WJEC Wales Biology A Level

SP 3.2b: Effect of light intensity on the rate of photosynthesis

Practical notes

Introduction

Photosynthesis is a chemical reaction that takes place inside photosynthetic organisms (e.g. plants, algae) and converts **light energy** into **chemical energy**:

$$\text{carbon dioxide + water} \xrightarrow{\text{light}} \text{glucose + oxygen}$$

The rate of photosynthesis can be assessed using **hydrogencarbonate indicator** which changes colour depending on the **concentration of carbon dioxide** and the resulting **pH** of the solution:

pH	Low (Acidic)	Neutral	High (Alkaline)
CO_2 concentration	High	Atmospheric	Low
Colour	**Yellow**	**Red**	**Purple**
Rate	photosynthesis < respiration	photosynthesis = respiration	photosynthesis > respiration

Green algae immobilised in alginate beads to form '**algal balls**' are a good experimental material.

The rate of photosynthesis is influenced by different **factors** including temperature, light intensity, and pH. The effect of each of these factors can be determined by changing **one variable only**, and observing its effect on the rate of reaction.

Equipment

- 5 cm^3 green algae solution
- 3cm^3 3% sodium alginate solution
- 200 cm^3 calcium chloride
- Hydrogen carbonate indicator
- Distilled water
- 10 cm^3 syringe
- 2× 250 cm^3 beaker
- 5× 10 cm^3 vial
- Glass rod
- Mesh strainer
- 150 W light bulb
- Lamp
- Heat filter (e,g, water-filled container)
- Meter ruler
- Stopwatch
- Hydrogen carbonate indicator colour chart

Risk assessment

Hazard	Risk	Precaution	Emergency
Broken glass	Cuts	Keep glassware away from the edge of the desk	Dispose of broken glassware carefully; elevate cuts and apply pressure; do not remove glass from cuts; seek medical assistance
Lamp	Damage to eyes	Do not look directly at the light bulb	Seek medical assistance
	Burns	Do not touch the lamp whilst hot	Run burn under cold water; seek medical assistance
Calcium chloride solution	Irritation to eyes	Avoid contact with eyes; wear safety goggles	Flood eye(s) with tap water; seek medical assistance

Method

Making the algal balls

1. Add **5 cm^3** of the green algae solution and **3 cm^3** 3% sodium alginate solution into a beaker. **Stir** using a glass rod.
2. Using a **10 cm^3 syringe**, transfer the mixture **one drop** at a time into a 250 cm^3 beaker of **200 cm^3** calcium chloride solution. Algal balls will begin to form.
3. Leave the algal balls in the beaker for 5 to 10 minutes, until they become **solid.**
4. **Strain** the algal balls through a mesh strainer with distilled water.
5. Place the algal balls in a 250 cm^3 beaker of distilled water.

Experiment

1. Rinse each vial with hydrogencarbonate indicator before use.
2. Take 50 algal balls and 5 vials. Place **10** algal balls in each vial.

3. Completely fill each vial with hydrogencarbonate indicator solution.

4. Using the meter ruler, place each vial at a set distance from the switched-off light source: 20, 40, 60, 80 and 100 cm.

5. Note the **initial colour** of the hydrogencarbonate indicator in each vial.

6. Switch on the light source and immediately start the **stopwatch.**

7. After **30 minutes**, record the **colour** of the indicator in each vial using the colour chart. Record the results in an appropriate format (see below).

8. **Repeat** the experiment a further two times to obtain **three repeats** for each distance.

Variables

Independent variable

The variable that is **changed**.
i.e. the distance from the light source.

Dependent variable

The variable being **measured** whose value depends on the independent variable.
i.e. the colour of the hydrogencarbonate indicator.

Controlled variables

The variables that are kept **constant** during the experiment:

- Number of algal balls in each vial
  10 algal balls placed in each vial

- Length of time each vial is exposed to the light source
  Stopwatch used to time 30 minutes

- Light bulb power
  150 W light bulb used throughout the experiment

- Temperature
  Heat filter used to minimise the effect of heat produced by the light bulb

Results

Distance from the light source (cm)	Colour of the hydrogencarbonate indicator					
	Initial			After 30 minutes		
	1	2	3	1	2	3
20						
40						
60						
80						
100						

Conclusion

As the distance from the light source **increases** the hydrogencarbonate indicator turns **yellow**:

- Distance from light source increases
- Light intensity decreases
- Rate of photosynthesis decreases (light intensity becomes a limiting factor)
- Rate of respiration exceeds rate of photosynthesis
- Concentration of CO_2 increases
- pH decreases
- Solution turns **yellow**

As the distance from the light source **decreases** the hydrogencarbonate indicator turns **purple**:

- Distance from light source decreases
- Light intensity increases
- Rate of photosynthesis increases
- Rate of photosynthesis exceeds rate of respiration
- Concentration of CO_2 decreases
- pH increases
- Solution turns **purple**