2	Average
%				

- Breaks down glucose using anaerobic fermentation
- Produces ethanol

Exemplar student response: As S.cerevisiae is a facultative anaerobe, it will undergo anaerobic fermentation in the absence of oxygen and in the presence of glucose, produces CO2 gas and ethanol which can be distilled and mixed with octane to form bioethanol.

Question 3d

Marks	0	1	2	3	Average
%					

Both:

- Catalyses the reaction from acetaldehyde to ethanol
- Alcohol dehydrogenase facilitates the unloading of H from NADH

Any one of:

- Recycles the NAD+ into unloaded form
- Allows for more ATP
- Allows for glycolysis to continue

Question 3e

Marks	0	1	2	3	4	Average
%						

Any 4 of the following:

- IV: Amount of pyruvate/acetaldehyde (%/mmol/g/mg)
- DV: Rate of ethanol production (%/mmol/ml)
- CV: Amount of alcohol dehydrogenase (mg/g/mmol), volume / concentration of compound X, volume of Acetaldehyde
- CG: One test tube/treatment with no pyruvate/acetaldehyde / no inhibitor present
- Repeat 3x/increase sample size to increase accuracy