

GARY D. CHRISTIAN

# ANALYTICAL CHEMISTRY

FIFTH EDITION

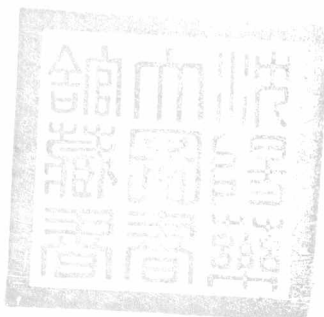
The book cover features a dark, textured background with a large, arched opening. Inside the arch, a bright beam of light enters from the upper right, passing through a transparent, faceted pyramid. The light is dispersed into a vibrant rainbow spectrum that fans out across the bottom of the frame. The overall aesthetic is scientific and dramatic.

F I F T H E D I T I O N

# ANALYTICAL CHEMISTRY

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University of Washington



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This book was set in 10/12 Times Roman by The Clarinda Company and printed and bound by Hamilton Printing Company. The cover was printed by Phoenix Color Corp.

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*Library of Congress Cataloging in Publication Data:*

Christian, Gary D.

Analytical chemistry / Gary D. Christian. — 5th ed.

p. cm.

Includes indexes.

ISBN 0-471-59761-9

I. Chemistry, Analytic—Quantitative. I. Title.

QD101.2.C57 1994

545—dc20

93-32933

CIP

Printed in the United States of America

10 9 8

# PREFACE

This text is designed for college students majoring in chemistry and fields related to chemistry. It is concerned primarily with quantitative analysis techniques and includes discussions of how to design an analytical method (which depends on what information is needed), how to obtain a laboratory sample that is representative of the whole, how to prepare it for analysis, what measurement tools are available, automated analyses, and the statistical significance of the analysis. Chapters are given at the end on applications to some specific types of samples, to give the student a realistic picture of the practice of analytical chemistry.

Examples throughout of the use of analytical techniques are drawn from the life sciences, clinical chemistry, air and water pollution, occupational health and safety, and industrial analyses. Experience has shown that analytical chemistry becomes more meaningful when the student realizes that an incorrect blood analysis may endanger a patients' life, or that an error in quality control analysis may result in serious financial loss for a manufacturer. Millions of dollars are saved in the chemical industry by performing on-line automated analyses of chemical processes, to assure maximum efficiency in chemical production.

This fifth edition of *Analytical Chemistry* is extensively revised and updated, but many features that were developed in previous editions remain. **Boldface type** is used for key terms, and important equations and concepts are boxed to aid in review, as are example problems. Each chapter is introduced with a summary paragraph that lists the topics to be covered, giving the student a broad overview of each subject. The use of dimensional analysis is emphasized throughout to give the student a better feel for the proper setting up of problems. The use of SI units or symbols (e.g., L, mL, mol, and s) is emphasized. The concept of normality and equivalents is introduced, but emphasis remains on the use of molarity and moles. A new feature is the inclusion of *margin notes* to further emphasize important concepts.

A number of chapters have been consolidated and rearranged, to better tie together related topics. Thus, precipitation reactions and titrations are treated

separately from complexometric titrations, while potentiometric and redox methods are presented in separate chapters on electrochemical cells and electrode potentials, potentiometry, and redox and potentiometric titrations. Membrane ion-selective electrodes and their ionophores are treated in greater detail, along with details for characterizing the electrodes. A chapter on voltammetry and electrochemical sensors focuses on modern voltammetric techniques and electrodes, with the omission of classical polarography, electrogravimetry, and coulometry, which are better treated in an instrumental analysis course. The principles of chromatography are described in terms of equilibrium between a stationary and mobile phase. The chapter on tools and operations of analytical chemistry is placed at the end of the text, where it serves as an introductory chapter for the experiments. It can be covered at the beginning of the course.

The experiments are grouped by topic. Each contains a description of the principles and chemical reactions involved, so the student gains an overview of what is being analyzed and how. Solutions and reagents to prepare in advance of the experiment are listed. Experiments are designed where possible to avoid the use of asbestos, chloroform, carbon tetrachloride, or benzene, consistent with occupational health and safety. Laboratory safety is still of prime importance, and the appendix contains a section on safety in the laboratory.

This edition of *Analytical Chemistry* contains a number of **new and expanded topics**. Some of these are:

- Statistics of small data sets
- Statistics of sampling
- Systematic approach to equilibrium calculations (mass and charge balance)
- Heterogeneous equilibria
- Logarithm diagrams for describing multiple equilibria species
- Buffer capacity
- Ultramicroelectrodes
- Chemically modified electrodes
- Diode array spectrometers
- Fourier infrared spectroscopy
- Near-IR instruments
- Fiber-optic sensors
- Solid-phase extraction
- Supercritical fluid chromatography
- Capillary electrophoresis
- Gas chromatography—mass spectrometry
- Flow injection analysis—expanded description of principles
- Personal computers, application software, computer interfaces

FIA experiments are added. New example problems, questions, and practice problems are included.

Special thanks go to the users of the text who have contributed comments and suggestions for changes or improvement; these are always welcome. A number of colleagues have aided immeasurably in providing specific suggestions for revision

of this text. Special mention goes to Professors Kenneth Chan, California State University–Fresno; Jack Hedrick, Elizabethtown College; Ralph Allen, University of Virginia; Donald Pietrzyk, University of Iowa; Joseph Wang, New Mexico State University; Harry B. Mark, University of Cincinnati; and Jerome O’Laughlin, University of Missouri–Columbia.

My wife, Sue, and my secretary, Sheila Parker, typed, cut and pasted, and assembled the voluminous manuscript, and compiled the index with efficiency and dedication, and offered encouragement and support. My deep gratitude goes to them.

### **Solutions Manual**

A comprehensive solutions manual is available for use by instructors and students, in which all problems are completely worked out and all questions are answered. Answers to even-numbered problems are given in Appendix F.

GARY D. CHRISTIAN

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