

Experiment 24

A Rate Law and Activation Energy



Drops of blood catalyze the decomposition of hydrogen peroxide to water and oxygen gas.

- To determine the rate law for a chemical reaction
- To utilize a graphical analysis of experimental data to
 - determine the order of each reactant in the reaction
 - determine the activation energy for the reaction

The following techniques are used in the Experimental Procedure:



The rate of a chemical reaction is affected by a number of factors, most of which were observed in *Experiment 23*. The rate of a reaction can be expressed in a number of ways, depending on the nature of the reactants being consumed or the products being formed. The rate may be followed as a change in concentration (mol/L) of one of the reactants or products per unit of time, the volume of gas produced per unit of time (Figure 24.1), or the change in color (measured as light absorbance) per unit of time, just to cite a few examples.

In Parts A–D of this experiment, a quantitative statement is determined as to how changes in reactant concentrations affect reaction rate at room temperature, the statement being the rate law for the reaction. In Part E, the reaction rate is determined at different temperatures, allowing us to use the data to calculate the activation energy for the reaction.

To assist in understanding the relationship between reactant concentration and reaction rate, consider the general reaction, $A_2 + 2 B_2 \rightarrow 2 AB_2$. The rate of this reaction is related, by some exponential power, to the initial concentration of each reactant. For this reaction, we can write the relationship as

$$\text{rate} = k [A_2]^p [B_2]^q \quad (24.1)$$

This expression is called the **rate law** for the reaction. The value of k , the **reaction rate constant**, varies with temperature but is independent of reactant concentrations.

The superscripts p and q designate the **order** with respect to each reactant and are always determined experimentally. For example, if tripling the molar concentration of A_2 while holding the B_2 concentration constant increases the reaction rate by a factor of 9, then $p = 2$. In practice, when the B_2 concentration is in large excess relative to the A_2 concentration, the B_2 concentration remains essentially constant during the course of the reaction; therefore, the change in the reaction rate results from the more significant change in the smaller amount of A_2 in the reaction. An experimental study of the kinetics of any reaction involves determining the values of k , p , and q .

OBJECTIVES

TECHNIQUES

INTRODUCTION



Figure 24.1 The rate of thermal decomposition of calcium carbonate is determined by measuring the volume of evolved carbon dioxide gas versus time.

Rate constant: a proportionality constant relating the rate of a reaction to the initial concentrations of the reactants

Order: the exponential factor by which the concentration of a substance affects reaction rate

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Marcel A. Müller



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