

Preface

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Overview

- A Organization
- B Role of Equilibrium Chemistry
- C Computational Software
- D How to Use The Electronic Textbook's Features
- E Acknowledgments

As currently taught in the United States, introductory courses in analytical chemistry emphasize quantitative (and sometimes qualitative) methods of analysis along with a heavy dose of equilibrium chemistry. Analytical chemistry, however, is much more than a collection of analytical methods and an understanding of equilibrium chemistry; it is an approach to solving chemical problems. Although equilibrium chemistry and analytical methods are important, their coverage should not come at the expense of other equally important topics. The introductory course in analytical chemistry is the ideal place in the undergraduate chemistry curriculum for exploring topics such as experimental design, sampling, calibration strategies, standardization, optimization, statistics, and the validation of experimental results. Analytical methods come and go, but best practices for designing and validating analytical methods are universal. Because chemistry is an experimental science it is essential that all chemistry students understand the importance of making good measurements.

My goal in preparing this textbook is to find a more appropriate balance between theory and practice, between “classical” and “modern” analytical methods, between analyzing samples and collecting samples and preparing them for analysis, and between analytical methods and data analysis. There is more material here than anyone can cover in one semester; it is my hope that the diversity of topics will meet the needs of different instructors, while, perhaps, suggesting some new topics to cover.

A Organization

This textbook is organized into four parts. Chapters 1–3 serve as a general introduction, providing: an overview of analytical chemistry (Chapter 1); a review of the basic equipment and mathematical tools of analytical chemistry, including significant figures, units, and stoichiometry (Chapter 2); and an introduction to the terminology of analytical chemistry (Chapter 3). Familiarity with this material is assumed throughout the remainder of the textbook.

Chapters 4–7 cover a number of topics that are important in understanding how analytical methods work. Later chapters are mostly independent of these chapters, allowing an instructor to choose those topics that support his or her goals. Chapter 4 provides a thorough introduction to the statistical analysis of data. Methods for calibrating equipment and standardizing methods are covered in Chapter 5, along with a discussion of linear regression. Chapter 6 provides an introduction to equilibrium chemistry, stressing both the rigorous solution to equilibrium problems and the use of semi-quantitative approaches, such as ladder diagrams. The importance of collecting the right sample, and methods for separating analytes and interferences are the subjects of Chapter 7.

Chapters 8–13 cover the major areas of analysis, including gravimetry (Chapter 8), titrimetry (Chapter 9), spectroscopy (Chapter 10), electrochemistry (Chapter 11), chromatography and electrophoresis (Chapter 12), and kinetic methods (Chapter 13). Related techniques, such as acid–base titrimetry and redox titrimetry, are intentionally gathered together in single chapters. Combining related techniques in this way encourages students to see the similarity between methods, rather than focusing on their differences. The first technique in each chapter is generally that which is most commonly covered in an introductory course.

Finally, the textbook concludes with two chapters discussing the design and maintenance of analytical methods, two topics of importance to all experimental chemists. Chapter 14 considers the development of an analytical method, including its optimization, its verification, and its validation. Quality control and quality assessment are discussed in Chapter 15.

B Role of Equilibrium Chemistry

Equilibrium chemistry often receives a significant emphasis in the introductory analytical chemistry course. Although it is an important topic, an overemphasis on the computational aspects of equilibrium chemistry may lead students to confuse analytical chemistry with equilibrium chemistry. Solving equilibrium problems is important—it is equally important, however, for students to recognize when such calculations are impractical, or to recognize when a simpler, more intuitive approach is all they need to answer a question. For example, in discussing the gravimetric analysis of Ag^+ by precipitating AgCl , there is little point in calculating the equilib-

rium solubility of AgCl because the equilibrium concentration of Cl^- is rarely known. It is important, however, for students to understand that a large excess of Cl^- increases the solubility of AgCl due to the formation of soluble silver–chloro complexes. To balance the presentation of a rigorous approach to solving equilibrium problems, this textbook also introduces ladder diagrams as a means for rapidly evaluating the effect of solution conditions on an analysis. Students are encouraged to use the approach best suited to the problem at hand.

C Computational Software

Many of the topics in this textbook benefit from the availability of appropriate computational software. There are many software packages available to instructors and students, including spreadsheets (e.g. Excel), numerical computing environments (e.g. Mathematica, Mathcad, Matlab, R), statistical packages (e.g. SPSS, Minitab), and data analysis/graphing packages (e.g. Origin). Because of my familiarity with Excel and R, examples of their use in solving problems are incorporated into this textbook. Instructors interested in incorporating other software packages into future editions of this textbook are encouraged to contact me at harvey@depauw.edu.

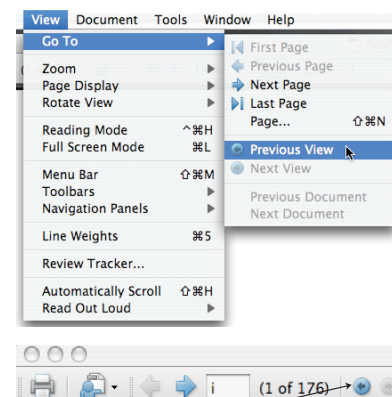
D How to Use The Electronic Textbook's Features

As with any format, an electronic textbook has advantages and disadvantages. Perhaps the biggest disadvantage to an electronic textbook is that you cannot hold it in your hands (and I, for one, like the feel of book in my hands when reading) and leaf through it. More specifically, you cannot mark your place with a finger, flip back several pages to look at a table or figure, and then return to your reading when you are done. To overcome this limitation, an electronic textbook can make extensive use of hyperlinks.

Whenever the text refers to an object that is not on the current page—a figure, a table, an equation, an appendix, a worked example, a practice exercise—the text is displayed in [blue and is underlined](#). Clicking on the hyperlink transports you to the relevant object. There are two methods for returning to your original location within the textbook. When there is no ambiguity about where to return to, such as when reviewing an answer to a practice exercise, a second [text hyperlink](#) is included.

Most objects have links from multiple places within the text, which means that a single return hyperlink is not possible. To return to your original place select **View: Go To: Previous View** from the menu bar. If you do not like to use pull down menus, you can configure the toolbar to include buttons for “Previous View” and for “Next View.” To do this, click on **View: Toolbars: More Tools...**, scroll down to the category for **Page Navigation Tools** and check the boxes for **Previous View** and for **Next View**. Your toolbar now includes buttons that you can use to return to your

Although you can use any PDF reader to read this electronic textbook, the use of Adobe's Acrobat Reader is strongly encouraged. Several features of this electronic textbook—notably the commenting tools and the inclusion of video—are available only when using Acrobat Reader 8.0 or later. If you do not have Acrobat Reader installed on your computer, you can obtain it from [Adobe's website](#).



Click this button to return to your original position within the text

original position within the text. These buttons will appear each time you open the electronic textbook.

There are several additional hyperlinks to help you navigate within the electronic textbook. The Table of Contents—both the brief form and the expanded form—provide hyperlinks to chapters, to main sections, and to subsections. The “Chapter Overview” on the first page of each chapter provides hyperlinks to the chapter’s main sections. The textbook’s title, which appears at the top of each even numbered page, is a hyperlink to the brief table of contents, and the chapter title, which appears at the top of most odd numbered pages, is a hyperlink to the chapter’s first page. The collection of key terms at the end of each chapter are hyperlinks to where the terms were first introduced, and the **KEY TERMS** in the text are hyperlinks that return you to the collection of key terms. Taken together, these hyperlinks provide for a easy navigation.

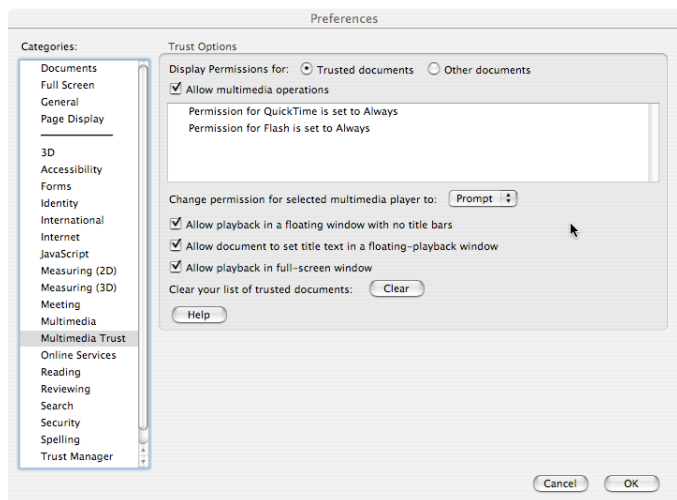
If you are using Adobe Reader, you can configure the program to remember where you were when you last closed the electronic textbook. Select **Adobe Reader: Preferences...** from the menu bar. Select the category “Documents” and check the box for “Restore last view settings when re-opening documents.” This is a global change that will affect all documents that you open using Adobe Reader.

There are two additional features of the electronic textbook that you may find useful. The first feature is the incorporation of QuickTime and Flash movies. Some movies are configured to run when the page is displayed, and other movies include start, pause, and stop buttons.

If you find that you cannot play a movie check your permissions. You can do this by selecting **Adobe Reader: Preferences...** from the menu bar. Choose the option for “Multimedia Trust” and check the option for “Allow multimedia operations.” If the permission for QuickTime or Flash is set to “Never” you can change it to “Prompt,” which will ask you to authorize the use of multimedia when you first try to play the movie, or change it to “Always” if you do not wish to prevent any files from playing movies.

A second useful feature is the availability of Adobe’s commenting tools, which allow you to highlight text, to create text boxes in which you can type notes, to add sticky notes, and to attach files. You can access the commenting tools by selecting **Tools: Commenting & Markup** from the menu bar.

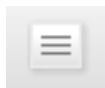
If you do not like to use the menu bar, you can add tools to the toolbar by selecting **View: Toolbars: Commenting & Markup** from the menu bar. To control what appears on the toolbar, select **View: Toolbars: More Tools...** and check the boxes for the tools you find most useful. Details on some of the tools are shown here. You can alter any tool’s properties, such



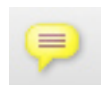
as color, by right-clicking on the tool and selecting **Tool Default Properties...** from the pop-up menu.



These tools allow you to highlight, to underline, and to cross out text. Select the tool and then click and drag over the relevant text.



The text box tool allows you to provide short annotations to the textbook. Select the tool and then click and drag to create a text box. Click in the textbook and type your note.



The sticky note tool is useful when you have a longer annotation or when you want to make your annotation easier to see. Click in the textbook at the spot where you wish to add the sticky note. Type your entry and then click the close button to collapse the note into its icon. Hovering the cursor over the icon displays the note and clicking on the icon allows you to edit your note.



The pencil tool allows you to use your mouse to write notes on the text. The eraser tool allows you to erase notes.



The paperclip tool allows you to attach a file to the textbook. Select the tool and click in the textbook at the spot where you wish to attach the file. Use the browser to find the file and select OK. The resulting icon is a link to the file. You can open the file by clicking on the icon.

E Acknowledgments

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HOW TO CONTACT THE AUTHOR

Working on this textbook continues to be an interesting challenge and a rewarding endeavour. One interesting aspect of electronic publishing is that a book is not static—corrections, new examples and problems, and new topics are easy to add, and new editions released as needed. I welcome your input and encourage you to contact me with suggestions for improving this electronic textbook. You can reach me by e-mail at harvey@depauw.edu.