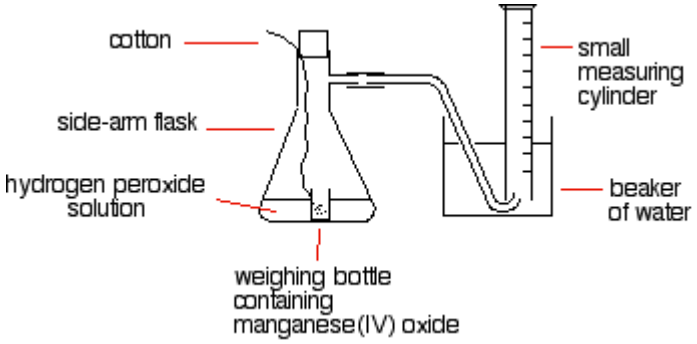
FINDING ORDERS OF REACTION EXPERIMENTALLY

1. Hydrogen peroxide solution decomposes in the presence of a manganese(IV) oxide catalyst to give oxygen.

$$2H_2O_{2(aq)} \xrightarrow{MnO_{2(s)}} 2H_2O_{(l)} + O_{2(g)}$$

You can find the order of reaction by measuring the time taken for a small volume of oxygen to be given off at the beginning of the reaction for a variety of different concentrations of hydrogen peroxide solution, and then processing the results. An apparatus you could use might look like this:



a) Explain the reason for starting with the manganese(IV) oxide contained in a weighing bottle.

b) Explain briefly how you would take a measurement using the apparatus set up as it is in the diagram.

c) To find the order of reaction, you would need to vary the concentration of the hydrogen peroxide solution while controlling various other variables. What variables would you need to control?

d) If the time taken for a particular reaction is t, then the initial rate of the reaction is proportional to 1/t - the longer the time it takes for the same volume to be produced, the slower the reaction. The rate equation for the decomposition of hydrogen peroxide is

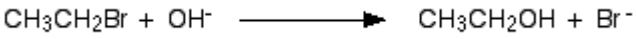
$$\text{rate} = k[H_2O_2]^n$$

where n is the order of the reaction, and k is the rate constant. If you take the logarithm of both sides, this gives

$$\log(\text{rate}) = \log k + n \log[H_2O_2]$$

Using this equation, describe how you would process your results in order to find the order of the reaction.

2. Orders of reaction can also be found by following the course of a single reaction and then processing the results. A commonly discussed example involves the reaction between bromoethane and hydroxide ions from sodium hydroxide solution.



Suppose you mixed 50 cm^3 of bromoethane solution with 50 cm^3 of sodium hydroxide solution of the same concentration to give 100 cm^3 of reaction mixture. You would start the timer on mixing.

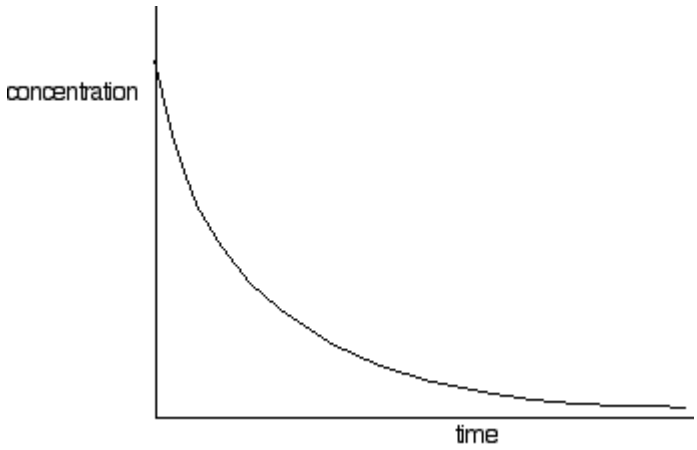
Then at intervals you could take a 10 cm^3 sample of reaction mixture using a pipette, and run that into some iced water, noting the time when the addition is half complete. Now titrate that as quickly as possible with suitable dilute hydrochloric acid to enable you to work out the concentration of the hydroxide ions at that time.

That would leave you with a list of concentrations of hydroxide ions against time from which you can work out the order of the reaction.

a) Explain why a sample of the reaction mixture is run into iced water before it is titrated.

b) What errors are introduced during the cooling and titration processes? Explain your answer.

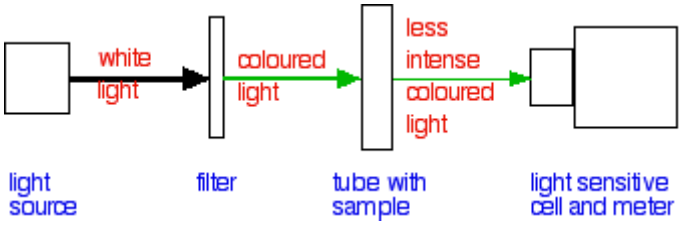
c) Suppose you plotted a graph of concentration of hydroxide ions against time, and it looked something like this:



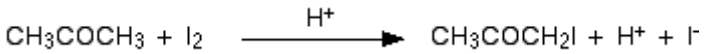
Explain briefly how you would use this graph as a basis for working out the overall order of the reaction.

3. This question is about the use of a colorimeter in rate of reaction experiments. If you are sure that your examiners don't want you to know about colorimetry, ignore the question.

   The diagram, taken from the Chemguide page you have just read, shows a simple block diagram of a colorimeter.



   Suppose you wanted to use a colorimeter to follow the course of this reaction:



   The solution would start off strongly coloured because of the iodine, but the colour would fade as the iodine gets used up.

   a) Suppose your colorimeter came with a box of differently coloured filters. How would you quickly choose which filter to use? (This isn't explained in detail on the Chemguide page. It is *very* simple - think it out for yourself!)

   b) During the reaction more light would pass through the colorimeter on to the meter as the colour of the iodine faded. Suppose you plotted meter readings against time. How would you convert those meter readings into values for the concentrations of the iodine solution at each time?