AQA Chemistry A-level

Required Practical 7

Measuring the rate of reaction: by an initial rate method and by a continuous monitoring method

Initial rate method: 'Iodine Clock' experiment

- Hydrogen peroxide reacts with iodide ions to form iodine and the thiosulfate ion immediately reacts with iodine:

  $H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2H_2O(l)$
  $2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

- $S_2O_3^{2-}$ ions are used to remove iodine as it forms.

Method	Accuracy	Explanation
1. Fill the 50 cm^3 burette with potassium iodide solution.	• Rinse a 50 cm^3 burette with potassium iodide before	
2. Transfer 10.0 cm^3 of hydrogen peroxide solution from a burette to a 100 cm^3 beaker	• Beaker should be clean and dry	
3. Use a 50 cm^3 measuring cylinder to add 25 cm^3 of sulfuric acid to a 250 cm^3 beaker.	• Beaker should be clean and dry	
4. Use a 25 cm^3 measuring cylinder to add 20 cm^3 of distilled (deionised) water into the 250 cm^3 beaker.		
5. Use a plastic dropping pipette to add about 1 cm^3 of starch solution to this beaker.		
6. Use the burette to add 5.0 cm^3 of potassium iodide solution to the mixture in the 250 cm^3 beaker.		
7. Finally, add 5.0 cm^3 of sodium thiosulfate solution from a burette to the mixture in the 250 cm^3 beaker.		

8. Stir the mixture in the 250 cm^3 beaker. Pour the hydrogen peroxide solution from the 100 cm^3 beaker into the 250 cm^3 beaker and immediately start the timer.	• Stir the mixture	
9. Stop the timer when the mixture in the 250 cm^3 beaker turns blue-black. Record the time.		
10. Rinse the 250 cm^3 beaker with distilled (deionised) water and dry it with a paper towel.		
11. Repeat steps in four further experiments changing the concentration of potassium iodide.		This will allow the order of reaction to be determined.
12. Plot a graph of initial rate (y) versus concentration (x) to determine the order.		

Improvements:

- Use a colorimeter to minimise human error in timing.

Continuous monitoring method:

Method	Accuracy	Explanation
1. Add 50 cm^3 of 0.8 $moldm^{-3}$ hydrochloric acid to a conical flask.		
2. Set up the gas syringe or alternative gas collection equipment.		

3. Add a 6 cm strip of magnesium ribbon to the conical flask, place the bung firmly into the top of the flask and start the timer.	Swirl the flask every few seconds.	
4. Record the volume of hydrogen gas collected every 15 seconds for 2.5 minutes.		
5. Alter the concentration of HCl and repeat steps (1) to (4).		

Experiment considerations:

- A typical gas syringe only measures 100 cm^3 of gas so you don't want a reaction to produce more than this volume. Quantities of reactants need to be calculated carefully.
- Measuring initial rate is preferential as the concentrations is known at the start of the reaction.
- In reactions where there are several reactants, if the concentration of one of the reactant is kept in a large excess then that reactant will appear not to affect rate and will be essentially zero order . This is because its concentration stays virtually constant and does not affect rate.

Analysis:

- Plot a graph of volume of hydrogen produced on the y-axis against time in seconds for each hydrochloric acid concentration. Draw a line of best fit.
- Draw a tangent to each line of best fit at time, t = 0 s.
- Calculate the gradient of each tangent in order to deduce the initial rate of each reaction at each concentration.
- Compare the rate values obtained.

Other ways of following the reaction:

- Colorimeter: If any of the reagents or products are coloured (normally iodine), the reaction can be followed by measuring time vs absorbance. The absorbance is proportional to the concentration of iodine (a calibration graph is required to calculate the exact concentration of iodine).
- Quenching: Aliquots of a reaction mixture can be sampled at different times (without disturbing the reaction). The aliquots are quenched to stop the reaction by either cooling, diluting, or neutralising an acid/base catalyst. The aliquots can then be titrated against to workout concentrations of reagent present.
- Measuring mass lost
- Measuring pH

Diagram: