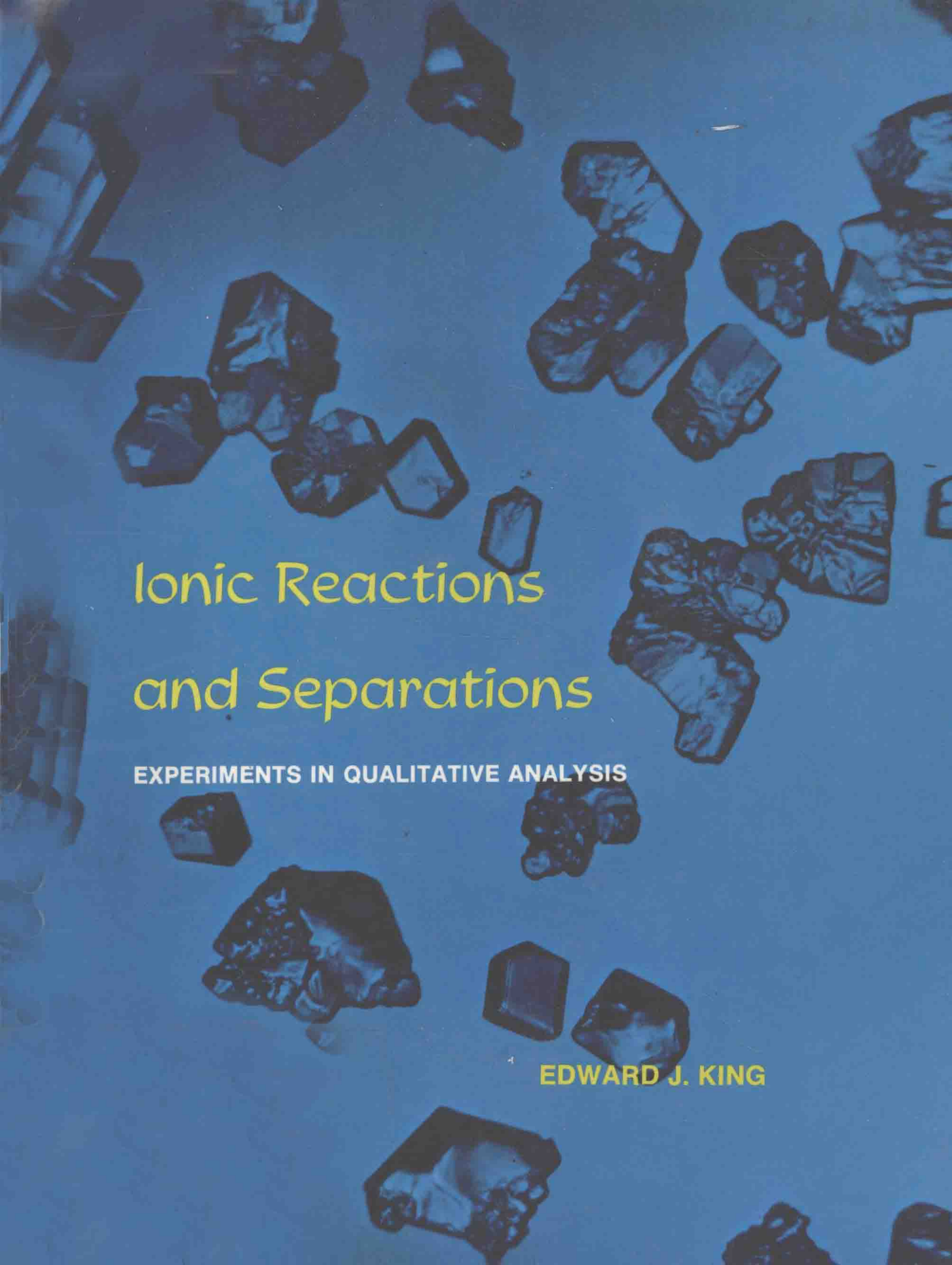

Ionic Reactions and Separations

EXPERIMENTS IN QUALITATIVE ANALYSIS

EDWARD J. KING

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Preface

When my textbook *Qualitative Analysis and Electrolytic Solutions* was published in 1959, qualitative analysis was taught as a separate second-year course in the chemistry curriculum. Since then it has been almost universally incorporated into the general chemistry course. Today, as students encounter qualitative analysis in the laboratory, they are attending lectures and reading chemistry textbooks that give them the basic principles of the theory of solutions, electrolytes, and chemical equilibrium. Therefore, *Ionic Reactions and Separations*, while reviewing aspects of these subjects, seeks more expressly to show their specific applications to qualitative analysis—applications that are necessarily slighted in the general chemistry textbook.

Chapter 1 surveys various types of ionic reactions and shows how their extent under standard conditions can be judged from the magnitudes of K, $E°$, or $\Delta G°$. The sections on $E°$ and $\Delta G°$ can be omitted or deferred until these properties have been reached in the class lectures. Chapter 2 treats the important ionic separations, both by verbal description and by numerical calculation.

Chapter 3 presents the techniques of the analytical laboratory, which are then used in the procedures of Chapter 4 dealing with the detection of the anion. The principles introduced in Chapter 1 and applied in Chapter 4 are reviewed in Chapter 5 in a programmed format designed for self-study by the student. Procedures for detecting the cation are given in Chapter 6.

The analysis of simple substances containing only one cation and one anion presented in these chapters is an effective way to study ionic reactions. Therefore, courses in which only six weeks are assigned to qualitative analysis can use Chapter 1, parts of Chapter 2, and Chapters 3 through 6. Courses that have a full quarter or a term at their disposal can deal with the analysis of mixtures treated in Chapters 7 to 14.

The scheme of analysis for the cations given in *Qualitative Analysis and Electrolytic Solutions* has stood the test of time and has been modified in only a few details for its inclusion here. The original lengthy description of the chemistry of the ions has been replaced by a concise summary of the general characteristics of each group, but the discussion of the steps in the systematic analysis has been expanded so that the specific properties of the ions used in the analytical procedure are presented in some detail. Illustrative numerical calculations are also included to show the application of equilibrium principles to various steps in the procedure. In this book, the anion procedures have been simplified and the number of anions has been reduced from fifteen to eleven.

I take this opportunity to thank the many teachers and students whose comments and suggestions have been very helpful.

Edward J. King

To the Student

What is this white solid—baking powder or rat poison? Does that detergent contain phosphate? Can we detect manganese in this Etruscan sculpture and so prove that it is a forgery? Does this moon rock contain titanium? Such are the questions to which qualitative analysis can give a definite answer.

The true analyst, in contrast with the one-finger-in-the-book determinator, wants to know the principles on which his work is based. In qualitative analysis, he learns the practical implications and limitations of the theory of electrolytes. This is a mainstream of chemical interest that overflows into biochemistry, physiology, molecular biology, and geology. In qualitative analysis, for example, we use buffers to control separations between ions. The same principles of buffer action are important in regulating the acidity of body fluids. In qualitative analysis, we develop the principles governing the formation of precipitates. These principles apply also to formation of mollusk shells, to the deposition of calcium carbonate in the ocean or in caves, and to the creation of veins of sulfide minerals.

In the course of the laboratory work you, the analyst, will acquire experience with inorganic substances. The facts you learn may not seem important in themselves, but in the aggregate they constitute a reservoir of knowledge. With this experience you can independently interpret results and observations; without it you are forced to rely on the opinions and interpretations of others. You may ultimately forget much of this specific information about inorganic substances, especially if you study no more chemistry, but you will have experienced how scientists use knowledge gained by first-hand observations to shape their thought.

Scientific work is not required to be dull! Qualitative analysis will excite your sense of wonder. Add ammonia to a green solution of a nickel salt and watch it suddenly turn blue. Mix colorless solutions of an antimony salt and a sulfide and see a beautiful bright orange solid appear.

Qualitative analysis can be dull and routine if you choose to be a "cookbook" chemist. Or it can be enjoyable and satisfying if you keep your eyes open, develop your powers of deduction, and learn to be resourceful in dealing with the puzzling observation that does not jibe with your preconception or with some statement in this book.

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Principles