Book & Media Reviews

Chemical Kinetics and Reaction Dynamics

by Paul L. Houston

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reviewed by John Krenos

Paul Houston's *Chemical Kinetics and Reaction Dynamics* is a teaching text, not a reference work; an intriguing treat, not a daunting treatise. The author's aim is to teach the underlying principles of kinetics and dynamics through relevant examples and current research. Houston places great stress on the words *modern* and *clarity*. The book is richly illustrated and nicely balanced. The treatment of essential background material (chapters on kinetic theory, reaction rates, theories of chemical reaction, and transport properties) establishes a firm foundation for the development of specialized applications (chapters on liquid solutions, solid surfaces, photochemistry, and molecular reaction dynamics). Houston uses many clever examples to enhance basic understanding before introducing more specialized applications. Up-to-date technical methods are covered in separate sections, appendices, and problem sets. Extra mathematical detail, if needed, is provided in appendices at chapter's end. Houston concludes each chapter with a summary section recapitulating chapter highlights and key concepts followed by an extensive and useful list of suggested readings. Problems are generally ample in number; answers and solutions to a selected number of them are given in the back. The first few problems in each chapter are mostly conceptual, of the short-answer or multiple-choice variety. According to the publisher, a separate solutions manual for all 144 problems is available as a supplement containing detailed explanations, diagrams, and references to original sources.

The introduction section is particularly useful for instructors. Houston breaks the material into fundamental, supplemental, and advanced topics in a helpful flowchart. He assigns approximate lecture times to each suggested group of sections. This is important for instructors who labor under different semester or quarter lengths. A 14-week semester easily accommodates the material in the entire text, but much of the material can be covered in semesters of shorter duration. Because chapters are mostly independent of each other, instructors have the flexibility to adapt the text to a variety of syllabi. The text is suitable for advanced undergraduate and introductory graduate courses. It is also a useful resource for instructors of physical chemistry seeking insight into how chemical reactions occur.

The coverage of essential material is thorough and complete. I especially appreciate the beginning chapter on kinetic theory, the underpinning of modern chemical kinetics. The level of treatment is on par with that in most physical chemistry textbooks; the number of problems is ample. Unusual examples within the chapter relate the student to common experience. In one case, Houston uses the grade distribution on a class exam for an introduction to averages; in another, the attraction of bees to honey to illustrate probability density; and in still another, the size, number, and speed of skaters on a rink to explore collision frequency. Mathematics is introduced as needed and explained with care. The chapter on chemical reaction rates is lengthy and includes mechanisms as well as rate laws. Important mechanisms, such as Lindemann for unimolecular decay and Michaelis–Menten for enzyme catalysis, are treated in depth. The basic theories of chemical kinetics (collision theory and activated complex theory) are treated somewhat sketchily in the third chapter. The material is fleshed out, however, in the problems and in the applications developed in later chapters. Highlights of examples from an excellent chapter on transport properties include the heat flow through fiberglass insulation and the distance traveled by a gas-phase molecule in one day by diffusion (contrasted with convection).

Houston begins the chapter on reactions in liquid solutions with the cage effect, treated on the molecular level through evolution of cluster growth leading to formation of solvent. A nifty derivation of the Marcus theory treatment of electron transfer is another highlight. Experimental techniques such as temperature jump and ultrafast lasers provide a nice finishing touch. A few more problems, however, are needed. The chapter on surface reactions is also comprehensive and up to date. Important advanced topics covered include surface diffusion, temperature-programmed desorption, and modulated molecular beam methods.

Up next is photochemistry, one of Houston's research specialties. There is excellent material here on photophysical processes and atmospheric chemistry. Houston develops the advanced topic of photodissociation dynamics by providing thoroughly explored sections on pump-probe techniques, laser-induced fluorescence, multiphoton ionization, unimolecular dissociation (RRKM theory developed and applied), photofragment angular distributions, and photochemistry on very short time scales. Last, but hardly least, is the pièce de résistance, the capstone chapter on molecular reaction dynamics. Treated here are sections on chemical lasers, molecular scattering, potential energy surfaces, and molecular energy transfer. The chapter ends in a crescendo with superb performances of orientation effects, bond-selective chemistry, and van der Waals complexes.

Paul Houston is an outstanding scientist working in the areas of chemical reaction and photodissociation dynamics; this book demonstrates that he is a gifted educator as well. As one who has taught a graduate course in chemical kinetics on and off for over 25 years, I am eager to put his text to the test under classroom conditions. For physical chemists everywhere, *Chemical Kinetics and Reaction Dynamics* merits a prominent spot on your bookshelf.

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