

Equilibrium—Preface

Chemical equilibrium is a dynamic concept, and a difficult concept for students to understand. The properties and principles of equilibrium challenge students to think about chemical reactions in a new way. Most chemical reactions do not proceed in one direction and do not give 100% yields of products. Many chemical reactions are reversible, and both reactants and products are present at equilibrium. The purpose of *Equilibrium*, Volume 15 in the Flinn ChemTopic™ Labs series, is to provide high school chemistry teachers with laboratory activities that will help students understand and apply the principles of equilibrium. A variety of experiments, demonstrations, and group activities allow students to explore the nature of equilibrium and to develop more accurate models of how and why chemical reactions occur.

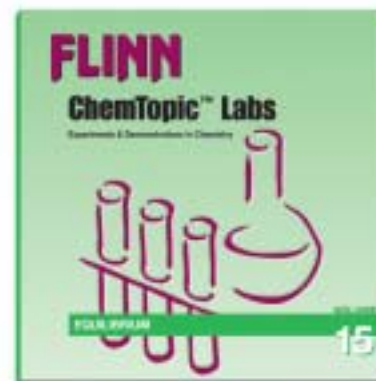
Introducing Equilibrium

What is equilibrium? What evidence is there that both reactants and products are present at equilibrium? In “Exploring Equilibrium,” students investigate two different reversible reactions. Back-and-forth color changes involving complex ions or acid–base indicators illustrate the properties of equilibrium and conditions that affect equilibrium. The experiment may also be performed as a demonstration in “An Overhead Equilibrium.” Two classroom activities in the *Demonstrations* section use physical analogies to simulate equilibrium. In “Penny-Ante Equilibrium,” students use pennies to represent reactants and products in a reversible reaction. As students keep track of the number of pennies that react in either direction, they see how the concentrations of reactants and products change in the approach to equilibrium and why the concentrations no longer change once equilibrium is reached. Additional “penny reactions” lead students to the definition of the equilibrium constant and LeChâtelier’s principle. In “Equilibrium Water Games,” students use water rather than pennies to model a reversible reaction as it approaches equilibrium.

LeChâtelier’s Principle and the Equilibrium Constant

LeChâtelier’s principle predicts how equilibrium can be restored when the balance between the forward and reverse reaction rates is disrupted. One of the most familiar examples of equilibrium and LeChâtelier’s principle is the “pink-and-blue” reaction involving cobalt complex ions. Two versions of this classic equilibrium—the experiment “Restoring Balance” and the demonstration “Pink and Blue”—have been included in this book to give teachers greater flexibility in designing lesson plans. One of the concepts in the “pink-and-blue” experiment is that there are an infinite number of equilibrium positions, but only a single value of the equilib-

rium constant at a given temperature. In “The Equilibrium Constant,” a technology-based experiment, students use colorimetry to determine the equilibrium constant for a reaction and test if the equilibrium constant is, indeed, a constant.



Gas Phase Equilibria

Many important reactions that take place in the atmosphere involve equilibrium concentrations of gas-phase reactants and products. Two activities in this book offer innovative approaches to study these reactions in the high school classroom. In “Gas Phase Equilibrium,” students use sealed, microscale pipet bulbs to investigate the equilibrium of nitrogen oxides. This experiment is a great way to illustrate the applications of equilibrium in the environment. The “Equilibrium in a Syringe” demonstration takes advantage of an everyday phenomenon, the solubility of carbon dioxide in water, to teach equilibrium. Three types of equilibria—gas-phase, solubility, and acid–base—all come together in this interesting demonstration.

Safety, flexibility, and choice

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Equilibrium is one of the most challenging topics in the high school chemistry curriculum. Do your students think that reactant and product concentrations must be equal at equilibrium? Do students insist that the equilibrium constant means that concentrations of individual reactants and products are fixed and cannot change? The selection of experiments, demonstrations, and group activities in *Equilibrium* will help you dispel these common student misconceptions. Best of all, no matter which activities you choose, your students are assured of success. Each experiment and demonstration in *Equilibrium* has been thoroughly tested and retested. Use the experiment summaries and concepts on the following pages to locate the concepts you want to teach and to choose activities that will help you meet your goals.

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