Overview of the Text

This text is intended for a one-semester course in Analytical Chemistry or Quantitative Analysis. Many topics follow directly from freshman-level general chemistry, and the level of the text is aimed at sophomore-level college students. Compared to most other texts on this subject, this text is less encyclopedic and more cohesive in building upon prior topics. It uses a spiraling approach to try to achieve better retention of the underlying concepts. Spreadsheet use is integrated throughout the chapters.

Focus and Features

The topics in the text are foundational material for students in chemistry, life sciences, and other technical fields. The overall theme is on making measurements and reporting results correctly. The text stresses fundamental concepts such as calibration, chemical equilibria, and it introduces the most common instrumental analytical methods. To support this objective I follow a traditional selection of topics, i.e., including how aqueous equilibria impacts analyte chemistry during a measurement.

There are two sets of spreadsheets for student use. The first set serves as general tools for various calculations and plots that are common in analytical chemistry:

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Spreadsheet Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>formula weight calculation</td>
<td>formula-wt-calculator.xlsx</td>
</tr>
<tr>
<td>liquid-liquid extraction efficiency</td>
<td>extraction.xlsx</td>
</tr>
<tr>
<td>ionic strength/activity coefficient calculations</td>
<td>activity-coefficients.xlsx</td>
</tr>
<tr>
<td>pH calculation (weak acid/weak base/buffer)</td>
<td>pH-calculation.xlsx</td>
</tr>
<tr>
<td>polyprotic acid alpha plots</td>
<td>alpha-plot-polyprotic-acid.xlsx</td>
</tr>
<tr>
<td>metal-ligand complex alpha plots</td>
<td>alpha-plot-ML-complexes.xlsx</td>
</tr>
<tr>
<td>intrinsic solubility calculation</td>
<td>solubility.xlsx</td>
</tr>
</tbody>
</table>

The second set of spreadsheets, you-try-it-#.xlsx files, is keyed to the individual chapters of the text. You-try-it boxes placed at appropriate places within each chapter refers the student to a specific worksheet, which contains relevant calculational or plotting exercises. There is also a step-by-step guide available online for each you-try-it spreadsheet.

The spreadsheets were developed in Excel 2007 and saved in both Excel 2003 and Excel 2007 formats. The overall layout is the same in all spreadsheets, with an initial worksheet labeled ‘Notes’ providing an overview and some background information. Files are being updated throughout summer 2009, and the spreadsheets and other resources are maintained on a text support website:

http://www.files.chem.vt.edu/chem-ed/a-text/index.html

Scope

The text is organized into three parts to arrange the individual chapters into a cohesive whole:

Part I - Quantitative analysis using reactions that go to completion.
Part II - Reactions that do not go to completion: Equilibria in aqueous solutions.
Part III - Instrumental methods and analytical separations.

There is extensive spiraling, both in revisiting prerequisite general chemistry topics and within the text. For example, equilibrium calculations, usually learned as an algorithmic process in general chemistry, are
first evaluated to determine the effect of ionic strength and the need to correct the equilibrium constant, before setting down the actual calculation. As an example within the text, separation concepts are introduced in Chapter 2 for extraction and chromatographic sample preparation and then revisited in Chapter 12 on instrumental separations.

Improving student problem solving skills is assisted with the you-try-it spreadsheets and step-by-step guides. By assigning deadlines to these work-along exercises, they will assist student’s time on task. A major challenge in teaching is getting students to read a text. My goal is to create a streamlined and integrated text that will be read by students, with better outcomes for learning and retention.

The coverage of the text follows in the next several tables. Within each chapter I’ve categorized the topics as either a review or new topic. The distinction between these two categories is not sharp. Some students will not have exposure to some topics that I consider “review,” and other students will have some knowledge of the topics that I label as “new.”

**Part I: Quantitative analysis using reactions that go to completion.**

| Chapter 1 Introduction to Analytical Measurements | review: accuracy and systematic error  
precision and random error | new: good-laboratory practice (GLP)  
calibration  
sampling |
| --- | --- | --- |

| Chapter 2 Sample Preparation, Extractions, and Chromatography | review: solvents  
solutions  
solubility | new: sample preparation  
extraction, including solid-phase (SPE)  
introduction to chromatography |

| Chapter 3 Classical Methods | review: types of chemical reactions  
equilibrium concepts and conventions | new: gravimetry  
titration and titration curves  
coulometry |

| Chapter 4 Molecular Spectroscopy | review: electromagnetic radiation  
electromagnetic spectrum  
spectroscopic transitions | new: UV-vis absorption spectroscopy  
Beer-Lambert law  
molecular fluorescence |

**Part II Reactions that do not go to completion: Equilibria in aqueous solutions.**

| Chapter 5 Acid-Base Equilibria and Activity | review: acids and bases  
water and $K_w$ | new: relative acid strength  
ionic strength and activity  
acid-base equilibrium calculations |

| Chapter 6 Buffer Solutions and Polyprotic Acids | review: buffer solutions  
polyprotic acids | new: weak acid titration curve  
alpha fraction plots |

| Chapter 7 Complex Equilibria | review: complex terminology | new: competing equilibria |
complex equilibria | stepwise complexation

Chapter 8 Insoluble Salts and Precipitation Equilibria

review: precipitate equilibrium
molar solubility

new: precipitation and competing equilibria

Chapter 9 Reduction and Oxidation Reactions

review: introduction
standard reduction potentials
Nernst equation
electrochemical cells

new: spontaneous reactions and equilibrium

Part III Instrumental methods and analytical separations.

Chapter 10 Electroanalytical Chemistry

review: potentiometry

new: ion-selective electrodes (ISE)
voltammetry

Chapter 11 Atomic Spectroscopy and Mass Spectrometry

review: ---

new: atomic absorption spectroscopy (AAS)
atomic emission spectroscopy (AES)
introduction to mass spectrometry (MS)
advanced topic: interaction of radiation with matter

Chapter 12 Analytical Separations

review: ---

new: thin-layer chromatography (TLC)
high performance liquid chromatography (HPLC)
gas chromatography (GC)
electrophoresis

Part IV Appendices.

Appendix A: Spreadsheets and Statistics

review: truncating insignificant figures
standard deviation

new: Excel use and statistical functions
standard error and confidence intervals
rejecting a suspected outlier
linear regression and calibration curve

Other Appendices provide numerical values of equilibrium constants, physical constants, and other useful information.