

# Rates of Reaction

# Lab 32

Text reference: Chapter 17, pp. 471-475

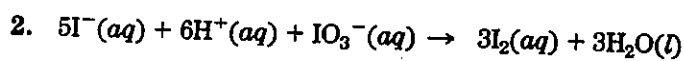
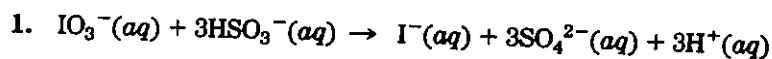
## Pre-Lab Discussion

The **rate** of a chemical reaction is the time required for a given quantity of reactant(s) to be changed to product(s). Reaction rate usually is expressed in terms of moles per unit time. This rate is affected by several factors, including the nature of the reactants, concentration of the reactants, temperature, pressure, and the presence of catalysts. In this experiment, you will study the effects of temperature and concentration.

A chemical reaction is the result of effective collisions between particles of reactants. Increasing the temperature of a system raises the average kinetic energy of the particles of the system. This results in more collisions and, of greater importance, more effective collisions per unit time. This affects the rate of the reaction.

At constant temperature, increasing the concentration of one or more of the reactants increases the number of particles present and, hence, the number of collisions. This affects the rate of the reaction.

In this experiment, two solutions will be mixed, and the completion of the reaction will be marked by a color change. One solution contains the iodate ion ( $\text{IO}_3^-$ ). The other contains the hydrogen sulfite ion ( $\text{HSO}_3^-$ ) and soluble starch. The entire reaction takes place in two stages. The ionic equations for these stages are:



In the presence of starch molecules (not shown), molecular iodine ( $\text{I}_2$ ) produces a characteristic blue color. The rate of the entire reaction can be determined by timing the interval between the time the two solutions are mixed and the appearance of the blue color. By varying the concentration of one of the reactants (at constant temperature) and then varying the temperature alone, you can observe and record the effects of these two factors on reaction rate.

This experiment should provide a better understanding of reaction rates and the factors that affect these rates.

## Purpose

Study the effect that changing the concentration of a reactant has on the rate of a chemical reaction. Study the effect that changing the temperature has on the rate of a chemical reaction. Formulate hypotheses about how reaction rates are affected by changes in temperature and in concentration of reactants.

## Equipment

beaker, 250-mL	timer (stop watch or clock with second hand)
beakers, 100-mL (2)	safety goggles
graduated cylinders, 10-mL (2)	lab apron or coat
test tubes, 18 × 150-mm (2)	
thermometer	

## Materials

Solution A (with $\text{IO}_3^-$ ion)	distilled water
Solution B (with $\text{HSO}_3^-$ ion and soluble starch)	ice cubes

## Safety



Avoid spilling reagent solutions on your skin or clothing. Wash off any spills immediately with cold tap water. Note the caution alert symbols here and with certain steps in the "Procedure." Refer to page xi to review the precautions associated with each symbol. Always wear safety goggles and a lab apron or coat when working in the lab.

## Procedure

### PART A

1. Using a clean, dry, 10-mL graduated cylinder, measure exactly 10.0 mL of Solution A and pour it into a 100-mL beaker.
2. Using a second 10-mL graduate, measure exactly 10.0 mL of Solution B and pour it into a second 100-mL beaker.
3. Prepare to time the reaction. While one lab partner pours Solution A into Solution B, the second partner should immediately start timing the reaction. Pour the solutions back and forth several times from one beaker to the other to ensure thorough mixing. Then allow the mixture to stand. At the instant a color change occurs, the partner timing the reaction should note the elapsed time. Record this in your data list. Rinse and dry the beakers and graduated cylinders.
4. Measure exactly 10.0 mL of Solution B into one of the beakers. Using a clean graduated cylinder, measure exactly 9.0 mL of Solution A into the other beaker. Dilute this solution by adding exactly 1.0 mL of distilled water. Follow the step 3 instructions for mixing the solutions and timing the reaction. Record the elapsed time in your data list. Rinse and dry the beakers and graduated cylinders.
5. Repeat step 4 four more times, using increasingly dilute samples of Solution A. Use the following ratios of Solution A to distilled water (in mL): 8 to 2; 7 to 3; 6 to 4; and 5 to 5. Rinse and dry the beakers and graduated cylinders after each trial. Record elapsed times in Part A of "Observations and Data."

## 32 Rates of Reaction (continued)

### PART B

6. Measure 10.0 mL of Solution A into one test tube and 10.0 mL of Solution B into a second test tube.



7. Half fill a 250-mL beaker with cold tap water. Add ice cubes to the water and stir *carefully* with the thermometer. Continue stirring (and adding ice as needed) until the temperature of the ice-water mixture is about 5°C.

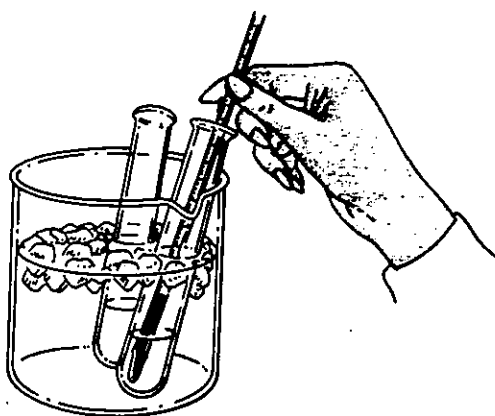


Figure 32-1

8. Place the two test tubes in the ice-water bath and let them stand until the solutions are at the same temperature as the ice water (Figure 32-1). *Always rinse and wipe the thermometer after removing it from a solution.*

9. When the solutions are at the same temperature as the ice water, prepare to time the reaction. One lab partner should start timing the reaction the instant the second partner pours Solution A into Solution B. Quickly pour the mixture back and forth from test tube to test tube several times and return the mixture to the ice-water bath. At the instant a color change occurs, note the time elapsed. Measure the temperature of the mixture immediately. Record the exact temperature and elapsed time in your data table. Discard the mixture as instructed. Rinse and dry the test tubes.

10. Repeat step 6.

11. Prepare a water bath at a temperature of about 15°C. Repeat steps 8 and 9 at this new temperature. Record your observations in your data table.

12. Repeat these procedures using warm baths at the following temperatures: 25°C; 35°C; 45°C. Use warm tap water to prepare these baths. Rinse and dry the test tubes after each trial.

## Observations and Data

### PART A

<u>Solution B (mL)</u>	<u>Solution A (mL)</u>	<u>H<sub>2</sub>O (mL)</u>	<u>Time (sec)</u>
10	10	0	_____
10	9	1	_____
10	8	2	_____
10	7	3	_____
10	6	4	_____
10	5	5	_____

### PART B

#### DATA TABLE

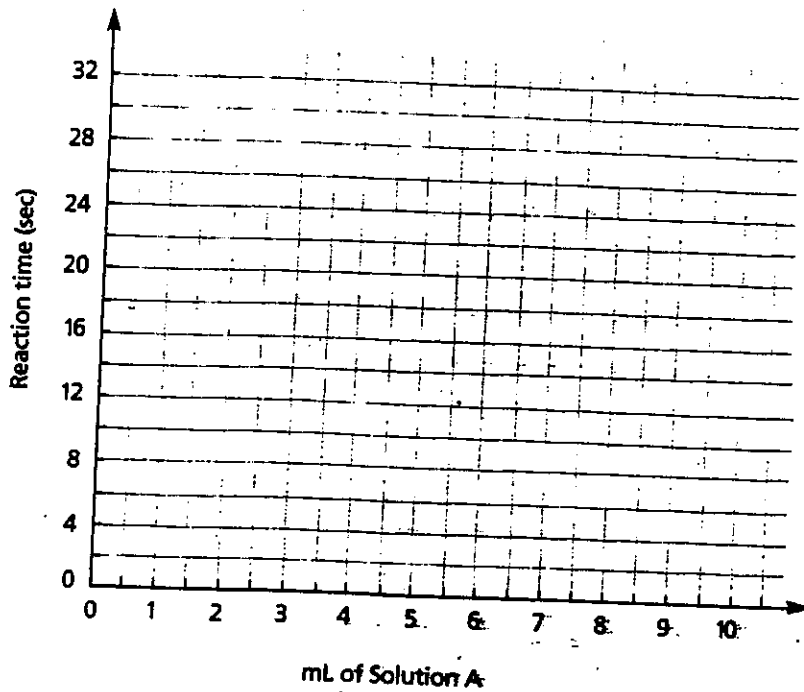
<u>Trial #</u>	<u>Temperature (°C)</u>	<u>Time (sec)</u>
1		
2		
3		
4		
5		

## Calculations

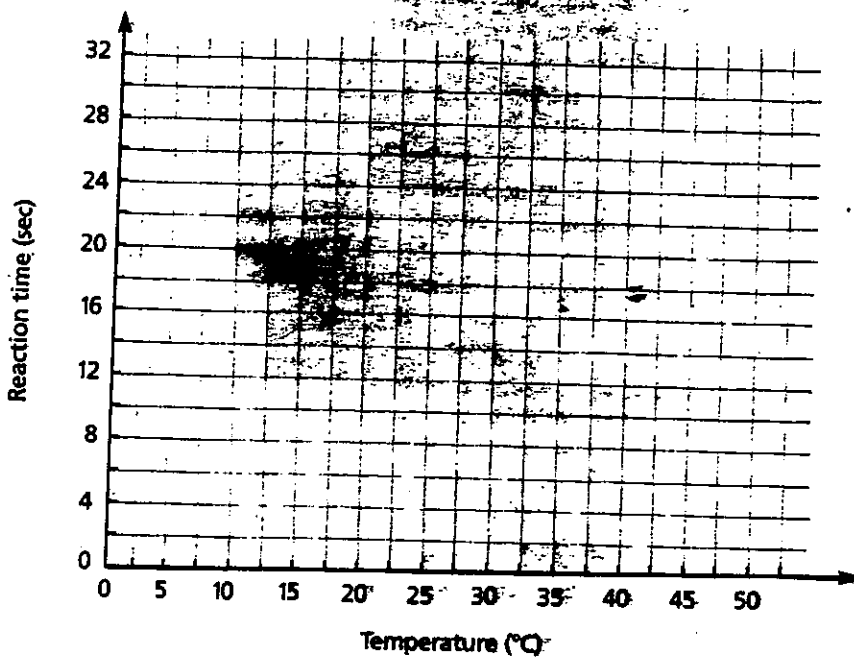
1. Plot your data from Part A on the grid provided. Draw a line through the plotted points to produce a curve showing the effect of concentration of reactants on reaction rate.

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# 32 Rates of Reaction (continued)



2. Plot your data from Part B on the grid provided. Draw a line through the plotted points to produce a curve showing the effect of temperature on reaction rate.



## Conclusions and Questions

1. Based on your experimental data, make a general statement (hypothesis) about the effect of concentration of reactants on reaction rate.

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2. Make a similar hypothesis about the effect of temperature on reaction rate.

3. What other factors affect the rate of a reaction?

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4. How does the "collision theory" relate to the rate of a chemical reaction?

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