Concentration Effect and Reaction Rate

Student Handout

Purposes

1. To investigate the effect of concentration on the rate of the reaction between $S_2O_3^{2-}(aq)$ and $H^+(aq)$.
2. To determine the rate equation for the reaction between $S_2O_3^{2-}(aq)$ and $H^+(aq)$.

Introduction

Sodium thiosulphate reacts with dilute acids to form yellow precipitates of sulphur.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$$

Instead of measuring the rate of decrease in concentration of the reactants, rate of formation of a fixed amount of sulphur is selected as the variable for measurement. As the formation of sulphur depends on the consumption of $S_2O_3^{2-}(aq)$, the rate of decrease in concentration of $S_2O_3^{2-}(aq)$ is measured indirectly in the experiment.

Safety

Sulphur dioxide produced in the reaction is toxic. Never smell the gas directly. The experiment should be performed in a well-ventilated laboratory. Avoid skin contact with the chemicals.


EYE PROTECTION MUST BE WORN

Materials and Apparatus

1 M $H_2SO_4(aq)$ 
IRRITANT

0.25 M $Na_2S_2O_3(aq)$, deionised water, two 8-well reaction strips, micro-tip plastic pipette, stop watch, 50 cm^3 beaker, microspatula, cotton swabs, a piece of white paper, pencil, light table (if available).

Experimental Procedures

Part A: Effect of varying the concentration of $S_2O_3^{2-}(aq)$

1. Using clean micro-tip plastic pipettes, transfer drops of 0.25 M $Na_2S_2O_3(aq)$ and deionised water to a clean 8-well reaction strip (Strip A) as follows:

Well no.	A1	A2	A3	A4	A5	A6	A7
Drops of $Na_2S_2O_3(aq)$	1	2	3	4	5	6	7
Drops of deionised water	6	5	4	3	2	1	0

2. Transfer drops of 1 M $H_2SO_4(aq)$ and deionised water to another 8-well reaction strip (Strip B) as follows:

Well no.	B1	B2	B3	B4	B5	B6	B7
Drops of $H_2SO_4(aq)$	7	7	7	7	7	7	7
Drops of deionised water	2	2	2	2	2	2	2

3. Rest an 8-well reaction strip on a piece of white paper and trace its shape by a pencil. Mark a cross (X) on each of the 7 well images (see Fig. 1). (Place the piece of white paper on top of a light table, if available).
4. Invert Strip A, stack it atop Strip B so that the wells of strip A is directly above those of strip B.
5. Hold the two strips firmly and lower them suddenly. Turn the strip combination upside down several times so that the solution mixtures in the wells mix together ("shake-down" technique). Start the stop watch at the same time.
6. Shake down all the solution to Strip B. Detach Strip B from the double arrangement and place it on the white paper over the array of crosses (see Fig. 2).
7. Record the time (*t*) taken for the total disappearance of each cross.
8. **To prevent the colloidal sulphur from sticking onto the wells, use a micro-tip plastic pipette to withdraw the product mixtures immediately after the experiment and dispose of them into a waste beaker. Clean the wells with a wet cotton swab together with some detergent and finally rinse with tap water.**

Fig.1

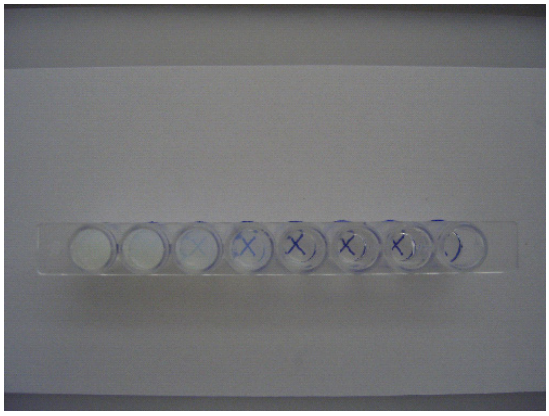

Fig. 2

Part B: Effect of varying the concentration of $H^+(aq)$

9. Using clean micro-tip pipettes, transfer 1 M $H_2SO_4(aq)$ and deionised water to a clean 8-well reaction strip (Strip A) as follows:

Well no.	A1	A2	A3	A4	A5	A6	A7
Drops of $H_2SO_4(aq)$	1	2	3	4	5	6	7
Drops of deionised water	6	5	4	3	2	1	0

10. Transfer 0.25 M $Na_2S_2O_3(aq)$ and deionized water to another 8-well reaction strip (Strip B) as follows:

Well no.	B1	B2	B3	B4	B5	B6	B7
Drops of $Na_2S_2O_3(aq)$	7	7	7	7	7	7	7
Drops of deionised water	2	2	2	2	2	2	2

11. Repeat steps (4) to (8).

Results

Complete the following table:

Part A			Part B		
Relative conc. of $S_2O_3^{2-}(aq)$	$\ln[S_2O_3^{2-}(aq)]$	t / s	Relative conc. of $H_2SO_4(aq)$	$\ln[H^+(aq)]$	t / s
1	0.00		1	0.00	
2	0.69		2	0.69	
3	1.10		3	1.10	
4	1.39		4	1.39	
5	1.61		5	1.61	
6	1.79		6	1.79	
7	1.95		7	1.95	

Treatment of Data

Start the Excel program and complete the above table. Highlight the figures in the $\ln[S_2O_3^{2-}(aq)]$ and t columns and executes the Graph Wizard function. Choose the "X-Y Scattered Plot" option and label the graph plotted.

Discussion Questions

1. Deduce the order of reaction with respect to $S_2O_3^{2-}(aq)$ from the graph of $\ln[S_2O_3^{2-}(aq)]$ against t.
2. Deduce the order of reaction with respect to $H^+(aq)$ by inspecting values of t.
3. Deduce the rate equation for the reaction.