Review of A Life Scientist's Guide to Physical Chemistry

ARTICLE *in* JOURNAL OF CHEMICAL EDUCATION · AUGUST 2013

Impact Factor: 1.11

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JOURNAL OF CHEMICAL EDUCATION

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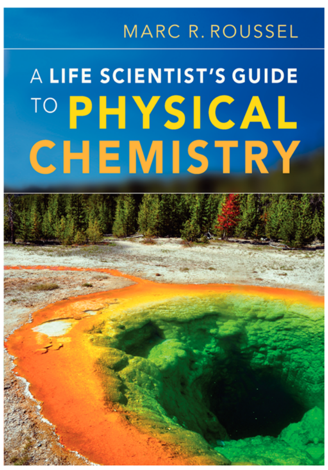
A Life Scientist's Guide to Physical Chemistry, by Marc R. Roussel. Cambridge University Press: Cambridge, U.K., 2012. 442 pp. ISBN: 978-1107006782 (paperback). $60.

Much has been written on the topic of increasing the interdisciplinary approach to undergraduate science education to include enhancing the level of mathematics and physical sciences in life science programs.[1−3] Many faculty believe increasing mathematics and physical sciences components of these programs results in students better prepared for professions that deal with biological systems. As a result of this educational movement, undergraduate physical chemistry course texts with an emphasis on biological systems have proliferated.[4−7] Marc R. Roussel of the University of Lethbridge, Alberta, Canada has written an excellent addition to the list, *A Life Scientist's Guide to Physical Chemistry*. Roussel designed his text to engage life science students by exploring topics of biological interest through a conversational style to illuminate the underlying techniques and procedures of physical chemistry as applied to these topics. In this regard, the book is very successful.



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A Life Scientist's Guide to Physical Chemistry is designed to support a one-semester course and is presented in three parts: quantum mechanics and spectroscopy; thermodynamics; and kinetics. Part 1 introduces quantum mechanics and spectroscopy; at 49 pages, it is the shortest of the three parts. It begins with a chapter titled "A Quick Tour of Quantum Mechanical Ideas" that introduces basic concepts as a lead in to the following chapter titled "Spectroscopy". The quantum mechanics overview includes basics of light, wave, and particle properties, quantization, and concludes with a brief development of the one-dimensional particle-in-a-box model. The one-dimensional box uses the practical example of conjugated cyanine dyes to apply the model to a system of chemical interest. The spectroscopy chapter covers the basics, including a nice section on the Boltzmann distribution. Roussel then breaks spectroscopy into the three broad classes of absorption, emission, and scattering, and provides brief examples with mathematical development of each of the classes. The section on Beer−Lambert is excellent and builds on the fundamentals most students learn in the introductory chemistry and biology courses. Likewise, the section on fluorescence quenching and energy transfer nicely develops the fundamentals of FRET spectroscopy. Beer−Lambert and FRET are likely of great interest to biologically oriented students, and Roussel's development of these topics makes physical chemistry relevant to students' experiences. An area that would enhance Part 1 of the text would be more detailed examination of NMR and MRI using physical chemistry techniques, as students have been introduced to this spectroscopic technique in their organic courses. As the organic course typically stresses how to analyze spectra to elucidate structure, quantum mechanical discussion of NMR and MRI would complement and provide further relevance to physical chemistry techniques.

Thermodynamics is the topic of Part 2 of the text. Roussel presents a conversational, yet thorough development of the three laws, free energy, and chemical equilibrium. Part 2 has 162 pages divided into seven chapters. The mathematical development is straightforward and targeted at upper-level undergraduates; numerous examples and problems reinforce the tools and techniques of physical chemistry applied to systems of biological interest, such as catabolizable energy and ATP hydrolysis. The thermodynamics section also includes chapters on nonideal behavior and electrochemistry. The nonideal behavior chapter includes development of Debye−Hückel theory of ions in dilute solutions, along with several example problems. The electrochemistry chapter includes a great application of fundamentals to explore the trans-membrane potential in living cells.

Roussel covers kinetics in Part 3, which includes eight chapters over 153 pages. In order, the chapters are the following: "Basics of Chemical Kinetics", "Initial Rate Experiments and Simple Empirical Rate Laws", "Integrated Rate Laws", "Complex Reactions", "Enzyme Kinetics", "Techniques for Studying Fast Reactions", "Factors That Affect the Rate Constant", and "Diffusion and Reactions in Solution". The integrated rate laws chapter includes a section on fluorescence kinetics, which relates directly to FRET spectroscopy Roussel introduced in the spectroscopy chapter, including an example of the kinetics of cameleon protein fluorescence kinetics. The chapter on enzyme kinetics is straightforward in its development of rate laws. The section on Michaelis−Menten is excellent and students should appreciate its step-by-step

Published: August 21, 2013

structure. The discussion on the limitations of the Lineweaver–Burk plot are sure to be illuminating for students, and his presentation of the alternative Eadie–Hofstee plot provides a contrasting method for students to consider. Roussel develops the Arrhenius equation by using the Boltzmann equation introduced in the spectroscopy chapter, providing another nice tie-in for students. There is a section on transition state theory and Eyring plots, with several biological examples using these concepts. The final chapter covers diffusion and reactions in solution. Roussel develops Fick's laws, the Stokes–Einstein relationship, the Grotthuss mechanism for proton diffusion, and concludes with several examples of macromolecules in solutions.

The text also has a wonderful set of appendices that include the following: thermodynamic data, standard reduction potentials, physical properties of water, SI units, constants and conversions, periodic table, isotopic masses, exponential and logarithmic functions, and integral calculus. One appendix offers additional review problems and answers to the exercises within the chapters. Inclusion of the answers, many with explanations of how the answers were attained, is most useful for students and keeps them from having to purchase a supplemental "solutions manual", as with many other texts. The thorough set of appendices makes the text a stand-alone resource for most students as there will be little information students must search for from other reference material. The text includes many worked example problems within each chapter, in-chapter exercise problems for students to work as they are studying each section, and a set of review exercise problems at the end of each chapter.

Overall, *A Life Scientist's Guide to Physical Chemistry* is a great text to support a one-semester undergraduate course in physical chemistry. It strengths are a student-friendly writing style, sufficient mathematical rigor without becoming mathematics-onerous, and a nice focus on thermodynamics and kinetics. For faculty seeking a text to support more depth in quantum mechanics and spectroscopy as applied to life science systems, Roussel's text is a good start, but would require supplementary materials to further develop these topics.

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Notes

The authors declare no competing financial interest.

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