Rate of passive transport through cellulose tubing

Student worksheet

Introduction

Cellulose tubing is a partially permeable membrane that can be used to model passive transport through cell membranes, in other words, diffusion through membranes that is driven by concentration differences and does not require an input of energy.

Equipment and materials

- 15 cm length of cellulose tubing knotted at one end and attached to a sawn-off plastic syringe barrel
- Elastic band
- 0.01 mol dm^{-3} solution of methylene blue
- 100 cm^3 beaker
- Clamp stand and boss
- Colorimeter and suitable filter (red)

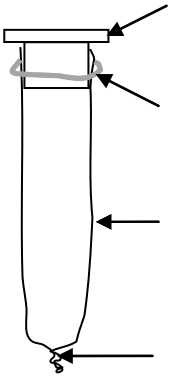


Figure 1 Cellulose tubing attached to cut-off top of a plastic syringe.

Method

Care: Wear eye protection. Methylene blue is harmful.

1. Put a small beaker, with a magnetic stirring bar in it, on a magnetic stirring plate.
2. Soak the cellulose tubing in deionised water and use an elastic band to fasten it to the sawn-off syringe barrel.
3. Pour the methylene blue solution into the cellulose tubing to a depth of about 4 cm.
4. Clamp sawn-off syringe barrel so that the cellulose tubing is hanging in the beaker with the top of the methylene blue solution about half way up the height of the beaker.
5. Pour deionised water into the beaker until it is level with the top of the methylene blue solution in the cellulose tubing.
6. After 5 minutes, remove some of the solution in the beaker, transfer it to a cuvette and measure its absorbance using a colorimeter. Do this as quickly as possible and then pour the solution back into the beaker.
7. Repeat step 6 at further 5 minute intervals.

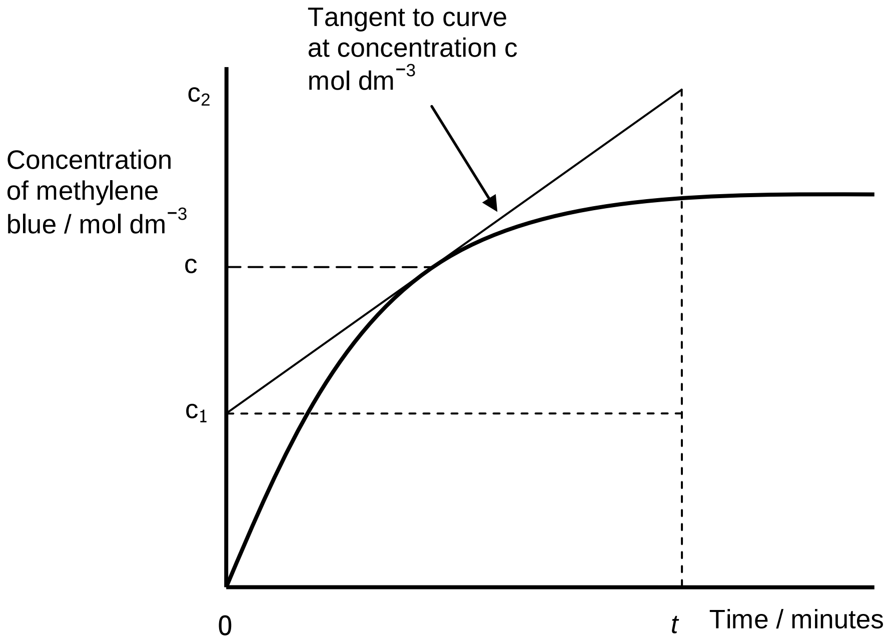
   Note: 10 or 15 minute intervals might be used rather than 5 minutes.

Recording data

1. Record results in the first two columns of a three-column table like this:

Time / minutes	Absorbance	Concentration of methylene blue / mol dm^{-3}

2. Use a calibration graph to calculate the concentration of methylene blue, in mol dm^{-3}, from the absorbance values.
3. Plot a graph of concentration of methylene blue against time. The graph should look something like the one shown in Figure 2. The tangent to the curve at any one concentration gives the rate of passive transport at that concentration.



The rate of diffusion when the concentration of methylene blue in the beaker is *c* mol dm^{-3} $= \dfrac{(c_2 - c_1)}{t}$ mol dm^{-3} min^{-1}

Figure 2 Calculating a rate at a given concentration using tangents.

4. Use the graph to calculate the diffusion rate at six different methylene blue concentrations using the tangent method.
5. Plot a graph of rate of diffusion against methylene blue concentration.

Interpreting the data

1. Describe the shape of the graph of rate of diffusion against methylene blue concentration.

   Note: If you run the experiment for just a short period you may get a linear graph. The slope gives the initial rate of diffusion.
2. Is the diffusion of methylene blue zero order, first order or second order? Explain your answer.

Note: Colorimeter calibration curve

The colorimeter needs to be calibrated using standard solutions of methylene blue (see *Determination of soil CEC using methylene blue*).