Rate and order of reaction

Driving Question:
What is the rate and order of the reaction of a solution of sodium thiosulphate with hydrochloric acid?

Thinking about the question

When a sodium thiosulphate solution reacts with hydrochloric acid, a precipitate of sulphur is formed:

$$Na_2S_2O_3\ (aq) + 2\ HCl\ (aq) \rightarrow 2\ NaCl\ (aq) + SO_2\ (aq) + H_2O\ (l) + S\ (s)$$

sodium thiosulphate + hydrochloric acid → sodium chloride + sulphur dioxide + water + sulphur

In this activity you will determine the rate of this reaction by measuring how much light passes through the formed solution.

Materials

In your investigations you will use:

- Data-logger e.g. CMA €Lab,
- Turbidity sensor,
- Measuring cylinder (10 mL)
- Beaker (100 mL)
- Chemicals:
    - 10 ml of hydrochloric acid HCl (0.1 M),
    - 10 ml of sodium thiosulphate $Na_2S_2O_3$ (0.1 M).

Safety

- Wear safety glasses and a lab coat.
- Be careful when handling chemicals
- Dispose of all chemicals properly.

Investigations

1. Connect the turbidity sensor to the input 1 of your interface.
2. Open the Coach activity “Rate and order of reaction”
3. Mix 9 mL thiosulphate-solution and 9 mL hydrochloric acid in the beaker. The reaction has already started at this point, so you’ll need to hurry.
4. Pour the mixture into the empty cuvette, screw on the lid and put the cuvette in the turbidity sensor. Close the sensor lid and start the measurement.
5. Save the results by copying the column with measurement data. Give the new column the name ‘Exp1’.
6. How does the appearance of the solution change during the reaction?
7. Mix 4.5 mL 0.1 M hydrochloric acid, 4.5 mL water and 9 mL thiosulphate-solution in the beaker. The reaction has already started at this point, so you’ll need to hurry. Repeat the experiment.
8. Save the results by copying the column with measurement data. Give the new column the name ‘Exp2’.
9. Mix 3 mL 0,1 M hydrochloric acid, 6 mL water and 9 mL thiosulphate-solution in the beaker. The reaction has already started at this point, so you’ll need to hurry. Repeat the experiment.
10. Save the results by copying the column with measurement data. Give the new column the name ‘Exp3’.
11. What does the graph tell you about the progress of reaction?
12. Determine the reaction rate in which certain amount of sulphur has been formed, in other words a certain level of turbidity is reached.
    (Use '1/time' as a measure for the reaction rate, do you know why?)
13. For each reaction determine the reaction rate.
14. Calculate the concentration of hydrochloric acid in each experiment.
15. How does the reaction rate depend on the hydrochloric acid concentration?
16. Optional: Determine the order of the reaction with respect to hydrochloric acid
    a. If you don’t know how, ask your teacher
17. Optional: How would you find the order of reaction with respect to sodium thiosulphate?

Resources:

Coach 6 Activity: Rate and order of reaction.cma

Coach 6 Result: Rate and order of reaction.cmr