Photosynthesis Apparatus

EQUIPMENT NOTES

Photosynthesis Apparatus

This apparatus is designed for estimation of the rate of photosynthesis in terms of the rate of evolution of gas by an aquatic plant. (In these notes, Elodea sp. is used as an example, although any narrow-stemmed, multi leaf aquatic plant should be suitable).

The variation of rate of photosynthesis with light intensity, temperature and carbon dioxide concentration can be demonstrated.

APPARATUS DETAILS

The apparatus comprises a graduated capillary tube, with the bore increased in diameter at one end to accept a plant stem, and the other end connected by plastic tubing to a 3 way tap and two syringes.

This apparatus is designed for the estimation of the rate of photosynthesis in terms of the rate of evolution of gas by an aquatic plant. Elodea sp. or any other narrow stemmed, multi leaf aquatic plant can be used.

OPERATING PROCEDURE

1. Brightly illuminate a tube or beaker containing shoots of Elodea (or other suitable plant) until bubbles begin to appear. If gas is not being evolved rapidly within one hour, add a small amount of potassium hydrogen carbonate solution to the water (about $5cm^3$ of 10% solution per $100cm^3$ of water)
2. In the meantime, fill a beaker or test tube with water and allow it to reach room temperature.
3. Cut off a shoot of pond weed which is bubbling steadily, and place it in the container of water, cut end up. As this water is at room temperature, there should be no fluctuation in its temperature during the experiment.
4. Remove the apparatus from the back board (if mounted) and fill it up with water. Do this by immersing the **end** of the capillary tube in water and drawing water slowly through using the vertical syringe. **Do not** totally immerse the capillary as this will affect the adhesion of the scale to the glass. If there are any air bubbles they can usually be removed by using the horizontal syringe to draw some more water through. Remount the apparatus and clamp in a suitable position.
5. Place the flared end of the capillary tube below the water level in the vessel containing pond weed. Insert the cut (and bubbling) end of the plant into the tube and start the stopwatch. You should see the bubbles collecting at the top of the wide part of the capillary tube.
6. After 5 minutes (or longer), draw the bubbles produced slowly and carefully into the graduated part of the tube and record its length. If there is more than one bubble, tap the glass gently so that they join up together.
7. If a very accurate result is required, you could do the experiment under more controlled conditions. The temperature of the water could be kept constant by placing the plant in its container in a water bath (allow 15 minutes for the temperature to equilibrate).

   The amount of light the plant receives could be controlled by completely covering the water bath with foil or paper, and illuminate the plant with a lamp shone through a slit in the cover.

EXPERIMENT 1 – Relationship between light intensity and rate of Photosynthesis

Cover the vessel containing the plant in foil and illuminate it through a slit in the cover. The light source should be positioned at a fixed distance 'd' (eg. 32cm), from the apparatus and the gas produced in a given time (eg. 2 minutes) measured by drawing the bubbles into a graduated tube. This procedure should be repeated several times to obtain an average for the gas production.

Move the light source closer to the apparatus (eg. d = 20cm), and repeat the above procedure.

Assuming that the intensity of light at a given point is inversely proportional to the square of the distance between the source and that point, by selecting a series of distances, the evolution of gas can be plotted against the inverse square of the distance to determine the relationship.

d (cm)	$1/d^2$	*Gas produced in 2 minutes bubble length (mm)*
10	0.01	
14	0.005	
20	0.0025	
32	0.0001	
No light, tube blacked out		

EXPERIMENT 2 – Relationship between temperature and rate of photosynthesis

This experiment is to demonstrate the variation of temperature and photosynthesis and should be carried out in a water bath set at, say 18°C and 29°C, at two light intensities, high and low, ie., with the light close to, and then further from, the water bath.

	Gas produced in 2 minutes bubble length (mm)	
Temperature	*Low light intensity*	*High light intensity*
18°C		
28°C		

At high light intensity, temperature alone is the limiting factor, but at the lower intensity, the rate of photosynthesis is limited by the light intensity. It should be noted that the solubility of oxygen in water varies with temperature, so that allowances must be made for this.

Temperature	*Solubility of oxygen in 100cm3 water*
0°C	4.89cm^3
25°C	3.16cm^3
30°C	2.45cm^3

EXPERIMENT 3 – Relationship between carbon dioxide concentration and rate of photosynthesis

The light intensity and temperature should be kept constant, and the rate of evolution of gases measured using different strengths of HCO_3 solution. After each solution has been in the apparatus, it should be flushed through with distilled water before the next solution is added.

Measure the rate of gas production using the following concentration of potassium hydrogen carbonate.

Potassium hydrogen carbonate concentration	*Gas produced in 2 minutes Bubble length (mm)*
0.01%	
0.05%	
0.15%	
0.20%	
0.30%	
0.40%	

ANALYSIS OF GAS INVOLVED

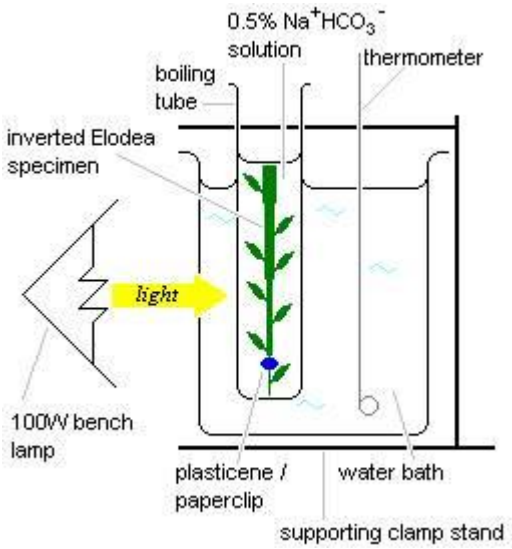
Collect a large sample of gas and analyse it using solutions of potassium hydroxide and potassium pyrogallate. The apparatus can be used in the same way as a 3-tube.

(see 'Maintenance of the Organism', page 7)

REQUIREMENTS

Elodea

- ✓ *Elodea sp.* (or similar)
- ✓ Beaker, 600 cm^3
- ✓ Test Tube
- ✓ Lamp, 100w (or Mercury vapour plant irradiator)
- ✓ Laboratory Stands, bosses and clamps
- ✓ Sheet of glass (for heat shield
- ✓ Stop clock
- ✓ Rule, (1m)
- ✓ Thermometer – 5° to +50°C x 0.1°
- ✓ Aluminium Foil
- ✓ Potassium hydrogen carbonate



REFERENCES

Nuffield Advanced Biological Science (1970)
'Maintenance of the organism'
Longman/Penguin Books laboratory guide, page 127

M.B.V. Roberts 'Biology – A Functional Approach (1974)
Student Manual, Nelson, page 92

C D Brown & J Creedy, 'Experimental Biology Manual' (1970)
Heinman, page 173

Stock Number 904318