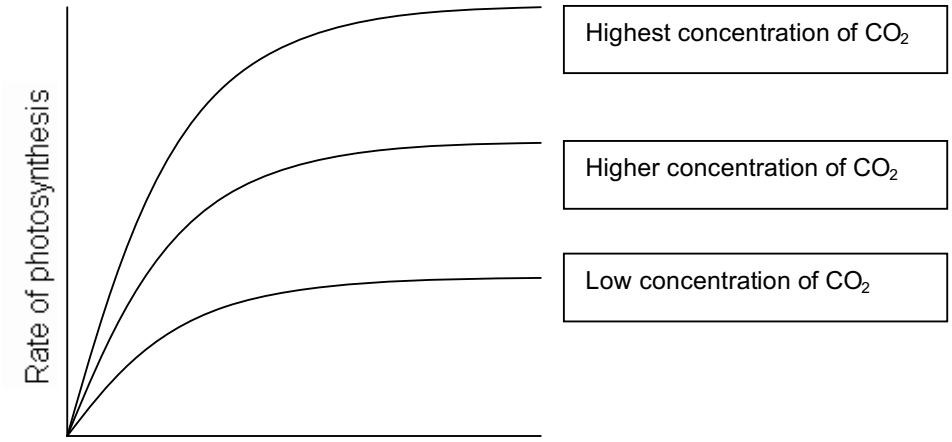
Planning of photosynthesis investigation

Aim:
The aim of this experiment is to investigate into the effects of the change of carbon dioxide concentrations on the rate of photosynthesis.

Prediction:
My hypothesis is that as the concentration of carbon dioxide increases the rate of photosynthesis will also increase.

Graph showing the effects of carbon dioxide on the rate of photosynthesis



Scientific reasoning:
Photosynthesis is the process by which chlorophyll containing organisms capture energy in the form of light and convert it to chemical energy.
Plants make food through a process called photosynthesis. Using energy from the sun, cells in the leaves turn simple materials into energy rich food. Spongy cells are partly surrounded with pockets of air, which enable the cells to exchange gases with the atmosphere. The stomata are small openings in the lower epidermis under the leaf. Carbon dioxide enters through the stomata. Carbon dioxide combines with water and is photosynthesised into oxygen and sugar.

Equation for photosynthesis
$6\ CO_2 + 12H_2O \pm C_6H_{12}O_6 + 6O_2 + 6H_2O$

Oxygen escapes through the stomata and the sugar dissolved in water is carried throughout the plant providing energy for growth.

Photosynthesis consists of two stages: a series of light- dependent reactions, which are temperature independent and a series of light independent reactions, which are temperature dependent. Increasing light intensity can increase the rate of the light dependent reactions. Increasing the temperature can increase the rate of the light independent reactions. Photosynthesis begins with the absorption of light by pigments. Chlorophyll and other pigments known as carotenoids absorb different wavelengths of light, which broadens the spectrum of light energy that can be fixed through photosynthesis. Photosynthesis takes place within cells called chloroplasts that contain the chlorophylls and enzymes that are necessary for various reactions.

Carbon dioxide is important in the light independent reaction. This reaction takes place in the stroma (matrix) of the chloroplast, where the energy stored in the ATP and NADPH is used to reduce carbon dioxide to organic carbon. The is done by going through the reactions known

as the Calvin cycle where one molecule of carbon dioxide enters and combines with a five-carbon sugar called RuBP (ribulose 1,5-biphosphate) to form two molecules of a three-carbon compound called GP (3-phosphoglycerate).

The factors that affect photosynthesis are wavelengths of light, temperature and carbon dioxide concentrations. Wavelengths of light effects the rate of photosynthesis as different light sources emit specific wavelengths or using filters of different colours between the light source and the photosynthometer. Light intensity also affects the rate of photosynthesis, which is demonstrated through the preliminary experiment I have carried out. This involved taking a piece of pondweed and inserting it into the photosynthometer where the amount of O_2 produced was measured. I found that as the distance of the lamp from the beaker increased the rate of photosynthesis decreased as the light intensity decreased. Therefore it is proven that light intensity effects the rate of photosynthesis. Temperature affects the rate of photosynthesis as the enzymes used to catalyse the reactions during photosynthesis may be increased if the temperature is increased to a certain temperature called the optimum temperature. Carbon dioxide concentrations increase the rate of photosynthesis at the optimum concentration, which is 0.1%.

Analysis of variables:

Independent variable: The independent variable is the range of CO_2 concentrations. This will be in the form of $NaHCO_3$, as when this is dissolved in water CO_2 is released which then becomes available to the plant. This will be done by making up solutions of different concentrations and this can be seen in the following table:

Concentration percentage ($g.100cm^{-3}$)	Mass of $NaHCO_3$ solid (made up to 1 dm^3 with water)
0	0
0.01	0.1
0.05	0.5

Dependent variable: The dependent variable is the volume of O_2 that is produced during the reaction.

Fixed variables:

- The light intensity must be kept constant and using a fixed distance can do this. Measuring the distance must also be done accurately.
- The voltage of the bulbs used in the lamps must also be kept constant.
- Natural light may be a problem during the experiment so this must be kept constant by shutting off the artificial lights and preventing any natural light from coming in causing an uneven source of light.
- Temperature from the light source must also be constant as it heats the water and this affects the enzymes used in the Calvin cycle. Gases dissolve less at higher temperatures therefore it may also reduce the rate of dissolving CO_2 and O_2. This can be prevented by using a heat shield (beaker filled with water). This is used as water absorbs the heat due to water's specific heat capacity.
- Specimen should come from the same source for each experiment and the length of the plant should be kept constant each time as genetic variations in plants may affect the results.
- The pH of the solution must also be kept constant and using litmus paper can do this. Too much CO_2 may inhibit the rubisco therefore affecting the results

Control:

Water will only be used for the control of this experiment instead of $NAHCO_3$. However, there is still some CO_2 dissolved in the water. This must be taken account of when taking each reading and should be deducted from the total volume of O_2 at that concentration.

Reliability issues:

The measurements should be taken 6 times so that the results are reliable and that any anomalous results could be ignored.

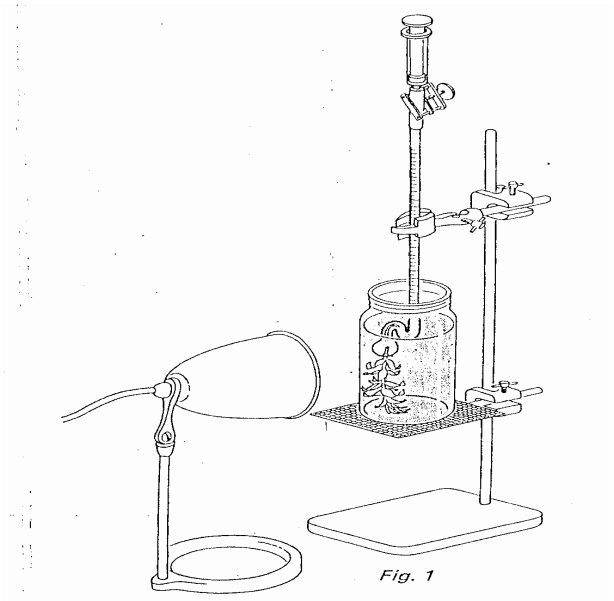
Apparatus

- Photosynthometer (nm) – used to measure the rate of photosynthesis by measuring the volume of O_2 collected.
- Water bath – to keep the temperature of the solutions in the beaker constant.
- Mercury thermometer ($^{\circ}C$) – To measure the temperature f the solution
- Volumetric flask ($1500cm^3$) – to dissolve the solid $NaHCO_3$ into 1 litre of water
- Syringes ($5.0\ cm^3$) – to discard of air bubbles and to collect the O_2 produced.
- Digital top pan balance – to measure the weight of solid $NaHCO_3$
- Meter ruler – to measure the distance the air bubble travels and the distance of the lamp from the beaker
- Razor blade – to cut the Elodea to a certain length (5-10cm)
- White tile – to provide a surface to cut the Elodea
- Litmus paper – to measure the pH of the solution to keep the CO_2 concentration constant
- Shoot of Elodea – to investigate the amount of CO_2 used and O_2 produced by this plant
- Clamp + Clamp stand – to hold the photosynthometer and the syringe in place
- Capillary tube + syringe – to measure the volume of O_2 being produced and to discard of air bubbles
- Lamp – to provide light energy for the photosynthesis reaction to take place
- Distilled water – so that Elodea is emerged in water with less impurities that may affect the results acquired
- Stop watch – to measure the amount of time it takes for the reaction to take place

Method:

- To being the experiment the standard solution of $NaHCO_3$ must first be produced. This can be done using the table that can be found in the independent variable section. The solid $NaHCO_3$ must be added to a volumetric flask of distilled water, which must be filled to the line that is etched on the neck of the volumetric flask. Make sure you check that the solution is jus bellow the curved meniscus at eye level.

- Fill a large beaker with distilled water
- Set up the apparatus as shown in the diagram below, using the clamp to hdd the stem of the burette with the bulb clear of the water



- Cut a piece of Elodea 5-10 cm long and push the cut end into the bulb of the burette securely.
- Lower the burette so that the shoot and the bulb are immersed in the water.
- Withdraw the plunger of the syringe to fill the burette with water. Fit the screw at an angle so as to enclose as much of the rubber tubing as possible and close the screw tightly.
- Place the lamp at a distance of 15 cm and observe the Elodea until streams of bubbles appear.
- As the bubbles are coming from the plant, unscrew the clip to allow the collection of gas bubbles into the stem of the burette. Collect the gas for one minute.
- Close the clamp and read the volumes of gas into the stem and take at least three readings.
- To start a fresh series of readings, withdraw the plunger of the syringe to remove all the air bubbles.
- Record your results into a table like the one below.

Concentration of $NaHCO_3$ (%)	Time (min)	Distance travelled by O_2	Volume of O_2	Temperature (^oC)
0				
0.01				
0.05				

Safety

As you will be using a lamp the bulb of the lamp will be hot so effort should be made in order to make sure that you do not touch the light bulb and keep clear from it. Another safety hazard is that water could splash on the bulb and could cause an electric shock and this can be avoided by keeping the water far away from the lamp. An additional safety hazard is the use of razors to cut the Elodea. Using the razor carefully and not walking around with the razor can reduce this.

References

- Toole. G & Toole. S, 2004, A2 Biology for OCR, Nelson Thornes Ltd pages 20-31
- Robertson. J & Mays. T, 2001, Revise GCSE Biology, Letts Educational pages 58-61
- Jones. M, Fosbery. R, Taylor. D, 2000, Biology 1, Cambridge University Press 2000 page 93