Foundations of Analytical Chemistry

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Foundations of Analytical Chemistry

A Teaching–Learning Approach

Springer

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To our families, for everything they have given us.

To the analytical chemists who have shaped and will continue to shape Analytical Chemistry in the XXI century.

Foreword

The new agreements concerning the European Space for Higher Education, and the need to harmonize university science programs throughout the world, have raised a pressing demand for a new approach to the disciplines in university curricula. In today's rapidly changing world, education in chemistry cannot absorb all recent developments in its area of knowledge. For this reason, the undergraduate and master programs to be taught by universities should be harmonized by critically and thoroughly reflecting on the foundations of each subject.

Principles of Analytical Chemistry, a previous book by Miguel Valcárcel published by Springer in 2000, was a useful tool for understanding the fundamentals of this chemical discipline. His recent book *Fundamentos de Química Analítica. Una aproximación docente–discente*, which is co-authored by Ángela I. López-Lorente and M^{a} Ángeles López Jiménez, and was released in Spanish by UCO Press early in 2017, provides an image-laden description of Analytical Chemistry and a highly interesting, attractive tool for teaching this discipline and its main concepts in the digital era. An English version of the book was thus highly desirable and needed.

This book is very original in that it introduces an innovative way of presenting university teaching material. Also, it is unusual because it follows a teacher–student approach: One of the co-authors is a student who learned the material recently in her chemistry studies. Approaching the subject from a student's point of view will certainly provide lecturers with highly valuable feedback and facilitate modulation of their teaching. In addition, the visual (slides) and written material (explanations, examples, and exercises) in the book can be of great help to plan lessons and seminars, and also to guide students' non-face-to-face work.

The book is very well structured. The initial chapters (Parts I and II) lay the foundations for analytical science and lead seamlessly to a highly innovative, contemporary view of the socioeconomic projection of Analytical Chemistry in Part III. Parts I and II provide the background needed to understand that Analytical Chemistry is the metrological discipline of chemistry and that it plays a key role in assuring quality in (bio)chemical information. Each chapter ends with a set of questions answered in Annex 2 for students to self-assess their learning. Also, the book includes a highly instructional glossary of terms in Annex 1. All topics are discussed in an orderly, clear manner.

To our minds, this book is a major contribution to a much needed shift from obsolete teaching practices to active, student-driven learning. Undergraduates not only in chemistry, but also in medicine, biology, pharmacy, and environmental science will surely benefit from its contents and structure, which convey a faithful image of Analytical Chemistry: a first-hand choice for solving a myriad of real-life problems with appropriate, fully validated methods.

With the current growing use of information and communication technologies at university, the image-based approach followed in the book makes it a convenient tool for teachers and students alike. We are certain that the English edition will be highly successful.

February 2017

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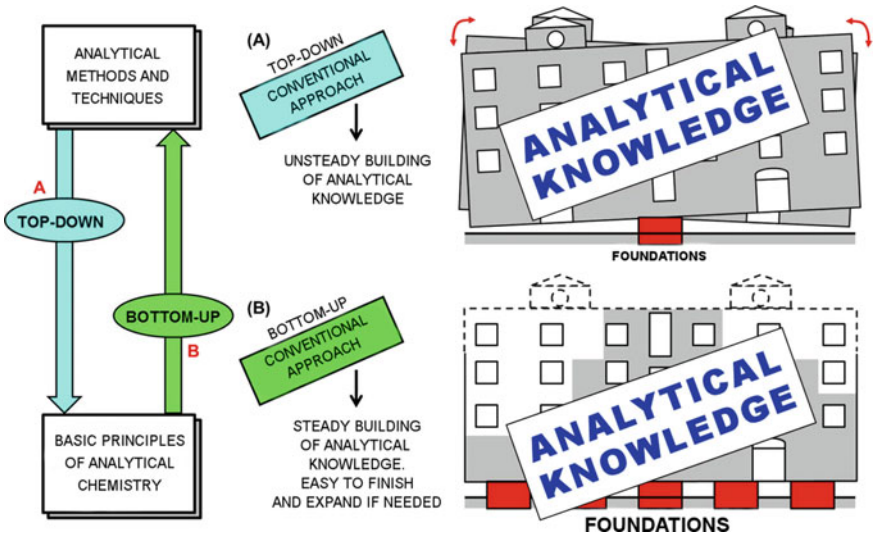
Preface

The authors were compelled to write this book by two main "drivers." One was their wish to further endorse the strategic significance of the true fundamentals of Analytical Chemistry in order to help students first approaching this discipline to understand them and to erect their "analytical chemical building" on solid foundations.



Two opposite approaches to the teaching and learning of Analytical Chemistry in undergraduate curricula. The traditional, top-down approach, which goes from descriptions to fundamentals, leads to an unsteady building and to abilities prevailing over attitudes. On the other hand, the bottom-up approach, which is used in this book, goes from fundamentals to the description of methods and techniques in order to construct a solid, steady building that can be completed with further analytical chemical subjects

The twofold primary aim of this book is to have students acquire a truthful image of Analytical Chemistry in order to develop abilities and attitudes that are consistent with the essence of the discipline, and to provide a firm background for addressing

other analytical chemical subjects (e.g., analytical separation systems, instrumental analysis).

Rather than to prepare the typical lectures for delivery in the classroom, this book requires teachers to contextualize concepts, emphasize especially relevant notions, support their messages with examples, and respond to students' questions. This novel teaching approach certainly calls for some changes in lecturers' traditional role.

The authors' second "driver" for writing this book was their commitment to teaching innovation in a subject that is initially difficult to understand. For this reason, the book contains a large collection of animated PowerPoint slides that are individually explained with text and illustrated with many examples testifying to the roles of Analytical Chemistry in today's world. This new teaching approach is expected to change the minds of those students who might initially be reluctant to be taught slide-driven lessons.

Because of its unusual teaching–learning standpoint, the preliminary sections of the book have been expanded with a technical introduction and a brief guideline for efficient use.

This book was previously released in Spanish by UCO Press (ISBN 978-84-9927-273-3) in January 2017. The authors are indebted to the publishing manager, Prof. Juan Pedro Monferrer Sala, for his support and help to have it released in English by Springer. Also, they wish to thank Antonio Losada, MSc, for his translation of the Spanish manuscript, and acknowledge the University of Córdoba for partial funding of the translation budget.

This book would never have been possible without the warm welcome and support of Dr. Steffen Pauly, Editorial Director of Springer.

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Contents

Introduction

This section describes the most salient technical features of the book and provides suggestions for use by lecturers and students.

Technical Features

To the authors' minds, the unconventional teaching–learning approach to the *Foundations of Analytical Chemistry* used in this book may be easier to follow if it is previously summarized in terms of its most salient features.

Relative importance of slides and text in the book

1. The primary goal is to *facilitate teaching and learning* of the cornerstones of Analytical Chemistry as the discipline responsible for analysis, which is the third basic component of chemistry in addition to theory and synthesis.
2. The book is intended to be used by *undergraduates* on various programs (e.g., chemistry, pharmacy, food technology, biology, biochemistry) being *exposed to Analytical Chemistry for the first time* in their studies (that is, by young students with a limited scientific and technical background). To ease their first encounter with Analytical Chemistry, the authors have produced slides and accompanying text that are straightforward and easy to understand; also, they have strived to explain analytical chemical concepts with reference to a large number of real-life examples for even easier understanding. The fact that one

of the authors M.A. López-Jiménez is a chemistry undergraduate is expected to help convey the book's teaching message from a student's viewpoint.

3. One other major goal of the book is to *dismiss the wrong view of Analytical Chemistry* acquired by students who are directly introduced to concepts such as ionic equilibria, chemical calculations. Such is the case, for example, with the classic book *Analytical Chemistry*, by Gary Christian et al., now in its seventh edition (Wiley–VCH, USA, 2014). In fact, very few general analytical chemistry textbooks start with topics other than calculations or equilibria. Insisting on dealing with ionic equilibria as if they belonged in the *Foundations of Analytical Chemistry* in the twenty-first century is a gross error that seriously damages its image and should be avoided at any rate.
4. The book comprises *two distinct but mutually consistent elements*, namely a collection of more than three hundred, mostly animated, slides, which is its greatest strength, and explanatory text for each individual slide. In addition, it contains a glossary of terms and the answers to all questions posed in the nine chapters—240 in all.
5. The *book contents* are organized in three parts consisting of three chapters each. Part I is concerned with the principles of Analytical Chemistry, Parts II with the processes used to obtain (bio)chemical information from objects and systems, and Part III with the socioeconomic impact of the discipline.
6 *Each slide is unequivocally identified* by the number of the chapters where it appears, followed by that in the chapter sequence. Thus, Slide 2.5 is the fifth slide in Chap. 2. Also, the elements appearing in animated slides are identified by a further number according to their place in the animation sequence. Thus, the three paragraphs explaining the sequence of notions in Slide 2.5 are numbered 2.5.1, 2.5.2, and 2.5.3.
7. Each chapter contains the following sections:

    1. An introductory part including a Summary, a list of the chapter sections and subsections, and the teaching objectives to be fulfilled.
    2. Section X.1 (X being the chapter number) explains each individual slide. This section accounts for about 85% of the text in each chapter.
    3. Section X.2 provides students with suggested readings selected according to relevance and accessibility.
    4. Section X.3 is a list of questions on the chapter topic for students to answer. The questions are all answered in Annex 2 to facilitate self-assessment.
    5. Section X.4 is a proposal for shortening the chapter contents when delivered to undergraduates on programs other than chemistry.

8. *Internal consistency in the book contents* was permanently borne in mind in writing the text and is ensured by multiple cross-references to slides in other chapters. In this way, the chapters are not tight compartments bearing no mutual relationship; also, students are provided with an integral view of the discipline that is easier to understand.
9. The Glossary of Terms in Annex 1 briefly defines 250 keywords used in the book in order to acquaint students with *analytical chemical jargon*.

10. One other primary concern of the authors was to illustrate the book with appropriate examples of *required (bio)chemical information* and how to obtain it. The role of Analytical Chemistry is explained with real-life situations intended to arouse students' interest and to help them understand their implications.
11. Last but not least, Section X.4 in each chapter poses relevant questions and problems for students to review its contents and self-assess their learning. The questions are solved and problems worked out in Annex 2. In this way, continual evaluation is made possible.

Guidelines for Using the Book

Because this is an unusual book intended to facilitate the teaching–learning process, the authors wish to respectfully make some suggestions to students and lecturers in this respect.

Lecturers delivering a subject such as *Foundations of Analytical Chemistry* may feel that using a book that places the whole teaching material in students' hands will undermine their role as teachers. However, it is far from the authors' intention to replace the irreplaceable: the extremely high added value of taught lessons, personal teacher–student contact, doubt-solving sessions, online question posing, direct monitoring of students' progress, and continuous evaluation of their learning achievements.

Obviously, lecturing for students to simply take notes or merely going through slide contents in class is at the opposite end of the authors' proposal. What are lecturers expected to do then? Simply to be whole teachers, know their discipline in depth, use their own words to explain the slides—and connect their parts when needed—emphasize the relationships between concepts explained in other chapters, continuously interact with their students, help them with their doubts and the questions in each chapter, both in class and online, set up case-study seminars to solve specific analytical problems, and, especially, "conspire" to make students feel they are being permanently supported.

Students following the proposed teaching–learning approach will have to switch their mindsets if they are to improve their performance without resorting to the typical one-off efforts of traditional examinations. Because this book promotes and facilitates continuous evaluation of their progress, students should instead strive to (a) preview the slides for the topics to be dealt with in each lecture and read the accompanying text; (b) play an active role in lectures and seminars; (c) earn the lecturer's complicity, and (d) not learn contents by heart, but rather through dedicated, perseverant class and homework. The required switch in working method is almost certain to appeal to any student eager for change.

Part II
The Analytical Process

Part III
Socio-economic Projection of Analytical Chemistry