How the molar concentration of $NaHCO_3$ (Sodium Hydrogen Carbonate) affects the rate of photosynthesis in Elodea.

In the experiment I am conducting, I will attempt to discover how the molar concentration of $NaHCO_3$ affects the rate of photosynthesis in Elodea by setting up simple equipment, recording the results as well as attempting to draw some conclusions from my results. I will be looking to find if a relationship/correlation exists between the concentration of $NaHCO_3$ and the amount of bubbles produced during a set duration.

Factor chosen:
I shall vary the molar concentration of $NaHCO_3$ (Sodium Hydrogen Carbonate) in order to change the concentration of available CO_2.

My variables:
In my experiment, my dependent variable will be the amount of oxygen produced, my independent variable will be the concentration of $NaHCO_3$ and my control variable will be light intensity/distance of lamp from Elodea as well as temperature.

Amount of oxygen produced: - the amount of oxygen produced will increase or decrease according to the strengths and amounts of the other factors. Oxygen is created as a result of photosynthesis along with glucose, and this oxygen will be present in the form of a bubble which I will attempt to count.

Concentration of $NaHCO_3$:- It gives out carbon dioxide, and when it is heated at relatively high temperatures, it gives out even more carbon dioxide. The greater the concentration, the more carbon dioxide will be produced thus more oxygen will be produced as a result of photosynthesis. I will vary this variable so that I can discover if there is a proportional relationship between this and the amount of oxygen produced as a result of photosynthesis.

Light intensity:- if the light intensity is increased, the number of bubbles produced by the Elodea will also increase which is why I have to make sure that it remains constant, so as to produce more accurate results.

I will make sure that the lamp remains at the same distance from the Elodea by marking its position with a pencil. I will also make sure that the temperature remains the same by checking it from time to time and if it is above I will let it drop and if it below I will heat it to the desired level.

Prediction:
I predict that if the molar concentration of $NaHCO_3$ (Sodium Hydrogen Carbonate) is increased; the number of bubbles which will appear will also increase.

I further predict that if I double the molar concentration of $NaHCO_3$ (Sodium hydrogen carbonate) the number of bubbles will increase by approximately 25%.

Justification of prediction:

The bubbles are produced as a result of photosynthesis (oxygen is produced) and the equation for photosynthesis is:-

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

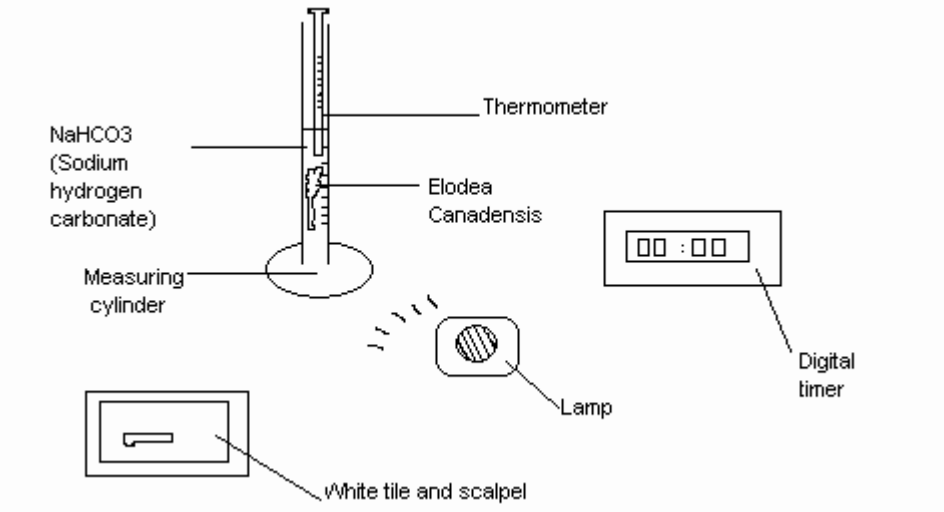
Carbon Dioxide + Water → Glucose + Oxygen

This equation for photosynthesis shows that carbon dioxide, water, glucose and oxygen are all related- thus if you increase one side, the other will also increase. When the molar concentration of $NaHCO_3$ is increased, there should be more carbon dioxide available. As a result of this, (because of the added carbon dioxide) there should be more oxygen formed, thus there should be a greater number of bubbles.

I predicted that the number of bubbles will increase by 25% when the molar concentration of $NaHCO_3$ is doubled, because I feel that the doubling of the molar concentration of $NaHCO_3$ will not result in the doubling of the amount of carbon dioxide produced thus it will not result in the doubling of oxygen produced so I predicted that it would increase by in-between 0% and 50% (25%).

Method:

Diagram of my proposed set-up:



List of apparatus:

- Distilled water
- Large supply of $NaHCO_3$
- Metre ruler
- Elodea/Canadian pondweed
- Two measuring cylinders
- Digital timer
- Lamp
- Thermometer
- Scalpel
- White tile
- Paper clip

Experimental procedure:

1. I will gather all the equipment I needed (stated above).
2. I will pour 100ml of 0.2M $NaHCO_3$ into a measuring cylinder.
3. I will take one branch of Elodea and place it on a white tile and cut it at a 45^o angle so that the bubbles will be able to be released into the $NaHCO_3$.
4. Then, I will place a paper clip on the Elodea so that it stays at the same place (the water pressure is different at different heights, which may affect the rate of photosynthesis very slightly).
5. I will turn on the lamp and the timer simultaneously, with a thermometer placed in the solution.
6. I will then count the number of bubbles that appear during thirty seconds and record it down and continue to record it for three minutes whilst glancing over from time to time to check if there has been any temperature change.
7. Then, I will make my $NaHCO_3$ concentration 0.1M by removing half the amount of $NaHCO_3$ and adding this same amount of distilled water and stirring it (measuring the amount of water and sodium hydrogen carbonate with two separate measuring cylinders).
8. I will then repeat steps 3-4 for this concentration, until I have finished recording the number of bubbles that appear for all the concentrations I will use.

-I will use six different molar concentrations of $NaHCO_3$ (0.2M, 0.1M 0.05M, 0.025, 0.01M and 0M).

-I will record the number of bubbles that appear for three minutes instead of recording the number of bubbles for one minute, then repeating twice because there shouldn't be much of a change as the light intensity remains constant and there isn't much of a temperature change as I have learnt from a preliminary experiment I have done in which there was only a 0.5^0C temperature change in three minutes. Also, I will instead of tallying the number of bubbles which appear (which I did in a preliminary experiment), I will just attempt to count the number of bubbles mentally as I discovered that it would be impossible or incredibly inaccurate to tally as well as observe the bubbles.

-With these three different readings for each concentration, I will be able to have a more accurate

average. If I do have the time I will repeat my experiment and take as many readings as I can so that I can achieve more accurate results.

-I will be using a digital timer instead of a clock/watch so that the results will be more accurate.

-The possible hazards present are the possibility of contact with $NaHCO_3$ with the eyes or other sensitive areas. To prevent this from happening I will wear safety goggles in carrying out this experiment.

Results:

$NaHCO_3$ Concentration (M)	Time taken (seconds)	Number of bubbles (3 results)	Total number of bubbles	Temperature (^0C)
0.2	30	94,84,79	250	32
	60	103,92,111	306	32
0.1	30	71,78,74	224	32
	60	82,84,94	260	32
0.05	30	62,98,88	248	32
	60	82,88,94	254	32
0.025	30	48,90,84	222	32
	60	94,86,89	269	32
0.01	30	7,8,7	22	32
	60	6,7,7	20	32
0	30	0,0,0	0	32
	60	0,0,0	0	32

In general:

$NaHCO_3$ concentration (M)	Total number of bubbles produced
0.2	556
0.1	484
0.05	502
0.025	491
0.01	42
0	0

$NaHCO_3$ concentration (M)	Average number of bubbles produced in one minute
0.2	92.8333
0.1	80.5000
0.05	85.3333
0.025	81.8333
0.01	07.0000

0	0

The range of my concentrations is from 0M to 0.2M, the range of the total number of bubbles produced is 0-514 and the range of the average number of bubbles produced in one minute is 0-92.8333. Mathematically, the range of the total number of bubbles is 556 and the range of the average number of bubbles produced in one minute is 92.8333 but these ranges are unreliable because the differences between the numbers are too irregular.

Analysis and conclusions:

In my experiment, I have discovered that the molar concentration of $NaHCO_3$ does affect the rate of photosynthesis in Elodea and that if you increase the molar concentration of $NaHCO_3$ the number of bubbles produced does increase as predicted with only one exception/inaccuracy present.

In the following graph, it is clear that there is a general pattern that backs up this fact (that as the concentration of $NaHCO_3$ is increased, the number of bubbles produced also increases). Using the table above, the existing relationship is clear with the only exception to the pattern occurring in the number of bubbles produced when using a 0.1M concentration of $NaHCO_3$.

Using the table above, if you double the concentrations the increase of the number of bubbles is from, 491-502 and 484-556. This results in a 2.24% and a 14.87% increase, resulting in an average percentage increase of 8.555%. This makes my prediction at the beginning quite a way off the mark. I think my prediction was off the mark because I overestimated the amount of carbon dioxide which would be given off by $NaHCO_3$. Also, my results indicate that as the concentration of $NaHCO_3$ is increased, the rate of photosynthesis also increases resulting in more oxygen being produced, thus more bubbles.

(Percentage increase in this case = $\frac{\text{final quantity} - \text{initial quantity}}{\text{initial quantity}}$ then multiplied by 100).

Evaluation:

The anomalous result could be due to human inaccuracy and lack of advanced equipment.

Additionally, at high carbon dioxide concentrations it has been noted that there may be a vigorous giving-off of gas bubbles which is actually carbon dioxide and not oxygen.

In the procedure I have used, accuracy was a problem. I feel that I measured my results as accurately as possible but doing this experiment by myself meant that it was sometimes difficult to look at the timer and check the temperature occasionally whilst attempting to count the number of bubbles which appeared all at the same time- which undoubtedly led to some of the inaccuracies of my results. Also, the task of trying to count the number of bubbles by sight was incredibly difficult considering the rapidity with which they appeared. Also, in my procedure, I did not take into account the volumes/sizes of the bubbles which could have had a considerable effect on the accuracy of my results, for instance ten large bubbles could have easily be counted as seventy small bubbles). The apparatus for measuring the volume of these bubbles (such as a micro-burette) was not available and because the experiment was conducted by me alone, I was not able to do so many things simultaneously. So in general, the accuracy of each measurement could have been improved by the assistance of others and the availability of advanced equipment.

The reliability of my results is varied. The pattern I have concluded which exists may only exist for my range of concentrations which are relatively low. Possibly, there could be a maximum number of bubbles/oxygen produced due to other limiting factors. I think that all of my results are quite reliable besides one inaccuracy which could have affected the overall accuracy of the experiment. I still feel that my results warrant some proof that there is a general pattern regarding the concentrations of sodium hydrogen carbonate and the rate of photosynthesis.

If I were to suggest any improvements, I would definitely have repeated every one of my inaccurate results (which I couldn't do because of the lack of time) twice, I would have selected "the greenest and healthiest shoots", and attempting to avoid storing Elodea in vessels of water which have been known to restrain photosynthesis as noted by Blackman.

Also, I would have tried using more concentrations of sodium hydrogen carbonate, especially the ones in-between the concentrations I used so that I can achieve a greater line and accuracy on my graph.

To investigate further, if it were possible I would repeat this same experiment with more advanced equipment, with several repetitions to achieve greater accuracy and with more concentrations in order to improve the conclusions I have drawn from this experiment.