Light Intensity on the rate of photosynthesis

Photosynthesis:

Plants are autotrophic nutritious, which means that they produce their own food. They do this by a process called photosynthesis by which chlorophyll containing organisms (green plants) - capture energy in the form of light and convert it to chemical energy to form complex substances from carbon dioxide and water. Virtually all the energy available for life, in the Earth's biosphere, which is the zone in which life can exist; is made available through photosynthesis.

Photo means light and synthesis means to manufacture.
Using energy from the sun, cells in the leaves turn simple materials into energy rich food. Water, carbon dioxide and other minerals are the inorganic substances, which the plants use to tun into carbohydrates, fats, proteins and vitamins. The process takes place in chloroplasts. These are special structures in the leaves. A leafs skin is the upper epidermis, beneath this lies the palisade cells which are chief food producers. Spongy cells are partly surrounded by pockets of air, which enable the cells to exchange gases with the atmosphere. There are small openings called stomata, under the leaf in the lower epidermis. Veins in the leaf carry water and nutrients from the roots around the leaf. Carbon dioxide enters through the stomata. Cells in the palisades and spongy layer contain chlorophyll, which helps to absorb and trap energy from the sunlight, which helps to convert light energy into chemical energy. Carbon dioxide combines with water and photosynthesises to make carbohydrates, which is glucose, to form oxygen and sugar. The glucose can then be turned into starch, which will then be stored or turned back into glucose and used for respiration. Oxygen is produced and escapes through the stomata. The sugar dissolves in the water and is carried through out the plant, providing energy for growth. For photosynthesis to occur light energy is needed, this is the most essential substance because it provided energy for the process to be carried out.

Therefore we can say that the formula for plants is:

$$\text{Carbon dioxide + water} \xrightarrow[\text{Chlorophyll}]{\text{sunlight}} \text{glucose + oxygen}$$

The balanced equation for this is:

$$6CO + 6H2O \longrightarrow C6H12O6 + 6O2$$

This experiment is to show that light intensity if effecting the rate of photosynthesis, but before we do this we need to know that photosynthesis is actually occurring. There are many ways to prove this, like testing for starch, to show that oxygen is produced during photosynthesis, to show that carbon dioxide is needed for photosynthesis, to show chlorophyll is needed and to show that light is necessary. So before hand a number of other experiments were carried out to prove this.

Photosynthesis and starch test:

We cannot just put the iodine solution straight onto the leaf because the chlorophyll in the leaf will not allow us to see the black colour that will form if starch is present.
So first be boiled the leaf in boiling water in order to destroy the cellulose cell wall in the leaf. We then placed the soft leaf in a boiling tube full of ethanol. This will get rid of the chlorophyll as it devolves in the ethanol, so the chlorophyll will pass through the alcohol making it green. The leaf is then placed back into the boiling tube to soften. After this it is placed onto a tile, the leaf is now white. Iodine solution is then poured over it, the parts that will go black will not contain any starch and the parts that remain white will still contain starch.

To show that carbon dioxide is needed for photosynthesis:

We place two leaves, each in a separate conical flask. One with water inside it, this will be our control and the other with potassium hydroxide, which removes carbon dioxide. Only a little should be placed in each flask so the leaves do not touch the solutions. When the leaves are tested for starch the one with potassium hydroxide around it will stay cream, because no photosynthesis has occurred. The control leaf will turn black with the iodine solution, which shows that photosynthesis has occurred.

To show that chlorophyll is needed for photosynthesis:

A variegated leaf is taken and is tested for starch after it has been exposed to light. The green part of the plant will contain chlorophyll and so therefore when tested for starch will turn black showing that starch is present and that photosynthesis is taking place. The cream part of the leaf will remain cream, showing that there is no starch present, therefore no photosynthesis is taking place.

To show that light is necessary for photosynthesis:

This experiment probably helped us the most.
First we placed a growing plant in a cupboard for 2 –3 days, to de-starch the plant. It cannot photosynthesis because all the starch in the plant is already used up.
A leaf is taken from the de-starched plant and is tested for starch, it should remain the same colour as there will be no starch present.
A stencil (black paper or foil with a cut our shape) in foil is then placed over another leaf and the plant is left out in the sun.
Later the stencil is removed and the leaf it tested for starch. The regions that had been exposed to the light will turn black when tested with iodine for starch. Those regions that had foil or the black paper, which should be cream or of a lighter colour should remain the same, showing that there is no starch present, therefore no photosynthesis was taking place, showing that light is needed for photosynthesis.

So these experiments showed that carbon dioxide, light and chlorophyll is needed for photosynthesis. Meaning that if any one of them was subtracted from the formula or reduced in volume given to the plant then the rate of photosynthesis would decrease. Chlorophyll uses light energy to perform photosynthesis. It can only do this as fast as the light source is arriving. Carbon dioxide and water are the raw materials, water is never really in short supply but only a little of the air around us is carbon dioxide and so it is shortage and as chlorophyll is like and enzyme it works best when warm but no too hot. So if it's temperature exceeds above 45°c then the enzymes will be denatured cancelling out chlorophyll from the formula.

So the amount of light, the amount of carbon dioxide and the temperature are three factors that will effect the rate of photosynthesis. Reducing them or increasing them will change the rate of photosynthesis. This background knowledge helped me to come to my hypothesis/prediction

Aim:

The aim of this investigation is to see if light intensity has an effect on the rate of photosynthesis.

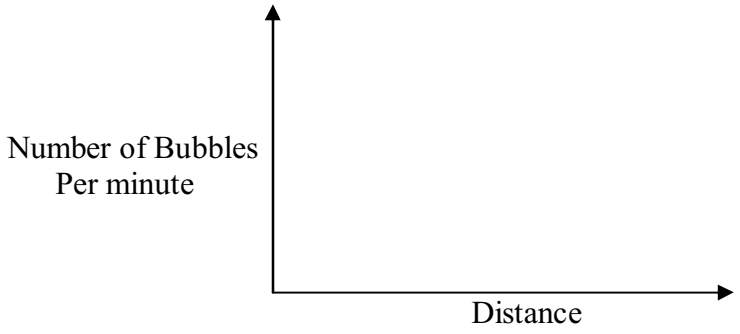
Prediction:

Based on my background knowledge of photosynthesis I predicted that as I increase the distance of the light source from the cylinder i.e. reducing the light intensity, the number of bubbles will decrease i.e. less oxygen will be given off. So therefore the closer the light source from the cylinder i.e. increasing the light source, the more bubbles will be produced, i.e. more oxygen will be given off so the rate of photosynthesis will be quicker. The rate of photosynthesis is the number of bubbles per minute.
So as the distance decreases the light intensity increases and the rate of photosynthesis increases, and as the distance increases the light intensity decreases and so the rate of photosynthesis decreases, therefore they are inversely proportional to each other.

$$LI = \frac{1}{d^2}$$

LI = light intensity
D = distance

So I predict that the graphs will look like this:



Apparatus:

- Measuring cylinder
- Elodea – weed
- Razor blade / scalpel
- Black paper
- Scissors
- Cello tape
- Paper clips
- Ruler
- Lamp
- Stopwatch
- Litmus paper
- Thermometer
- Spatula
- Sodium bicarbonate – NaH2CO3
- Electric balance
- Water
- Filter paper
- Beaker
- Paper towels
- Tile

We decided that it was best to use a weed like the alodea because it would be easier to measure that rate of photosynthesis from a weed with a smaller stem than a full size plant under water. We would be able to count the number of oxygen bubbles released in a given time therefore measuring the rate of photosynthesis.

Safety:

- Hair should be tied back do it does not come in the way as an distraction
- An over-all should be worn in case of spillage
- The lamp should be checked before hand for any faults
- The lamp may become too hot and so care should be taken when moving the lamp
- Keep all wires away from the apparatus so nothing falls
- Keep apparatus a distance away from the edge of the bench so to does not fall
- Do not cut your self whilst using the scalpel
- Make sure that the water does not spill as there is electrical appliances near by (lamp)
- Any spillage made should be cleared up with paper towels immediately
- Not too many people should queue up to fill up water, measure the sodium bicarbonate or to get the alodea from the tank

Constants:

- Through out the experiment the same alodea weed should be used so that the mass remains the same.
- The same lamp should be used through out the experiment, so that the same amount of light energy / wavelength is released throughout the experiment.
- The equilibrium time for each distance should be kept the same, 5 minutes so that it is a fair test. It would not be fair to have different equilibrium time for each distance.
- The time measured for each distance should be the same, 5 minutes
- The same volume of water should be kept for all the distances and experiments, 250mm
- The temperature should try to be kept constant, although the temperatures will increases with the number of people in the lab and so windows will need to be opened when needed, as there is no way of keeping it constant so it can be monitored to see if there is change, which will explain any anomalous results
- The temperature of the water should try to be kept the same, yet again there is no way of keeping it constant as the light may change the temperature, so this to can be monitored and can help to explain any anomalous results.
- The weight of the weed should be constant so the same weed will be used
- The pH number should be constant to so that it is a fair test, yet there is no way of keeping it constant so it will just be noted, to explain any anomalous results.