An Investigation Into The Factors Affecting The Rate Of Photosynthesis

Aim

The aim of this investigation is to find out which factors determine the rate of photosynthesis in pondweed.

Equipment List & Diagram:

- Sodium Hydrogen Carbonate
- Lamp
- Scales
- Beaker
- Photosynthometer
- Water
- Spatula
- Stop Clock
- Pondweed (Elodea)
- Retort Stand with Clamp

Possible Variables:

The key variables that may determine the rate of photosynthesis are:

- Light Intensity – The lamp's distance from the beaker containing water shall be varied.
- Concentration of CO^2 - Sodium Hydrogen Carbonate ($NaHCO^2$) shall be added to the H^2O in the beaker. Amounts of $NaHCO^2$ shall be varied.
- Temperature – This is not an option in this investigation because altering the temperature may denature the plant's enzymes, thus killing the pondweed.

Measurements:

The following measurements will be taken during the experiment:

- Amount of $NaHCO^2$ (g)

- Light Intensity (calculated via the formula $1/d^2$)
- Time Taken (secs/mins)
- Amount of O^2 Given Off By Plant

The results of the experiment will be recorded in a simple table.

Prediction:
I predict that as the amount of $NaHCO^2$ increases there will also be an increase in the amount of Oxygen (O^2) given off. This is because when the $NaHCO^2$ is added, the amount of Carbon Dioxide (CO^2) increases. Therefore the pondweed will respire more quickly than before the $NaHCO^2$ was added, taking in more CO^2 and giving off more O^2.

Scientific Theory:
Photosynthesis is the "[combination] of organic compounds from carbon dioxide and water (with the release of oxygen) using light absorbed by chlorophyll." [***COLLINS ENGLISH DICTIONARY***]

Here is the formula for **photosynthesis:**

Carbon Dioxide + Water $\xrightarrow{\text{Sunlight}}$ **Energy + Oxygen**

$6CO^2$ H^2O $\xrightarrow{\text{Sunlight}}$ **$C_6H_{12}O_6$ $6O^2$**

From the above formula we can see that as the plant takes in more carbon dioxide and water it produces more oxygen and energy. This is similar to human respiration, except we take in oxygen and give out carbon dioxide to produce energy.
In this experiment the $NaHCO^2$ increases the amount of carbon dioxide in the solution. Therefore more carbon dioxide molecules diffuse into the plant than before the $NaHCO^2$ was added. The CO^2 molecules pass through the plant's pores, letting the plant photosynthesise at a higher rate.

Preliminary Work:
Before carrying out the main experiment I proceeded to take preliminary results to ensure that my measurements are appropriate and that my readings are accurate. Here is a brief table of my preliminary results:

Amount of $NaHCO^2$ (g)	Bubble size of O^2 (cm^3)	Light Intensity ($1/distance^2$)
0	0.8	¼
0.5	1.6	¼
1	1.8	¼
1.5	2.0	¼
2	2.1	¼
2.5	2.0	¼

This table of brief results shows that the measurements were accurate and most appropriate. As we can see, as the amount of $NaHCO^2$ rises, the rate of O^2 given off increases until too much $NaHCO^2$ is added, in which the bubble size levels off and slightly decreases – probably due to there not being enough room for all of the CO^2 molecules to diffuse into the plant.

Method:
After setting up the experiment and placing the pondweed in the water filled beaker (100ml), attached to the photosynthometer (as shown in the diagram), I will push up the syringe to release air from the photosynthometer. When all this has been done I shall place the lamp 20mm away from the beaker and switch it on, pointed at the Elodea.
When all of this is set up I can begin taking experimental readings. Using a stopwatch I will time 3 minutes. After 3 minutes is up I shall measure the amount of air bubbles (oxygen) in the photosynthometer. After I have recorded these results I shall pull up the syringe again so it sucks up these air bubbles.
I will then repeat this, but now I will add specific amounts of Sodium Hydrogen Carbonate. The specific amounts will be 0.5g, 1g, 1.5g, 2g & 2.5g – all weighed out on scales before being added to the water solution and stirred in with the spatula.
To ensure quality results I shall repeat the whole procedure twice, thus I shall carry out the experiment 3 times. After collecting these results I shall calculate averages for each different amount of sodium hydrogen carbonate and present all this in a table.

Safe Testing:
To ensure that the test it safe I shall only have the lamp switched on whilst readings are being taken during the experiment, so this lowers the risk of someone burning themselves on the bulb.

Fair Testing:
To ensure that the experiment is fair I shall keep the light intensity the same, so that this does not affect the rate of photosynthesis. I shall also enforce only one variable, this being the amount of Sodium Hydrogen Carbonate ($NaHCO^2$) added to the water surrounding the Elodea (pondweed).
The temperature will also be kept at room temperature, which will not dramatically change, therefore this will not alter the results in any way.
Also I will ensure that the same volume of water is kept in the beaker ($100cm^3$), so that the concentration levels of $NaHCO^2$ can be determined.
Also, to make sure I have not recorded too many anomalies in the first experiment, I shall repeat the experiment twice.

Table of Results:

Amount of $NaHCO^2$(g)	**Light Intensity ($1/d^2$)**	Amount of O^2 given off from photosynthesis(cm^3)			
		1	**2**	3	**Average**
0	¼	1.2	**1.0**	1.1	**1.1**
0.5	¼	2.8	**2.9**	2.8	**2.8**
1	¼	4.3	**4.4**	4.2	**4.3**
1.5	¼	4.6	**4.3**	4.1	**4.3**
2	¼	4.8	**4.4**	4.1	**4.4**
2.5	¼	4.2	**4.0**	4.1	**4.2**

- The light intensity is always ¼ because the formula to work this out is $1/d^2$. The distance is 2cm and $2cm^2$ equals 4cm. Therefore the light intensity is ¼.
- On the next page is a graph, that presents the average of each amount of $NaHCO^2$.

Conclusion:
From my results I can see that up until 1.5g of sodium hydrogen carbonate has been added, the rate of photosynthesis increases. However after 1.5g has been added the rate of photosynthesis stays the roughly same, until over 2g is added in which the rate slowly decreases.

The rate of photosynthesis changed due to the amount of light omitted by the lamp, the amount of carbon dioxide present in the air and the amount of sodium hydrogen carbonate added. As the $NaHCO^2$ was added with the water, in the beaker, it reacted to give off carbon dioxide, which then diffused into the plant allowing photosynthesis to occur at a higher rate.

As more $NaHCO^2$ was added, more carbon dioxide was given off when it reacted with the water. Therefore, with more carbon dioxide now entering the plant, it will photosynthesise at a higher rate, producing more oxygen and glucose. But when too much carbon dioxide is trying to enter the plant the rate of photosynthesis will decrease, because the level of glucose in the plant is very high and the plant has no room to produce anymore.

Evaluation:
Over all I believe that the investigation went to plan and the readings and measurements I took were accurate and consistent. There were no anomalies, from the 3 experiments, which shows that I must have being carrying out the procedure well.

The experiment perhaps could have been more accurate if the light intensity had been kept the same, which is hard when working during the day. I believe though that given the circumstances, I kept the light intensity as accurate as possible.

Also, the photosynthometer is very small and it is hard to make out the oxygen bubbles with it. If I were to have used a burette I would have been able to spot more oxygen bubbles and therefore take more accurate readings. Also, the gas given off causes the amount of water in the burette to decrease – displacing the water in effect – which makes it easy to measure the amount of gas given off.

To extend the investigation I could practise more variables, such as altering the distance of the lamp from the beaker (light intensity) and change the temperature by heating the beaker in which the elodea is in. I could also alter the size/surface area of the pondweed to see if this affects the rate of photosynthesis.