22.1 Photosynthesis and limiting factors

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS photosynthesis • limiting factor

Objective

Photosynthesis and limiting factors. Original classroom practice for IB HL; not an official IB paper.

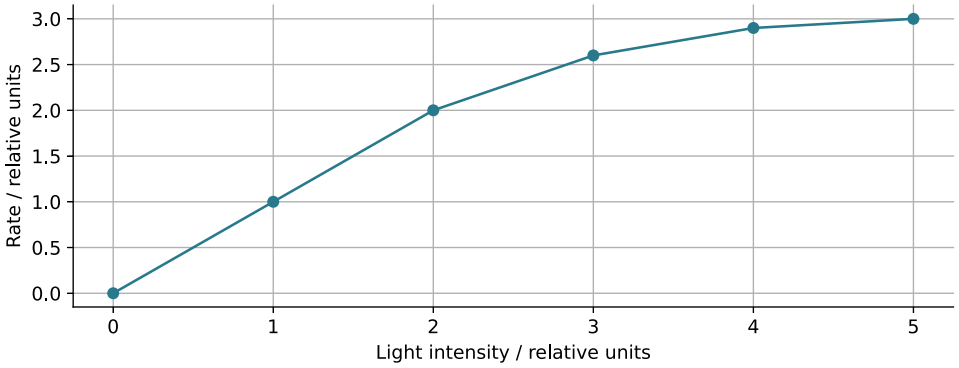
1 Key knowledge and worked examples

What would explain this observation?

- A brighter lamp does not always produce more oxygen from pondweed. Another factor may limit the process when light is already sufficient.

Build the model

- **Photosynthesis** transfers energy from light into chemical stores.
- Carbon dioxide and water form carbohydrate, releasing oxygen.
- Chlorophyll absorbs light; light intensity, temperature and carbon dioxide supply can affect rate.
- **limiting factor** : A factor whose shortage restricts rate.
- photosynthesis: Light-driven formation of carbohydrate.



Choose evidence that can test it

- Change only one factor when testing a limiting factor.
- At low light, extra light may increase rate.
- At a plateau, the changed factor is no longer the main limit in that range; the graph alone does not identify which other factor is limiting.

In the lab: Measure collected gas volume over a fixed time instead of assuming all bubbles have the same volume. Control temperature, plant size and carbon dioxide supply. Allow the plant to adjust before each reading and repeat.

Work from known quantities

- Known: 6.0 cubic centimetres of gas are collected in 3.0 minutes.
- Use rate = volume/time.
- Rate = 6.0/3.0 = 2.0 cubic centimetres per minute.
- Bubble counts can be a rough proxy, but bubbles of different size make comparisons less reliable.

Your turn: 9.0 cubic centimetres of gas are collected in 3.0 minutes. Find the rate.

Check the conclusion and its limits

- Moving a lamp changes light and may also change temperature.
- A photosynthesis experiment needs control of heating, not just a ruler.

Not true: All oxygen bubbles have exactly the same volume. Bubbles from pondweed vary in size and composition, so a bubble count is only a rough proxy for gas volume. Measuring collected volume, as in the calculation above, is more reliable.

Key:

- Photosynthesis transfers energy from light into chemical stores.
- Change only one factor when testing a limiting factor.
- Watch for: moving a lamp changes light and may also change temperature.

Write from a gas rate of 2.5 cubic centimetres per minute

- 10.0 cubic centimetres of gas are collected in 4.0 minutes.
- Find the rate. At a plateau, the factor you changed is no longer the main limit.

2 Practice

2.1 A rate-light graph reaches a plateau. What follows? Choose one answer.

- **A** Another factor may now limit the rate
- **B** Light is still certainly the only limit
- **C** Photosynthesis has stopped [1]

2.2 9.0 cubic centimetres of gas are collected in 3.0 minutes. Find the rate. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: Bubbles from pondweed vary in size and composition, so a bubble count is only a rough proxy for gas volume. [2]

2.4 A factor whose shortage restricts rate: write the technical term. [1]

3 Exam-style questions

3.1 A fictional plant produces 8 cm^3 in 4 min at low light and 12 cm^3 in 4 min at high light. Explain the change, and why an unchanged rate after a further light increase would not identify the next limiting factor. [4]

Solutions

2.1 A On the plateau, adding more light no longer raises the rate, so light is no longer the limiting factor; another factor such as carbon dioxide or temperature may now limit it. Photosynthesis has not stopped - the rate is constant, not zero.

2.2 rate=9.0/3.0=3.0 cm^3/min.

2.3 True. True. Bubbles from pondweed vary in size and composition, so a bubble count is only a rough proxy for gas volume. Measuring collected volume, as in the calculation above, is more reliable.

2.4 limiting factor. limiting factor means A factor whose shortage restricts rate.

3.1 Rates 2 and 3 cm^3/min, a50% increase. A plateau suggests another limitation under those conditions, but does not identify it. Control temperature and carbon dioxide, allow equilibration and repeat.