AT1: Photosynthesis and Limiting Factors

Aim:
In this experiment, I will test to see how heat affects the rate of photosynthesis in a water plant as a limiting factor.

Background Knowledge:
Photosynthesis is the process by which chlorophyll containing organisms, (namely green plants, algae, and some bacteria), capture energy in the form of light and convert it to chemical energy. Virtually all the energy available for life in the earth's biosphere, (the zone in which life can exist), is made available through photosynthesis.
A generalized chemical equation for photosynthesis is:
Carbon Dioxide + Water + light energy = Sugar (Glucose) + Oxygen + Water

This can be seen as two different chains of reactions…
One involves the transfer of light energy into chemical energy that is light intensity dependant - if it is lighter the reaction happens more efficiently.
The other shows the creation of glucose and is heat dependant. The glucose is created by carbon dioxide and water, and the reaction is powered by the chemical energy converted from solar energy. The carbon dioxide must be broken down using enzymes to form the basics of the glucose. This is heat dependant because enzymes work better at higher temperatures. This creates glucose ($C_6H_{12}O_6$) and waste products, oxygen (O_2) and a little water (H_2O).

Artificial Photosynthesis
If chemists were able to duplicate photosynthesis by artificial means it would result in systems having enormous potential for tapping solar energy on a large scale.
Much research is now being devoted to this effort. An artificial molecule that remains polarized sufficiently long enough to react usefully with other molecules has not yet been perfected, but the prospects of this are promising.

Prediction:
I predict that more heat will increase the rate of photosynthesis.
I predict that at 0°C there will be few bubbles and at around 40°C, it will be at its peak. After 40°C the rate of photosynthesis will again drop. I can show this in a simple graph:

I think this because the enzyme that breaks down the carbon dioxide stops working or is even obliterated by temperatures over 40°C as shown in my background knowledge. When the enzyme stops working the carbon dioxide is not broken down, so less glucose and oxygen are produced.

Apparatus List:
Boiling Tube
Elodea (Canadian Pondweed)
Water
Thermometer
Lamp
Ruler
Ice
Beaker Kettle (Boiling Water)

Method:
To show how I will assemble the equipment for this experiment I will draw a diagram.

Diagram:

I am going to count the bubbles at each level of heat for 2 minutes and see if there is any relationship between my results. The temperatures I will use are 0°C, 10°C, 20°C, 30°C, 40°C, 50°C and 60°C.
I am counting the bubbles because I think that if there are more bubbles then the rate of photosynthesis is increased, because the bubbles are oxygen and the more oxygen the plant is giving off the higher the rate of photosynthesis.
To make sure that any bubbles are not missed there will be 2 counters of bubbles to get a precise measurement.

Variables
Input: - I will change the temperature of the water that the plant is in by adding ice or hot water.

Control: - I will keep the light intensity the same by measuring the space between the lamp and the pondweed before each test. If the light intensity changes, the rate of photosynthesis would be affected, because light is a factor which photosynthesis relies on and if there is a high light intensity it increases the rate of photosynthesis because the energy from the light source would increase the rate.
I will also keep the amount of carbon dioxide in the water constant by changing the water after each test. If there is too little carbon dioxide in the water then the rate is decreased because the plant has no carbon dioxide to use in the photosynthesis reaction.
I will keep the plant the same length of 5cm and the same species of pondweed (Elodea).

Outcome: - I will measure the temperature of the water with a thermometer to get an accurate fair temperature for the plant to be in. I wil l also count the number of bubbles that the plant gives off.

To keep it fair I will obey the variables and do the test at each temperature 3 times to clear any anomalous results. This will be so that if are any anomalous results then I can reject them wit hout creating a gap in my results.

To keep this experiment safe I will mop up any water that I drop near the lamp or plug to stop any chance of electrocution. I will also keep in mind the heat that the lamp generates so I will be careful to not touch it.

Results

Temperature	Number of bubbles			
	1st test	2nd test	3rd test	Average
0 C	2	3	3	2.7
10 C	3	5	5	4.3
20 C	5	7	9	7
30 C	12	11		11.5
40 C	16	17	20	17.7
50 C	6	4	5	5
60 C	0	1	0	0.3

Firstly, I am going to discard the third test re sult for 30°C because it is clearly an anomalous result. It occurred because there was someone interfering with our lamp, disallowing the light to reach our plant. It may have also occurred if we forgot to change the water of the plant after the first day into the second day of testing.

Graph of Results:
The graph shows what my predicted graph showed; the rate of photosynthesis peaks at 40°C. The red line shows the average excluding the anomalous result.
The rate of photosynthesis drops before and after 40 °C because 37·5°C is the optimum temperature that most enzymes work at before they are destroyed.

Conclusion:
This experiment proved my prediction by showing that as the temperature rose so did the numbers of oxygen bubbles. The results and the graph show that the peak rate of the photosynthesis reaction was at 40°C and after 40°C the rate dropped significantly. It dropped because, as I predicted, the enzymes were obliterated decreasing the amount of carbon dioxide being broken down, which in turn caused a decrease in the amount of oxygen produced and thus reducing the rate of photosynthesis. This shows that heat is a limiting factor because as it exceeds 40°C the rate of photosynthesis decreases.

Evaluation
This is a very simple experiment and although I can draw a conclusion, it may be inaccurate because it is a very unstable environment, for example; the air temperature may have increased, because there were many other students also doing the experiment that led to increasing water temperature. The room also was not completely dark. Apart from our lamp; light from other experiments and gaps between blinds and windows could have voided the

test. The anomalous result can be explained because of these or because we forgot to change the water in the test tub e. Because of these reasons, the anomalous result and the possibility that the results could have been inaccurate, I do not think it shows a good representation of the rate of photosynthesis.
Therefore, I think that I can improve this experiment a lot. Fir stly, I think that the control of the environment should be improved; the best way of doing this would be to go to a dark room, sealed off from light. I would be on my own and the room would need good ventilation. Secondly, I think that the experiment itself had serious flaws. Counting bubbles is a rudimentary method of measuring. It would be better to use displacement of water as a measurement. This way I could measure in ml instead of bubbles that could be different sizes. It would look like this:

The larger beaker is so that there is always water to give up its oxygen to the plant. With this more advanced apparatus, all I need to do is find the difference between the amount of water in the beaker at the start and at the end. I would also do the experimen t for longer, for 30 minutes because otherwise there would not be enough collected oxygen to show for anything. This new experiment does not have the rudimentary form of miscounting any bubbles. Also, I would have a larger, 10cm piece of weed. This would provide a more stable and reliable set of results as the measurement method is more accurate and can be measured by volume. With this information, I could draw up a more detailed, reliable and accurate conclusion because I would have superior results and I could use this experiment as a precursory experiment.