Website: contoureducation.com.au | **Phone:** 1800 888 300
Email: hello@contoureducation.com.au

VCE Biology ¾
Photosynthesis & Biochemical Pathways [0.9]
Workshop Solutions

Error Logbook:

Mistake/Misconception #1		Mistake/Misconception #2	
Question #:	Page #:	Question #:	Page #:
Notes:		Notes:	
Mistake/Misconception #3		**Mistake/Misconception #4**	
Question #:	Page #:	Question #:	Page #:
Notes:		Notes:	

Section A: Multiple Choice Questions (21 Marks)

Question 1 (1 mark)

Consider the role played by light in the light-dependent stage of photosynthesis.

Which one of the following statements is correct?

A. Light is the source of electrons that provide the energy needed to produce ATP.

B. Light provides the energy that is absorbed by chlorophyll, which facilitates the light-dependent stage.

C. Light provides the heat required to split water molecules into hydrogen ions and oxygen gas.

D. Light breaks down ATP molecules, releasing the energy required for NADPH to be moved from the grana to the stroma.

Answer: B

Explanatory notes

Option A is incorrect. Light does not supply electrons to the chloroplasts.

Option B is correct. Light is used as an energy source to activate chlorophyll, which then facilitates the reactions that occur during the light-dependent stage of photosynthesis.

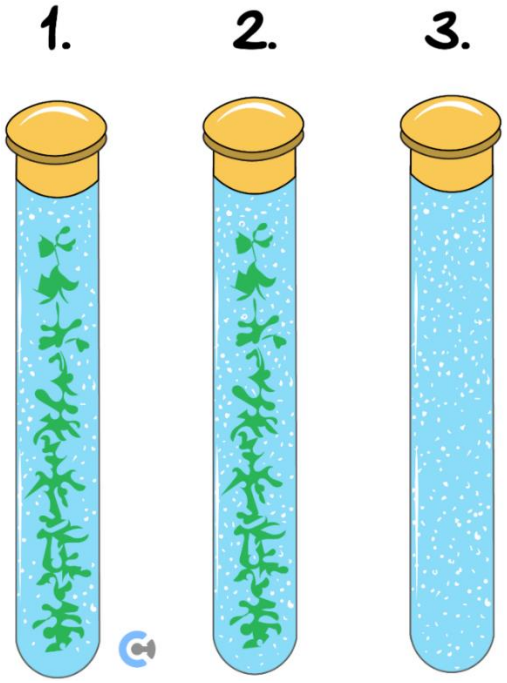
Option C is incorrect. Water molecules are not broken down into hydrogen ions and oxygen gas from being heated.

Option D is incorrect. NADPH is moved from the grana to the stroma by the proton gradient.

Space for Perso

The following information applies to the two questions that follow:

The following experiment was set up to test the rate of photosynthesis. Elodea (a type of aquatic plant) was used and each of the test tubes was left under a light for 10 minutes. The amount of oxygen produced in each test tube was recorded.



Test tube #		Result
1		gen were produced.
2	Deox bicar for	gen were produced.
3		was produced.

Explanatory notes

Option A is incorrect. The purpose of this tube is to be able to determine the difference in oxygen production that occurs when the elodea is exposed to sodium bicarbonate compared to when it isn't.

Option B is incorrect. The dependent variable is the outcome that is measured; it is not a variable whose effect will be established.

Option C is incorrect. Elodea does not produce carbon dioxide as a result of being supplied with sodium bicarbonate. The carbon dioxide is produced as a result of the sodium bicarbonate breaking down.

Option D is correct. All of the test tubes initially contained deoxygenated water. Because the test tube without elodea did not contain any oxygen at the end of the experiment and both of the test tubes containing elodea did contain oxygen, we can conclude that the oxygen in these two test tubes at the end of the experiment must have been produced by the elodea.

Question 2 (1 mark)

The purpose of including test tube 3 in the experiment was to:

A. Increase the sample size being tested.

B. Enable the effect of the dependent variable to be established.

C. Prove that supplying sodium bicarbonate to elodea plants causes them to produce carbon dioxide.

D. Prove that any oxygen present at the end of the experiment must have been produced by the elodea plants.

Question 3 (1 mark)

Which one of the following reasons accurately explains the difference in the results in test tubes 1 and 2?

A. Sodium bicarbonate is a t

B. Sodium bicarbonate acte to carry out photosynthesis.

C. Sodium bicarbonate prov ioxide and increased the rate of phot

D. Sodium bicarbonate acte tube 2 and caused the rate of photosynthesis to increase.

Explanatory notes

Option A is incorrect. The elodea exposed to the sodium bicarbonate produced more oxygen than the elodea not exposed to the sodium bicarbonate. Therefore, providing the elodea with sodium bicarbonate increased the rate of photosynthesis rather than decreased it. Therefore, it is not a toxin.

Option B is incorrect. Nutrients are not inputs of photosynthesis and would not cause the rate of photosynthesis to increase.

Option C is correct. Carbon dioxide concentration is one of the factors that affect the rate of photosynthesis. Supplying carbon dioxide in an alternative form provides more of the input required for photosynthesis, increasing the rate of photosynthesis and therefore increasing the amount of oxygen produced.

Option D is incorrect. Sodium bicarbonate is an inorganic substance; therefore, it cannot act as a coenzyme.

Question 4 (1 mark)

Chlorophyll is essential for photosynthesis. Concerning chlorophyll, it can be stated that it:

A. Provides electrons that are used to produce ATP.

B. Provides enzymes needed for photosynthesis.

C. Is found in the stroma of the chloroplast.

D. Absorbs light in the green part of the visible spectrum.

Question 5 (1 mark)

C4 plants are adapted to survive in tropical climates. They use a two-staged process to produce glucose whereby PEP carboxylase is used instead of RubisCO for the initial process of carbon fixation. The purpose of using PEP carboxylase to fix carbon dioxide is to:

A. Prevent the process of photorespiration, as oxygen can bind to PEP carboxylase.

B. Prevent the process of photorespiration, as oxygen cannot bind to PEP carboxylase.

C. Allow the process of photorespiration, as carbon dioxide cannot bind to PEP carboxylase.

D. Allow the process of photorespiration, as carbon dioxide can bind to PEP carboxylase.

Space for Personal Notes

Question 6 (1 mark)

Two Biology students, Arun and Chanul, are discussing the effect of coloured lights on photosynthesis. Arun believes that green light increases the rate of photosynthesis because plant leaves are green and absorb the wavelengths of green light. Chanul believes that violet and red light increases the rate of photosynthesis because plant leaves absorb the wavelengths of both violet and red light.

Which student is correct?

A. Arun only.

B. Chanul only.

C. Both Chanul and Arun.

D. Neither Chanul nor Arun.

Question 7 (1 mark)

Which one of the following is the location of the light-dependent reaction of photosynthesis?

A. The matrix.

B. The grana.

C. The cytoplasm.

D. The stroma.

Question 8 (1 mark)

Identify the plant that has stomata only open during the night.

A. C3 plants.

B. C4 plants.

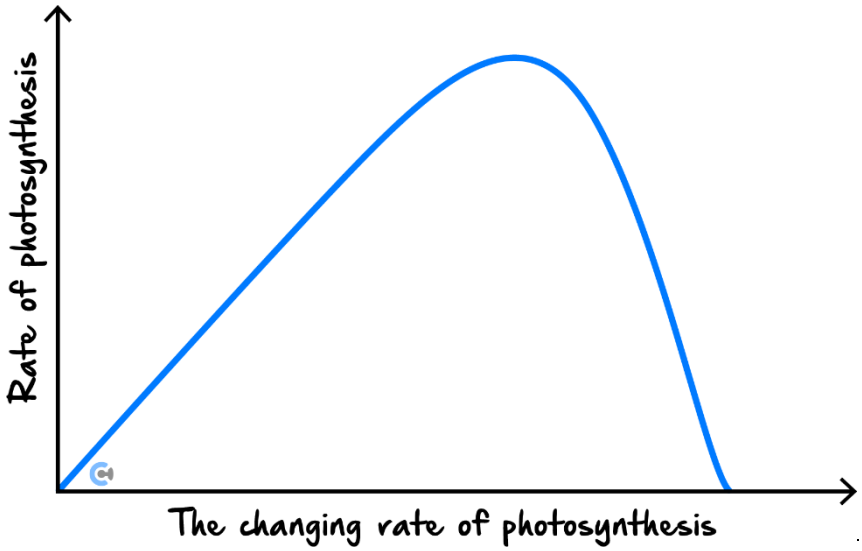
C. CAM plants.

D. All plants.

Space for Personal Notes

Question 9 (1 mark)

Identify the factor that affects the rate of photosynthesis shown in figure below.



A. Temperature

B. Light intensity

C. Availability of water.

D. Carbon dioxide concentration.

Question 10 (1 mark)

CRISPR-Cas9 can be used to modify the genome of RubisCO, increasing its affinity to carbon dioxide over oxygen. This improves photosynthetic affinity as:

A. Oxygen cannot act as a non-competitive inhibitor to carbon dioxide.

B. Carbon dioxide is required for the light-dependent reaction to occur.

C. Carbon dioxide is required for the light-independent reaction.

D. More atmospheric oxygen is available for cellular respiration.

Answer: C

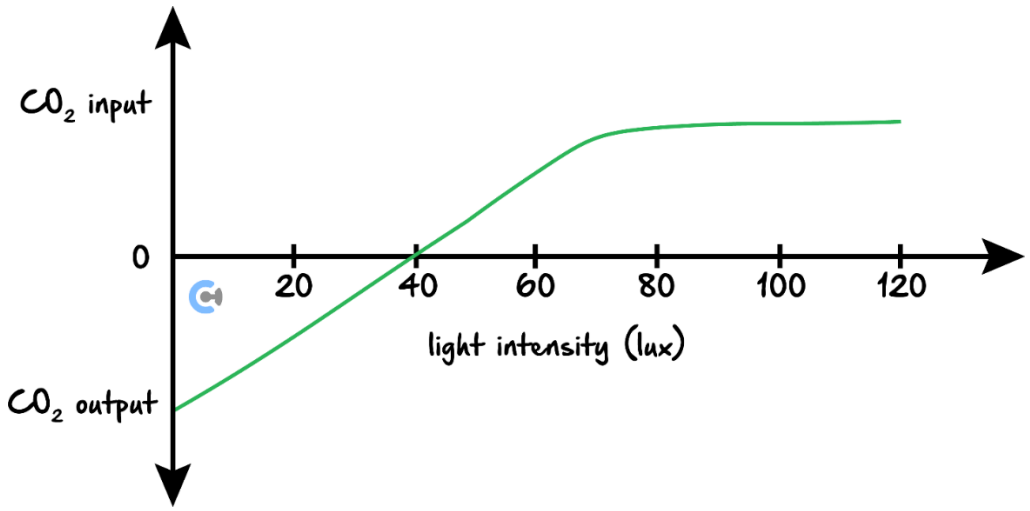
Explanation:

Oxygen acts as a competitive inhibitor for photosynthesis, binding to the active site and preventing carbon dioxide from bonding. Carbon dioxide is required for the light independent stage of photosynthesis.

Space for Personal Notes

Question 11 (1 mark)

The graph below shows the changes in carbon dioxide (CO_2) levels in a tomato plant as the light intensity is progressively increased.



Reading from the graph, it could be concluded that:

A. The rate of respiration in the tomato plant is at its lowest level at 0 lux.

B. The tomato plant is not photosynthesising at 20 lux.

C. The tomato plant is not metabolising at 40 lux.

D. The concentration of RubisCO is limiting the tomato plant's CO_2 input at 100 lux.

Question 12 (1 mark)

What is the difference between C3, C4 and CAM plants?

A. Unlike C3 and C4 plants, CAM plants, such as cactus, absorb carbon dioxide (CO_2) during the day.

B. C4 plants immediately integrate CO_2 into a 3-carbon compound, whereas C3 and CAM plants initially integrate CO_2 into a 4-carbon compound.

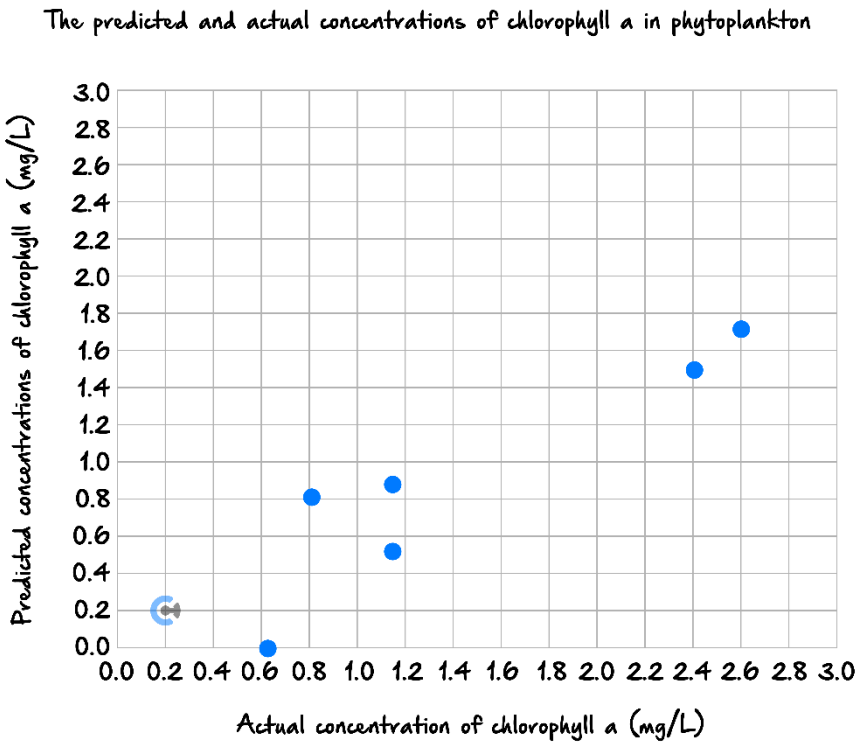
C. C3 plants absorb more CO_2 during the day, whereas C4 and CAM plants absorb more CO_2 at night.

D. CAM plants are suited to temperate climates, C3 plants are suited to dry environments and C4 plants are suited to marine environments.

Space for Personal Notes

Question 13 (1 mark)

The graph below shows the relationship between the predicted and actual concentrations of chlorophyll a in phytoplankton.



Source: Fairooz Binti Johan et al, 'Chlorophyll a conentration of fresh water phytoplankton analysed by algorithmic based spectroscopy, Journal of Physics: Conference Series, 1083 (2018) 012015, <https://iopscience.iop.org/article/10.1088/1742-6596/1093/1/012015/pdf>; licensed CC-BY3.0 <https://creativecommons.org/licenses/by/3.0/>

From the graph, it can be inferred that:

A. The actual concentration of chlorophyll a was lower than the predicted concentration in all recorded measurements.

B. At 2.4 mg/L, the actual concentration of chlorophyll a, the predicted concentration of chlorophyll a was 2 mg/L.

C. At 0.8 mg/L, the predicted concentration and the actual concentration of chlorophyll a were the same.

D. At zero predicted concentration of chlorophyll a, photosynthesis did not occur.

Space for Personal Notes

Question 14 (1 mark)

During photosynthesis:

A. ATP and NADH created in the light-independent stage are transported to the chloroplasts' thylakoid membranes.

B. ADP and NADH are used in the electron transport chain after being created in the light-dependent stage.

C. ATP and NADPH are created in the grana of the chloroplasts and are used in the light-independent stage.

D. ADP and NADPH are created during the Krebs cycle and carried to the stroma of the chloroplasts.

Question 15 (1 mark)

CAM plants are well adapted to arid environments because they:

A. Open their stomata at night to reduce water loss.

B. Perform the light-dependent and light-independent reactions in different cells.

C. Utilise a unique pigment that absorbs water more efficiently.

D. Can perform photosynthesis without opening their stomata.

Question 16 (1 mark)

Considering environmental factors, which of the following conditions would most likely enhance the efficiency of photosynthesis in C3 plants but not in C4 plants?

A. High light intensity and low temperatures.

B. High temperatures and high CO_2 concentrations.

C. Low oxygen concentrations and high CO_2 concentrations.

D. High oxygen concentrations and low CO_2 concentrations.

Space for Personal Notes

Question 17 (1 mark)

C4 and CAM plants have evolved mechanisms to minimise photorespiration. Which of the following statements correctly distinguishes between C4 and CAM plants?

A. C4 plants fix CO_2 into a four-carbon compound and perform the Calvin cycle in the same cell, whereas CAM plants separate these processes temporally.

B. C4 plants separate the initial CO_2 fixation and the Calvin cycle spatially within different cell types, whereas CAM plants separate these processes temporally within the same cells.

C. CAM plants exclusively use PEP carboxylase for carbon fixation, while C4 plants use both PEP carboxylase and RubisCO.

D. C4 plants are adapted to cold environments, while CAM plants are adapted to high-light environments.

Question 18 (1 mark)

How does an increase in carbon dioxide concentration affect the rate of photosynthesis up to a certain point?

A. It increases the rate of photosynthesis by increasing RubisCO activity until a saturation point is reached.

B. It decreases the rate of photosynthesis due to a reduction in oxygen availability for photorespiration.

C. It has no effect on the rate of photosynthesis as light intensity is the limiting factor.

D. It increases the rate of photosynthesis indefinitely as long as other factors are not limiting.

Question 19 (1 mark)

A biologist is examining a chloroplast exposed to light of varying wavelengths. She notes that oxygen production increases significantly under blue light. This observation is directly related to which aspect of the light-dependent reactions?

A. Absorption of light by chlorophyll leads to the splitting of water molecules, releasing oxygen as a byproduct.

B. Carbon dioxide is being fixed more efficiently into sugars, thereby requiring more oxygen output.

C. ATP and NADPH production rates are highest, leading to excess oxygen production.

D. Blue light increases the permeability of the chloroplast membrane to oxygen, enhancing its release.

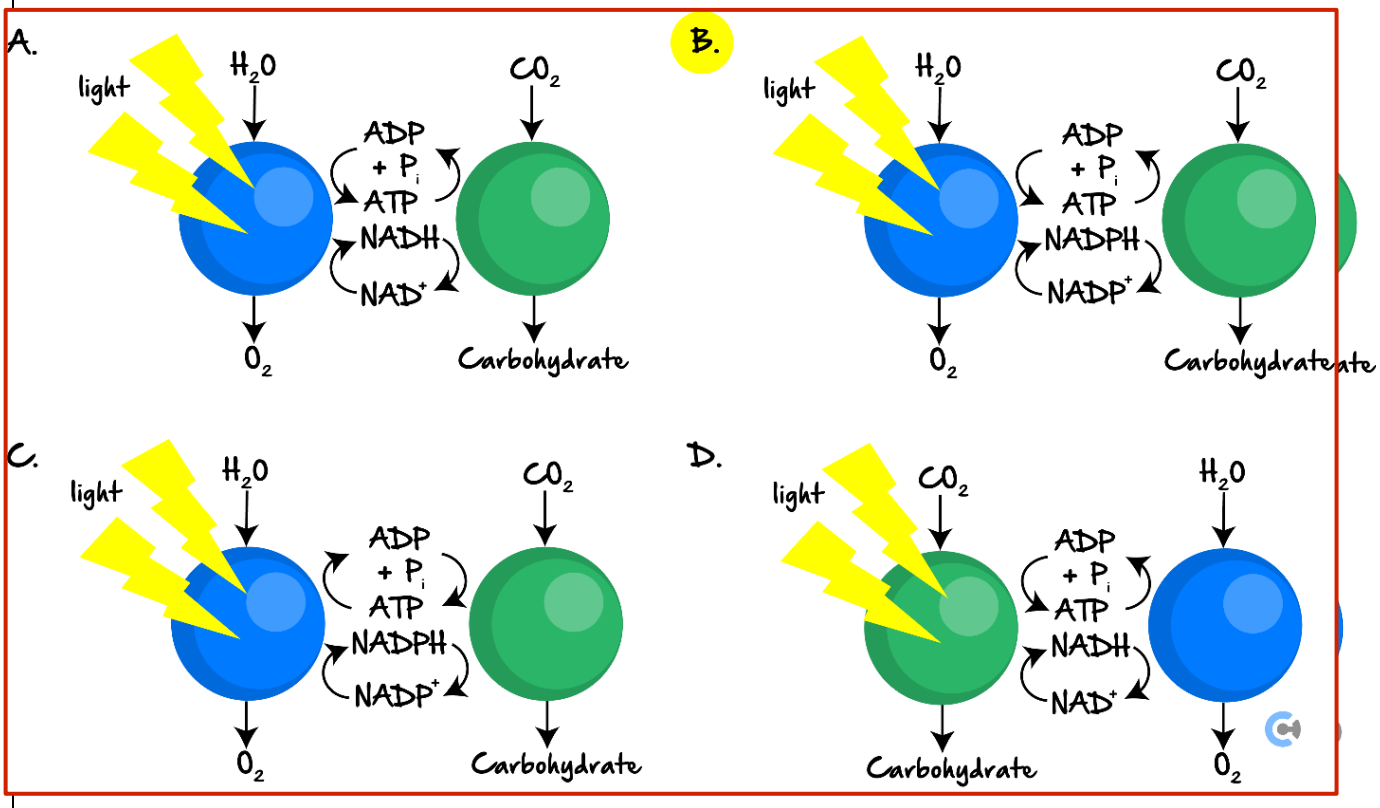
Question 20 (1 mark)

In the context of photosynthesis, evaluate the statements below about the light-dependent and light-independent stages. Which option accurately describes a feature of each stage?

	Light-dependent stage	Light-independent stage
A.	Liberates ATP.	Fixes oxygen.
B.	Splits water molecules.	Utilises ATP.
C.	Takes place in the thylakoid membranes.	Takes place in the cytoplasm.
D.	Generates NADPH.	Recycles ADP and P_i.

Question 21 (1 mark)

Which one of the following diagrams correctly represents the inputs and outputs of photosynthesis?



Space for Personal Notes

Section B: Short Answer Questions (108 Marks)

Question 22 (12 marks)

A high school runs an experiment that seeks to investigate a factor that may impact the rate of photosynthesis by using spinach leaves.

This involves submerging them in a solution of Sodium bicarbonate (to provide gas) and water. The spinach was cut into discs, which were then 'vacuum sealed' using a syringe to get rid of all the gases within it.

There were 15 discs in each solution and each solution was placed at a different distance from a lamp.

The time taken for the discs to start floating was measured and recorded.

a. What is the independent variable in this experiment? Describe theoretically how this factor impacts the rate of photosynthesis. (2 marks)

The light intensity supplied to the plant is the independent variable.

This impacts the rate of photosynthesis, as increasing this factor will increase the rate of photosynthesis, as more light can be absorbed by the chlorophyll. However, this will only increase until it is impacted by another limiting factor – that is, a lack of availability of another factor such as CO_2 may stop the rate from increasing indefinitely.

b. What is the dependent variable in this experiment? Describe how this is a valid method of recording the results. (2 marks)

The time taken for the spinach to float. Initially, they have no air within them, causing them to sink, but as photosynthesis proceeds, they are filled with gas and this is a valid way of measuring the results as we want to look at the rate of photosynthesis – the faster the rate of photosynthesis the quicker they will float, given an increased rate of gas production.

c. What gas is most likely to be present within the spinach leaf in the highest concentrations as they float? Where is this gas produced? (2 marks)

Oxygen – via photosynthetic splitting of water. This gas is produced in the light-dependent stage via chlorophyll, embedded within the thylakoid membranes of the chloroplast.

d. Name 2 controlled variables in this experiment. (2 marks)

- The concentration of the sodium bicarbonate as a source of CO_2.
- The amount of solution the spinach leaves were placed in.
- The number of spinach discs used.
- The size of the spinach discs.
- The temperature of the solution.

Any 2 - ask me if your answer is not on this list.

The results of this experiment indicated that there was an increase in the rate of photosynthesis, until a certain point at which the rate stopped increasing.

e. Considering the experimental set-up, what is most likely to have been the other limiting factor and why? (2 marks)

The concentration of CO_2 in water ordinarily is extremely minimal, hence, is the need for the sodium bicarbonate solution – it provides it via its breakdown. Given the small amounts of carbon dioxide, it is most likely going to be the limiting factor as there is plentiful water and light.

Hard question.

An experiment was conducted testing the effect that temperature had on the time taken for the least discs to float. The results are shown below:

Temperature (°C)	**Time taken for the leaf discs to float (seconds)**
15	480
30	90
45	150
60	480

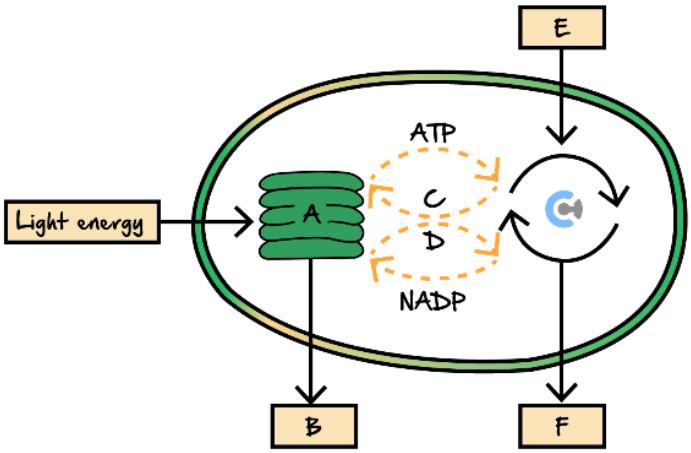
f. The results gained at 15°C and 60°C are the same, yet the explanation for them is very different. Explain these differences. (2 marks)

At low temperatures (15°C) the enzymes which catalyse photosynthesis and the substrates slow down their (kinetic) movement. This leads to fewer collisions between substrates and enzymes, meaning it will take more time for oxygen gas to accumulate in the leaf, lengthening the timeit takes for the leaves to float.

At high temperatures (60°C) the enzymes which catalyse photosynthesis start to denature (change their three-dimensional shape). Even though the movement of chemicals will be faster due to the increased heat, there will be less effective collisions between substrates and the (denatured) enzymes, meaning it will take more time for oxygen gas to accumulate in the leaf, lengthening the time it takes for the leaves to float.

Question 23 (12 marks)

The diagram below summarises the main steps of photosynthesis in C3 plants. Labels *A* - *F* represent structures or chemicals involved in the process.



a. Complete the table by naming components *A* - *F*. (4 marks)

Component	Name
A	grana/thylakoid membrane
B	oxygen
C	ADP and Pi
D	NADPH
E	carbon dioxide
F	glucose

4 marks

Award 4 marks for 6 correct table entries. Award 3 marks for 4–5 correct table entries. Award 2 marks for 2–3 correct table entries. Award 1 mark for 1 correct table entry.

F

b. What is the function of RubisCO? (1 mark)

RubisCO is an enzyme that catalyses the inclusion of carbon dioxide into the Calvin cycle, as it combines carbon dioxide and RUBP to form a C3 compound.

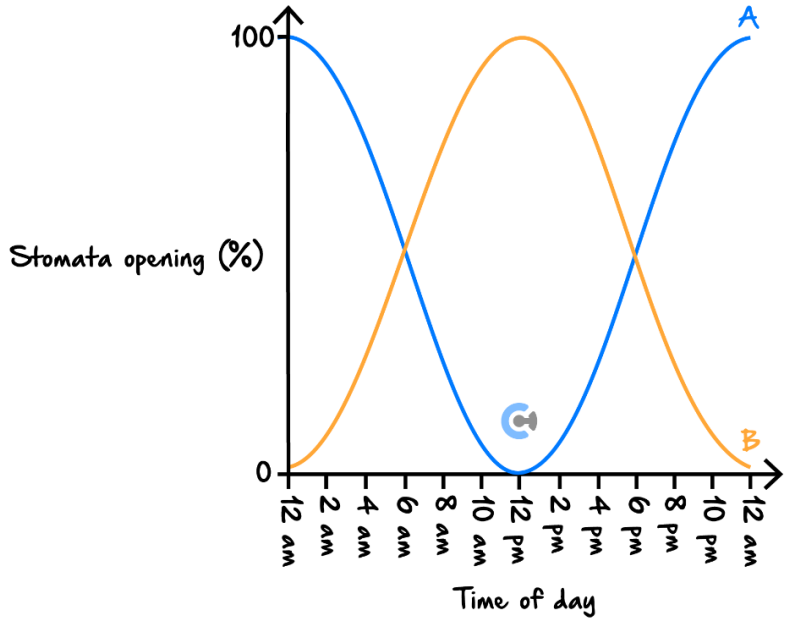
c. RubisCO can undergo another process called photorespiration.

When is photorespiration most likely to occur? (2 marks)

Photorespiration occurs when RubisCO binds with oxygen instead of carbon dioxide. (1 mark)

Thus, it is most likely that photorespiration will occur when there is a higher concentration of oxygen than carbon dioxide. (1 mark)

d. Plants have evolved in various ways to reduce the rate of photorespiration. The diagram below shows the pattern of stomatal opening for two types of plants, *A* and *B* over 24 hours.



i. The stomatal opening pattern of plant *B* suggests it is part of a group of plants that have evolved to reduce their rate of photorespiration.
Name the group of plants and state the type of environment in which they are usually found. (2 marks)

CAM plants 1 mark
hot, dry environment 1 mark

ii. Explain why a plant closing its stomata during the day would increase the rate of photorespiration. (2 marks)

Closing the stomata during the day prevents carbon dioxide from entering the plant. However, photosynthesis continues to occur, which increases the level of oxygen and hence increases the rate of photorespiration.

iii. Describe how the group of plants named in **part d.i.**, reduce the rate of photorespiration. (1 mark)

CAM plants take in carbon dioxide at night and store it as malate in the central vacuole. During the day, the malate is converted into carbon dioxide, which maintains the required level of carbon dioxide and thus reduces the incidence of photorespiration.

Question 24 (8 marks)

There are many different pathways in which plants are able to photosynthesise, including C3, C4 and CAM pathways.

a. In which conditions would C4 and CAM plants be most suited to operate? Explain and compare the two processes of photosynthesis. (4 marks)

These plants would be most effective in hot and dry conditions, as they are adapted to overcome the issue of photorespiration, albeit slightly differently from each other.

C4 plants are suited to hot and dry conditions as they separate RubisCO into a different cell from the light-dependent stage – this allows them to close their stomata whilst still maintaining a relatively low oxygen concentration around RubisCO itself, minimising photorespiration.

By contrast, CAM plants separate the cycle on the basis of time – they open their stomata at night to take in CO_2 and release it during the day in hot conditions with a closed stoma, to reduce water loss whilst also maintaining CO_2 concentrations inside the cell.

b. Explain why it may be beneficial to convert a plant like rice to C4 given the direction that global temperatures are heading in. (2 marks)

This may be beneficial as it allows them to perform photosynthesis much more efficiently in hot and dry conditions. This is the trend of climate change, especially in Australia, and hence, converting this plant will make it easier to grow, whilst maintaining its crop yield in the face of a changing climate.

c.

i. What DNA manipulation technology might be involved in this process? (1 mark)

CRISPR-Cas9

ii. If C4 and CAM are more efficient, propose a reason why all plants haven't evolved to suit this process. (1 mark)

Because there is an energy cost associated with the biochemical pathway, they have evolved to avoid photorespiration.

Space for Personal Notes

Question 25 (12 marks)

It is known that photosynthesis is temperature-sensitive in C3 plants and for a particular plant, there is an optimal temperature of photosynthesis and if it were to increase from there, the rate of photosynthesis would decrease. This is generally related to a particular enzyme's function and stomatal closure in plants.

a. How might temperature impact this specific enzyme and how does stomatal closure impact the rate of photosynthesis? (3 marks)

Increasing the temperature will increase the affinity of RubisCO to oxygen, which will increase the rate at which photorespiration will occur, reducing the rate of photosynthesis.

Higher temperatures mean the closure of the stomata in order to conserve water, which will increase the concentration of oxygen inside the plant due to the light-dependent stage.

Hence, this will increase the affinity of RubisCO to oxygen and increase the amount of photorespiration occurring, hence, reducing the rate of photosynthesis.

b. Name TWO other factors that impact the rate of photosynthesis. (2 marks)

Carbon dioxide availability.
Water availability.
Light availability.

c. State the reaction equation of photosynthesis. (1 mark)

See above in definition solutions.

d. Describe the function of photosynthesis. (1 mark)

The function of photosynthesis in plants is to produce sugar from light energy (of the sun), which provides them with the chemical energy to sustain their life.

e. Name the two stages of C3 photosynthesis in plants. (2 marks)

Light-dependent and light-independent.

f. What is the source of ATP in the second stage of photosynthesis? (1 mark)

Light-dependent stage produces ATP for the light-independent Stage.

g. What other coenzyme is involved in the second stage of photosynthesis? Describe its purpose. (2 marks)

NADPH – its purpose is to collect and carry the high energy electrons and protons that are produced in the light-dependent stage, to reactions within the Calvin cycle/light-independent stage.

Space for Personal Notes

Question 26 (9 marks)

In an urban greenhouse, a botanist came across a distinctive variety of plant. Lacking information on the plant's classification, the botanist conducted a series of experiments to gauge its photosynthetic performance. The experiments involved recording the rate of starch production each day while subjecting plants of uniform size to varying environmental factors. The findings are tabulated below.

Effect of different environmental conditions on starch production per day:

Temperature (°C)	**Light source**	**Carbon dioxide** (%)	**Relative humidity** (%)	**Rate of starch formed (mg/day)**
20	White	5	60	1.5
20	White	1	60	1.2
20	White	5	35	1.8
20	Green	5	60	0.3
20	Blue	5	60	1.4
40	White	5	60	2.8
40	White	1	60	2.4
40	White	5	35	3.0
40	Green	5	60	0.4
40	Blue	5	60	2.7

a. Considering the experimental outcomes, which photosynthetic classification (C3, C4, or CAM) does this unique plant species likely fall into? Provide a justification for your response. (3 marks)

"This is most likely going to be a CAM plant.
- Generally, we can see the plant produces more starch at higher humidity (3.0 vs 2.8 mg/day) which is suited for a CAM adaptation.
- Further, it has a higher rate of starch production at higher temperatures (indicating it has an adaptation to avoid photorespiration)".

b. Describe ONE other way that the scientist could determine which plant type it is. (2 marks)

Physical comparison, looking at the structure of the leaf.

c. Why does exposing the plants to green or blue light as opposed to white light affect the formation of starch? Justify your answer. (4 marks)

Light is an input for the light-dependent stage (LDS) of photosynthesis, and thus the amount available to a plant will directly impact the rate of formation of starch via this process. Plants are able to absorb a range of wavelengths from light.

- Chlorophyll pigments in plants are unable to absorb green wavelengths, hence, less light is available for the LDS, resulting in decreased starch production ($0.3\ mg/0.4\ mg$ per day).
- Blue light can be absorbed; hence, starch production did occur. However, there is less light available overall, as other wavelengths are unavailable to the plant.
- As all wavelengths are available, white light had the greatest rate of starch production.

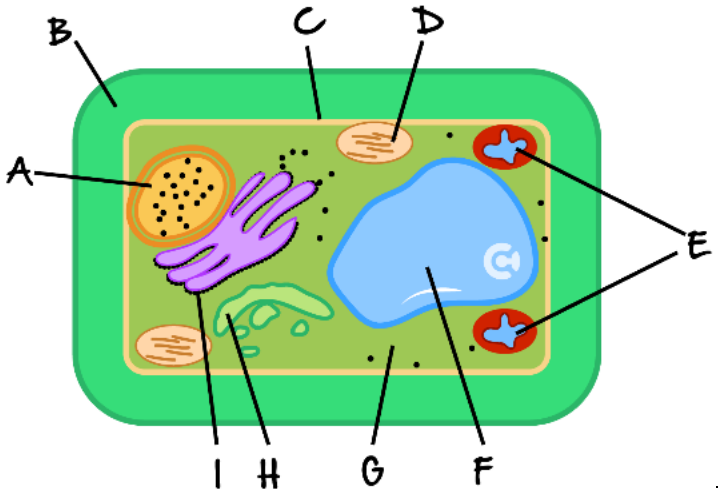
*Explain!

- 1 mark for the relationship of light + starch production.
- 1 mark for explaining green is not absorbed.
- 1 mark for explaining blue light.
- 1 mark for comparing white + blue light starch production.

Space for Personal Notes

Question 27 (3 marks)

The following diagram is of a photosynthetic plant cell. Labels *A* to *I* represent structures or areas that are important to the functioning of the cell.



In completing the parts below, state which of the labels (*A* to *I*) are consistent with the following structures/processes. Note that there may be more than one answer.

a. Which structures contain DNA? (1 mark)

A, *D* and *E* 1 mark

All three are required to be awarded the mark.

b. Which structure contains thylakoid membranes? (1 mark)

D (thylakoids are the grana membranes within the chloroplast)

c. In which area is the electron transport chain located? (1 mark)

E (electron transport is the last step of respiration occurring in the mitochondria)

Space for Personal Notes

Question 28 (11 marks)

CRISPR-Cas9 is an emerging technology that can be used to edit genomes in a faster, more cost-effective manner. The proposed usage of this technology is to edit tomato plants so that they become resistant to herbicides.

a. Why this might be a beneficial edit? (1 mark)

This may be a beneficial edit as it allows farmers to expend less energy and effort applying herbicide – they can apply it indiscriminately – hence, they will be able to grow more crops.

b. Discuss the ethical implications of this edit, using a consequences-based approach to ethics. (3 marks)

Consequences-based approach to ethics means looking at the outcomes and then judging whether this would be ethical.

Good – Tomatoes would be more efficient with their yields and land usage.

Bad – May spread to other crops.

Bad – May result in the overuse of herbicides.

Bad – Monopolisation of the market.

Good – Farmers have to put in less work on weed control, which may drip down into socioeconomic

c. Describe the process by which CRISPR-Cas9 could actually be applied to this scenario to edit the tomato plant. (3 marks)

- Identify a target sequence for a cut in the tomato plant and develop a synthetic guide RNA (sgRNA) complementary to it.
- Combine this with the Cas9 enzyme, altered with a PAM to suit the target.
- Depending on the type of edit – we could be introducing a gene or silencing one existing gene.
- Inject this into a target cell, and then the sgRNA will bind to the target DNA, and then signal the cut.
- Cell repair mechanisms will try and repair causing errors, thus, silencing the gene and preventing its expression OR the cell repair mechanisms will use what DNA was injected alongside to plug the cut.

These plants can also be edited to confer resistance to powdery mildew, a fungus that impacts the plant.

d. How might this edit improve crop yields? (2 marks)

Powdery mildew is a disease which may impact the amount of crop that can be harvested from the tomato – by conferring resistance to the powdery mildew, this may result in more tomato crops being available to harvest, thus, improving its crop yield. Further, with ingrained resistance, current resource-intensive methods may become obsolete, thus, allowing less effort and less resources being wasted on the prevention of powdery mildew, which may make it cheaper to grow.

C3 Photosynthesis is inefficient due to an enzyme that is less efficient in certain conditions.

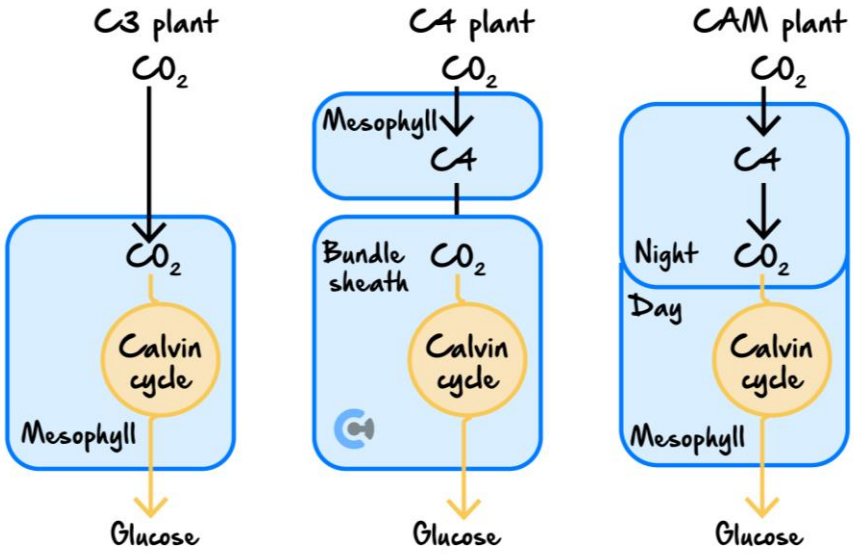
e. How could CRISPR-Cas9 technology be used to alter this enzyme in order to improve its function? (2 marks)

RubisCO – alter its active site to suit CO_2 more so than it suits O_2, thus, reducing the rate of photorespiration and increasing the relative rate of photosynthesis.

Space for Personal Notes

Question 29 (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 are 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)

It's a C4 plant because:

- the temperature falls in the same range
- the pathway to fix CO_2 is the same
- stomata are open during the day unlike CAM plants
- low photorespiration rate unlike C3 plants
- moderate amount of water loss.

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

Determine if Calvin cycle or Rubisco is present in bundle sheath or if any specific substrates or enzymes for this cycle are present.
The unknown plant could have physical or genetic comparisons made to other known plants.
The sample size could be increased, reducing effect of outliers.
Other originally controlled variables could be altered then measure the effect of growth, photosynthetic or photorespiration rate.

Space for Personal Notes

Question 30 (8 marks)

A researcher had just landed on Contour Land shores and realised that there were a bunch of sick-looking plants that he had never seen before. He tests them under a bunch of conditions to find out what they are.

Plant *A*

Temperature (°C)	**Light Intensity**	**CO_2 Concentration** (%)	**Stomata Status**	**Relative Humidity** (%)	**Starch Production (mg/day)**
18	Low	0.03	Always Open	70	0.9
18	High	0.03	Always Open	70	1.0
18	High	0.06	Always Open	70	1.1
25	Low	0.03	Always Open	70	1.0
25	High	0.03	Always Open	70	1.2
25	High	0.06	Always Open	70	1.1
40	High	0.06	Always Open	70	0.6

a. Based on the information provided, state whether the unknown plant is a C3, C4 or CAM plant. Justify your response. (4 marks)

The plant likely uses the C3 pathway. The consistent starch production regardless of light intensity and a slight increase with higher CO_2 concentrations fits the profile of a C3 plant, especially given that the stomata remains open. ***Not a complete answer.***

He finds another plant!

Plant *B*

Temperature (°C)	**Light Intensity**	**CO_2 Concentration** (%)	**Relative Humidity** (%)	**Starch Production (mg/day)**
20	Low	0.02	70	20
20	High	0.02	30	20
20	High	0.04	30	20
40	Low	0.02	70	30
40	High	0.02	20	21
40	High	0.04	10	18

b. Based on the information provided, state whether the unknown plant is a C3, C4 or CAM plant. Justify your response. (4 marks)

The plant is likely a C4 species, as the increased starch production is observed at higher CO_2 concentrations with higher relative humidity, which may indicate C4 photosynthesis. See annotations for further solutions.

Space for Personal Notes

Question 31 (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)

Solution Pending

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

Solution Pending

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)

Any two of:

- Photosynthesis is regulated by enzymes.
- Enzymes have an optimum temperature.
- Enzymes may denature at high temperatures or activity is decreased at lower temperatures.
- The greater the rate of reaction the more growth will occur.

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)

Any two of:

- Green plants reflect green light OR do not use it for photosynthesis.
- Red light is used in photosynthesis OR increased availability of light for photosynthesis.
- More glucose is produced due to greater rate of photosynthesis.

Question 32 (8 marks)

Seedlings of three different plant species were exposed to three different environments to compare their growth in each environment. One of the three plant species was classified as a C3 plant, another as a C4 plant and the third as a CAM plant. The three environmental conditions were as follows:

Environment 1: 22°C with daily watering, exposed to natural light conditions.
Environment 2: 30°C with minimal water, exposed to natural light conditions.
Environment 3: 30°C with minimal water, exposed to 24-hour light.

The following results were observed after two weeks under these conditions.

Environment	**Observations After Two Weeks**		
	Plant *A*	**Plant *B***	**Plant *C***
1	The plant has grown and appears to be healthy.	The plant has grown and appears to be healthy.	The plant has grown and appears to be healthy.
2	The plant has grown and appears to be healthy.	The plant has only grown a little and appears wilted and unhealthy.	The plant has grown and appears to be healthy.
3	The plant has only grown a little.	The plant has only grown a little and appears wilted and unhealthy.	The plant has grown and appears to be healthy.

a. From the table of observations, identify each of the plants *A*, *B* and *C* as either the C3 plant, C4 plant or CAM plant. Give reasons for your answers, referring to their adaptations to different environments. (4 marks)

Solution Pending

b. Describe the role of RubisCO in photosynthesis and describe the effects of high temperatures on this process. (2 marks)

Solution Pending

c. Describe a limitation of the type of data collected in this experiment and suggest a modification of the investigation that may address this. (2 marks)

Solution Pending

Question 33 (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)

Question 3a (2 marks)	Answer:
Describe how the adaptations of *C. balonensis* maximise the efficiency of photosynthesis in a warm, arid environment.	• *In CAM plants, stomate are closed during the day to limit water loss.* • *CO_2 is fixed into a 4-carbon compound at night (when stomata are open) and then released during the day (when the stomata are closed) to allow for photosynthesis.* **Marking protocol:** One mark for each of the above points.

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

Question 3b (2 marks)	Answer:
Briefly describe the role of Rubisco in synthesising glucose in photosynthesis and outline how coenzymes are involved in this process.	• *Rubisco fixes the carbon (from CO_2) to make glucose.* • *Coenzymes (ATP and NADPH) from the light-dependent stage provide the energy and hydrogen atoms needed to do this.* **Marking protocol:** One mark for each of the above points.

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

Question 3c (2 marks)	Answer
Referring to the role of Rubisco, explain why photorespiration is more likely to occur at higher temperatures.	• *High oxygen levels can occur when plants close their stomata to reduce water loss at higher temperatures. Since the stomata are the means by which oxygen exits the leaf, this can result in a build-up of oxygen, increasing Rubisco's affinity for oxygen.* • *If oxygen levels are high and carbon dioxide levels are low, then Rubisco is more likely to bind to oxygen, which causes photorespiration. (Carbon dioxide also has lower solubility at high temperatures.)*

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

Question 3d (3 marks)	Answer
Like CAM plants, C4 plants are adapted to hot climates. Compare the process of photosynthesis in C4 and CAM plants.	• *In CAM plants, initial carbon fixation is separated from the rest of the Calvin cycle over time. In C4 plants, the initial carbon fixation is separated from the rest of the Calvin cycle over space, rather than time.* • *In CAM plants, during the night, the plants open their stomata to take in CO_2 and use it to produce glucose during the day when their stomata are closed. C4 plants have their stomata open during the day.* • *In C4 plants, initial carbon fixation occurs in a mesophyll cell and the rest occurs in bundle-sheath cells. In CAM plants, only mesophyll cells are involved.*

Space for Personal Notes

CONTOUREDUCATION

Website: contoureducation.com.au | **Phone:** 1800 888 300 | **Email:** hello@contoureducation.com.au

VCE Biology ¾

Free 1-on-1 Support

Be Sure to Make The Most of These (Free) Services!

- Experienced Contour tutors (45+ raw scores, 99+ ATARs).
- For fully enrolled Contour students with up-to-date fees.
- After school weekdays and all-day weekends.

1-on-1 Video Consults	Text-Based Support
Book via bit.ly/contour-biology-consult-2025 (or QR code below). One active booking at a time (must attend before booking the next).	Message +61 440 137 387 with questions. Save the contact as "Contour Biology".

Booking Link for Consults
bit.ly/contour-biology-consult-2025

Number for Text-Based Support
+61 440 137 387