GCSE SCIENCE INVESTIGATION: PHOTOSYNTHESIS & LIGHT INTENSITY

Aim:
The aim of this experiment is to investigate how the intensity of light will affect the rate of photosynthesis in Kabambe (pondweed). To do this, Kabambe was placed in varying light intensities to test the amount of bubbles given off from a cut end to show the rate of photosynthesis occurring.

Intro:
Photosynthesis occurs only in the presence of light, and takes place in the chloroplasts of green plant cells. Photosynthesis can be defined as the production of simple sugars from carbon dioxide and water causing the release of sugar and oxygen. The chemical equation for photosynthesis can be expressed as: (light) $6CO2 + 6H2O = C6H12O6 + 6O2$ (in the presence of chlorophyll). Now from most experiments involving photosynthesis it has been seen that without light, the plant or organism will most certainly die. This is to rule out one null hypothesis that without light, no photosynthesis will take place. Light intensity affects the rate of photosynthesis because firstly a change in value would directly change the balancing factor of the equation, as stated above, therefore raising a output of the equation, e.g. most light would need more carbon dioxide and water to increase the amounts of glucose and oxygen, without there will be a limiting factor to the amount of light that can be put into the input part of the equation before photosynthesis cannot occur in an structured environment. But more importantly, energy (from the sun) falls onto the leaf of a plant which traps it into the chlorophyll, and uses it for chemical reactions within the plant, therefore more energy going into the plant, the more energy is available for chemical reactions, and more photosynthesis can occur. This can only suggest one prediction.

Prediction:
I predict that the higher the light intensity, the higher the rate of photosynthesis, hence, the closer the lamp is to the Kabambe, the more bubbles will be produced. However, I also predict that if the level of light intensity reaches a certain level, the rate of photosynthesis will stop, because there will be too much heat being produced from the lamp. So in essence, I predict that there is a maximum amount of light intensity that can produced to ascertain a rate of photosynthesis. But that does mean that the maximum amount of light that is produced equals the maximum amount of photosynthesis that can occur, because I predict that the maximum amount of light intensity (before heat begins to become a damaging factor) may produce X amount of bubbles, in the correct environment, with more water, and carbon dioxide, the maximum rate of photosynthesis will be Y (a greater value).

Diagram of Apparatus:

Method:
A 50ml beaker was taken. It was filled to the top with water (H_20). 50cm^3 of sodium hydrogen carbonate (Na(OH)) was then added to it. Next, a 5cm piece of Kabambe plant was weighted to the bottom of a test tube, upside down with a cut shoot facing upwards (towards the bottom of the test tube). The test tube was then filled to the top with water, a piece of paper towel used to keep water sealed in it with no air gaps, and placed inverted into the beaker, the piece of paper towel then removed underwater. Next, a lamp was placed at a given distance away from the beaker. When the first bubble appeared, the stopwatch was started, timing for one minute the amount of bubbles that appeared. The results were then recorded.

Preliminary:
A preliminary experiment was carried out to determine a suitable range of data collection. This needed to be done to ascertain firstly what would be a suitable time range to determine if photosynthesis was occurring, secondly to find what distance from the beaker was a sensible range to show light intensity changes, and thirdly to decide the increment in distance from the beaker to the maximum distance away from the beaker. The preliminary experiment was not entirely accurate enough due to the experiment mainly being carried out for measurement boundary findings and checking that the process of the experiment was correct. The preliminary however, did give a range of recordings which were used to make a graph which later could be compared to the main experiment. It also gave a chance for trends to be identified, thus venturing into analysis of pre-conclusion and hypothesis

truth. Methodology is not necessary for the preliminary experiment as it was the same for the main experiment, however, a set of results were recorded and as seen below a graph was constructed from these results.

Data Ranges:
From the preliminary experiment the data ranges were decided. Firstly, and most obviously the data that needs to be recorded is the amount of bubbles within a chosen time frame. This will be done from the first bubble that appears, and the minute following the first bubble will be recorded. E.g. if the light is 20 cm away, when the first bubble shows, the stopwatch will be started for one minute, with all bubbles within that minute being counted and recorded. The preliminary experiment also showed that repeats need to be done, so the main experiment will be repeated twice (as time permits any further experimentation), and an average will be made at the end, of which the graphs will be produced with. However, the preliminary experiment was only conducted once.

Preliminary Results:
From the preliminary experiment, the correct ranges were able to be produced, thus the preliminary experiment did what was required. This was all that was necessary, however from this preliminary it was simple and effective to simply find a trend and state the truth of a hypothesis on this. But the preliminary was simply a counting experiment, e.g. the bubbles that were produced were just counted. In the main experiment the graph from the results of the preliminary will be able to be used in conjunction to that of the main experiment to show a correlation between the two, to state whether or not the size of the bubbles actually do cause a major difference, or if the size of the bubbles does not really matter that much overall. The results from the preliminary are as follows:

DISTANCE FROM BEAKER (CM)	LIGHT INTENSITY ($1/D^2$)	AMOUNT OF BUBBLES
40	1/160 = 0.00625	029
30	1/090 = 0.01000	039
20	1/040 = 0.02500	060
10	1/020 = 0.05000	080
00	1/100 = 1.00000	102

This is displayed in the graph as follows:

Obtaining Evidence

As decided in the preliminary experiment, the main experiment was only carried out twice; these have been added to the table below, and the average given. O.4a O.6a

DISTANCE FROM BEAKER (CM)	LIGHT INTENSITY	1ST REPEAT	2ND REPEAT	AVERAGE
40	0.00625	032.0	030.0	031.0
30	0.01000	041.0	040.0	040.5
20	0.02500	060.0	059.0	059.5
10	0.05000	074.0	079.0	079.0
00	1.00000	096.0	105.0	101.5

O.8a O.4b O.6b

A graph has also been produced to show the distance from beaker against the average amount of bubbles produced. A best fit curve has also been shown on it.

Analysis:

From the above table it is seen that firstly, the further the lamp is away from the beaker, the lower the light intensity (based on the equation "Light Intensity = $1/d^2$"). Secondly, as a basic analysis of the results, it is seen that the higher the light intensity, the more bubbles are produced. Also, it appears that the results are constant, they do not have much different from the 1st and 2nd repeats, apart from the last one of which there is a fast rate of photosynthesis, and due to possible human error, an anomaly has occurred, but this still coincides with a steady increase in photosynthesis rate as light intensity increases.

From the graphs which have been produced it can be seen that the best fit line is of a curve, this is due to the points being in an obvious curvature shape. This shows that the amount of photosynthesis occurring increases as the light intensity increases and visa versa. This happened because when the lamp was moved closer towards the beaker, more energy was able to go into the Kabambe plant, thus increasing the amount of chemical reactions taking place. Now due to the high amounts of carbon dioxide in the water (due to the sodium hydrogen carbonate), there was ample amounts of carbon dioxide available to convert into oxygen, at the same time there was a high presence of water available (another major factor involving the healthy rate of photosynthesis occurring). When the lamp was moved closer, this increase in chemical reactions converted the carbon dioxide into oxygen, thus creating the bubbles which were the resultant data for the experiment. This in turn shows that the increase in light is directly proportional to the increase in photosynthesis. This in turn shows that my graphs support my predictions fully, including my hypothesis that the high the rate of light intensity, the higher the rate of photosynthesis. However, a limiting factor

has not necessarily been shown on the graphs, and therefore it cannot be said that there is a definite limiting factor shown within this experiment. However, the graphs do not show a point at which the plant stops photosynthesizing, and from past experiments it has been shown that when a plant is put into a place without light, it may turn yellow due to lacking of chlorophyll and becomes very long and elongated where the plants grows to try and find light sources. This shows aswell that a plant needs light for it to be healthy, but also shows that there may not be an exact limiting factor to the minimum amount of light intensity. E.g. it cannot be said that when light intensity reaches X (0.0001 for example), photosynthesis does not occur. Also it cannot be said at which point photosynthesis stops due to too much light intensity, as this was not tested. However, if the light increases, the heat increases also. This would lead to the predicted conclusion that if the light intensity reaches such a high level, the plant cannot photosynthesize due to the burning on the plant, which would break down the chemical reactions taking place within the plant.

Evaluation:

I think my experiment went well overall. The prediction that I made at the beginning was clearly shown to be accurate, and although limiting factors were difficult to make, some were found and it can be seen what the overall conclusions were. There were however many points in this experiment which were inaccurate these mainly were in the preliminary, but the purpose of the preliminary experiment was simply to find a suitable set of ranges for the purpose of the main experiment. There were a few major inaccuracies during the main experiment. The first of which was the anomalous measurements which were taken from the side of the beaker (nearest to the lamp), up to the front of the lamp. This meant that there was a possible difference of 5-10cm in each measurement. This may have affected the readings for the graphs, and if possible the experiment should be repeated with the correct readings being taken. Secondly, the background light was not at a light intensity of zero. This meant that it was possible for photosynthesis to occur without the lamp even being on. It is near impossible to produce an atmosphere were only the internal energy sources are being used to fuel the plant (e.g. the energy in the light being shone onto the beaker, and the carbon dioxide being produced from the sodium hydrogen carbonate). This may have changed the shape of the graph also. Another anomaly was the amount of sodium hydrogen carbonate used. At the start of each repeat, the amounts should have been weighed to make it a fair test, but instead a rough 50cm3 was added to the solution which may have meant that the repeats may have differed, but as it happens there was not much fluctuation in this, and the repeats are near exactly the same. These various inaccuracies show that although the experiment was sound, there are various methods in which the experiment can be carried out with more exact detail, providing more truthful data. However, due to limited time and equipment, the experiment was conducted in the best way possible

given the situation. This was good enough to support my hypothesis, and to finalize a conclusion. Of course, the easiest way to produce more accurate results would be to take many repeats of the experiment, and in a longer time span, of which would give more time to correct the inaccuracies. Also, this experiment has been able to show the rate of photosynthesis against light of a full spectrum of colors. It would be interesting to investigate the rate of photosynthesis again varying colors, and to see if different colours contain varying amounts of energy. It would also be interesting to investigate the rate of photosynthesis when additional solvents are added to the water, and to see which solvents affect the rate of photosynthesis, this could also lead to investigating the optimum pH level for photosynthesis to take place.