An Investigation into the Various Factors Affecting Photosynthesis

Aim:

The aim of this investigation is to determine the factors that affect the rate of photosynthesis and what affect they have.

Introduction:

Photosynthesis is a chemical reaction that takes place in green plants. The reaction is endothermic and uses light energy to produce glucose. Green plants feed autotrophically, which means that they use inorganic substances to make organic ones, this is called autotrophic nutrition. The inorganic substances that they use are CO_2, H_2O and minerals. Green plants use sunlight to give them energy to combine carbon dioxide with water, which produces glucose. This can be shown as the following word and symbol equations:

$$\text{CARBON DIOXIDE + WATER} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{GLUCOSE + OXYGEN}$$

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}0_6 + 6O_2$$

The word photosynthesis means light (photo) manufacture (synthesis). The plants need the suns light energy and so trap it in the chlorophyll, the pigment that makes them green. There are three factors that can limit the rate of reaction in photosynthesis and these are the light intensity, temperature and carbon dioxide levels available. Of course the amount of chlorophyll in the plant will affect the results but the same plant section will be used throughout the experiment.

The temperature at which the experiment takes place will affect the rate of reaction. The heat gives energy to molecules and allows the process to occur faster. However if the

temperature is too hot then the enzymes will degenerate and the reaction will not be able to take place at all. From previous experiments I know that the optimum temperature for the reaction is 30°C.

Carbon dioxide is another factor that limits the rate of photosynthesis if there is not enough. In the experiment carbon dioxide will be present in the water. The amount of water available to the plant will affect the rate of photosynthesis as well. This is because with out water, the stomata in the plants, which regulate oxygen and carbon dioxide, close to prevent any water vapour from escaping. This in turn prevents carbon dioxide entering, therefore stopping photosynthesis taking place. However, lack of water will not be a problem in this experiment because elodea will be used as the plant, which grows naturally underwater in ponds, so the experiment will be underwater.

The last factor to consider is the light intensity. In this experiment a light bulb in a lamp will represent the sun, providing the plant with the necessary energy. I will investigate the effect light intensity has on a plant because it will be the easiest variable to experiment with using the equipment that is available to me in the experiment. By decreasing and increasing the distance between the plant and lamp I will be changing the light intensity.

Elodea is used because it is a known photosynthesiser. It also gives off gas bubbles from a specifically cut edge, which can be seen when the plant is submerged in water.

Prediction:

I predict that as the intensity of light is increased so to is the rate of photosynthesis. The two are directly proportional to one another. This means that the closer the light bulb is to the elodea the more gas bubbles of oxygen there will be given off, and the more energy that is trapped in the chloroplasts, the more energy there will be. Therefore by doubling the light intensity you are doubling the energy released.

Light intensity is inversely proportional to the distance squared which can be shown as light intensity = $1/d^2$. This is because as the light bulb is moved further away from the elodea, the light energy is dispersed over a larger area and less of it reaches the elodea.

The light intensity will only increase the rate of reaction to a certain point because at that point something else will limit it, such as the levels of carbon dioxide or the temperature. The law of limiting factors states that if a reaction relies on a number of factors being favourable then the rate of reaction is limited by the factor that is closest to its limiting value.

Preliminary Work:

A preliminary investigation was carried out to find the most effective way of measuring the bubbles of oxygen given off from various light intensities. The experiment in the preliminary investigation was set out as shown below:

With the lamp measured 5cm away from the beaker the experiment was left for ten minutes for gas to collect in the test tube. The volume of gas was recorded and the experiment repeated with the lamp at distances of 10cm, 5cm and 20cm away from the beaker. However this method was not very accurate as the gas bubbles stuck to the funnel. Also ten minutes was not long enough for the plant to photosynthesise efficiently, to produce a sufficient volume of gas to record.

The experiment was tried again, however the elodea was placed straight into the beaker and the bubbles were counted individually. The distance of the lamp from the beaker ranged from 5cm to 20cm away.

In both experiments the elodea was weighed down with paperclips. For the investigation the second method will be set up and used as a control to compare results with. However, it will be left running for a longer period of time.

Variables:

The only factor that I will vary is the light intensity, the following will be kept constant:

- Plant, I will always use elodea and it will be cut to 8cm.
- Temperature, it will remain constant as close to room temperature as possible. It will be checked throughout the experiment with a thermometer.
- Water Volume, the water will be measured before the experiment, as long as there is more that 400ml in the beaker and 40ml in the test tube it does not matter what the exact value is.
- Carbon Dioxide, sodium hydrogen carbonate will be dissolved into the water in both the beaker and test tube. I will make sure there is always an abundance of CO_2 , one spatula should be enough.
- Light, the same light bulb will be used throughout the experiment to ensure the light wavelength and intensity of the bulb is always the same.

Safety:

Although this experiment may not be considered very dangerous, the following precautions should be taken:

- Make sure no water comes into contact with the electrical mains.
- Be careful when cutting the elodea with the sharp razor blade.
- Wash hands before and after handling the elodea and the pondweed.
- Do not touch the light bulb.
- Be careful when handling glass.

Fair Test:

To ensure that the experiment is as fair as possible the following rules should be applied:

- Keep all the other variables constant apart from light intensity.