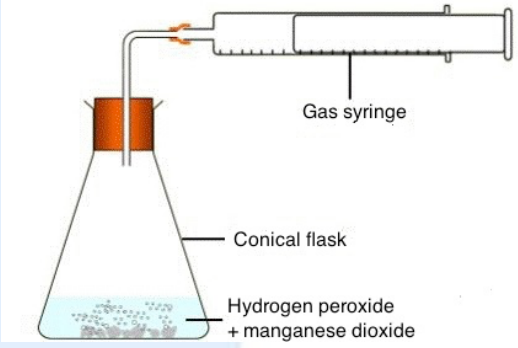
SL HL Paper 3 Section A Experimental work (5) with worked answers

Hydrogen peroxide decomposes according to the equation:

$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

The catalytic effect of adding solid manganese dioxide powder to an aqueous solution of hydrogen peroxide was studied using the set-up shown below.



In three separate experiments the volume of oxygen evolved was measured over time when no manganese dioxide was added, when 0.100 g of manganese dioxide was added and when 1.00 g of manganese dioxide was added to the same volume of hydrogen peroxide solution. The temperature was kept constant throughout.

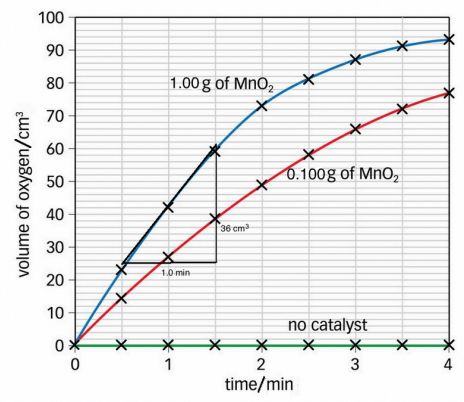
(a) In order to add the manganese dioxide the bung had to be taken out of the conical flask and replaced quickly. This altered the pressure in the apparatus and affected the initial reading on the syringe. Suggest a simple modification to the apparatus which would allow the manganese dioxide to be added to the hydrogen peroxide solution without the bung having to be removed. ***[1]***

Place the manganese dioxide powder in a small tube standing vertically inside the flask which can be knocked over to start the reaction. ***[1]***

(b) Manganese dioxide is a black powder and hydrogen peroxide solution is a colourless liquid. Describe what will be observed inside the flask, before, during and after the reaction involving manganese dioxide has taken place. ***[2]***

Initially there will be a colourless liquid. When the MnO_2 is added the black solid will be dispersed throughout the liquid and the liquid will effervesce as gas is evolved. ***[1]***
The effervescence will decrease as the reaction proceeds and when the reaction is complete the MnO_2 will settle as a black precipitate on the bottom of the flask leaving the clear solution above. ***[1]***

(c) The quantitative results obtained are shown graphically below.



(c) Determine the rate of reaction after one minute when 1.00 g of manganese dioxide had been used as a catalyst. ***[1]***

From the gradient (added to the graph above) the rate of reaction after one minute = 36 ÷ 1.0 = 36 cm^3 min^{-1}. ***[1]***

(d) Suggest why the rate of the reaction does not increase by a factor of ten when the mass of catalyst added is increased tenfold from 0.100 g to 1.00 g. ***[1]***

Although the mass increases tenfold the surface area does not and the hydrogen peroxide only reacts on the surface of the heterogeneous catalyst. ***[1]***

(e) Assuming that the total volume of oxygen evolved by the time the reaction has gone to completion is 100 cm^3 (measured at STP), calculate the amount (in mol) of hydrogen peroxide present initially. ***[1]***

1 mol of gas at STP occupies 22700 cm^3 (from data booklet or use $PV = nRT$)
Amount of oxygen evolved at STP = 100 ÷ 22700 = 4.41 x 10^{-3} mol
Two mol of H_2O_2 are required to produce 1 mol of O_2
Amount of H_2O_2 present initially = 2 x (4.41 x 10−3) = 8.82 x 10^{-3} mol ***[1]***