

Physical Chemistry for the Life Sciences

Second Edition

Peter Atkins, University of Oxford, and Julio de Paula, Lewis & Clark College, USA

NEW EDITION

- Offers a fully integrated approach to the study of physical chemistry and biology; lecturers and students alike have a text that is truly tailor-made for their course.

New to this edition

- Significant revision of the 'Fundamentals' chapter, to include Boltzmann theory and structural biology.
- New and expanded coverage of numerous topics, including Hückel and Ligand theories.
- New learning features, including Equation and Concept tags, used to flag up key pieces of information about equations, and Mathematical Toolkits, to deepen your understanding of mathematical concepts.
- 'Atlas' of biomolecular structures at the back of book depict the three-dimensional structures of a range of important biomolecules.

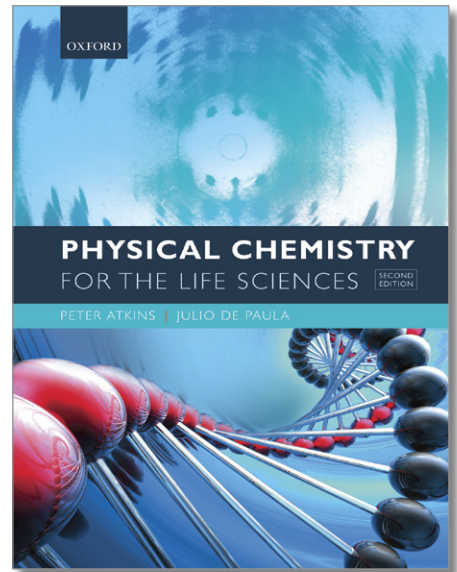
Physical Chemistry for the Life Sciences provides a balanced presentation of the concepts of physical chemistry, and their extensive applications to biology and biochemistry. It is written to straddle the worlds of physical chemistry and the life sciences and to show students how the tools of physical chemistry can elucidate and illuminate biological questions.

Physical Chemistry for the Life Sciences places emphasis on clear explanations of difficult concepts, with an eye toward building insight into biochemical phenomena. An extensive range of learning features, including worked examples, illustrations, self-tests, and case studies, support student learning throughout, while special attention is given to providing extensive help to students with those mathematical concepts and techniques that are so central to a sound understanding of physical chemistry.

Balancing clarity and rigor of exposition of basic concepts with extensive discussion of biological techniques and processes, Physical Chemistry for the Life Sciences is the perfect resource for every life science student who seeks to master those essentials of physical chemistry that underpin life itself.

Readership: First and second year undergraduates taking a first course in physical chemistry as part of a life science, biological chemistry, or biochemistry degree programme.

680 pages 2010 978-0-19-956428-6 Paperback £34.99



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- List of key equations for each chapter
- Living graphs, which present graphs from the text in interactive format
- Three-dimensional, interactive models of the biomolecules appearing in the end-of-book atlas of structures

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Microscopic systems and quantization

The first goal of our study of biological molecules and assemblies is to gain a firm understanding of their ultimate structural components, atoms. To make progress, we need to become familiar with the principal concepts of quantum mechanics, the most fundamental description of matter that we currently possess and the only way to account for the structures of atoms. Such knowledge is applied to rational drug design (see the chapter) when computational chemists use quantum mechanical concepts to predict the structures and reactivities of drug molecules. Quantum mechanical phenomena also form the basis for virtually all of the models of spectroscopy and microscopy that are now central to investigations of composition and structure in both chemistry and biology. Present-day techniques for studying biochemical reactions have progressed to the point where the information is so detailed that quantum mechanics has to be used in its interpretation.

Atomic structure—the arrangement of electrons in atoms—is an essential part of chemistry and biology because it is the basis for the description of molecular structure and molecular interactions. Indeed, without intimate knowledge of the physical and chemical properties of elements, it is impossible to understand the molecular basis of biochemical processes, such as protein folding, the formation of cell membranes, and the storage and transmission of information by DNA.

Principles of quantum theory

The role—indeed, the existence—of quantum mechanics was appreciated only during the twentieth century. Until then it was thought that the motion of atomic and subatomic particles could be expressed in terms of the laws of classical mechanics introduced in the seventeenth century by Isaac Newton (see Fundamentals 1.3). For these laws were very successful at explaining the motion of planets and everyday objects such as projectiles and projectiles. Classical physics is based on three 'classical' assumptions:

1. A particle travels in a trajectory, a path with a precise position and momentum at each instant.
2. Any type of motion can be excited to a state of arbitrary energy.
3. Waves and particles are distinct concepts.

These assumptions agree with everyday experience. For example, a pendulum swings with a precise oscillating motion and can be made to oscillate with any energy simply by pulling it back to an arbitrary angle and then letting it swing freely. Classical mechanics lets us predict the angle of the pendulum and the speed at which it is swinging at any instant.

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Towards the end of the nineteenth century, experimental evidence accumulated showing that classical mechanics failed to explain all the experimental evidence on very small particles, such as individual atoms, nuclei, and electrons. It took until 1926 to identify the appropriate concepts and equations for describing them. We now know that classical mechanics is in fact only an approximate description of the motion of particles and that the approximation is invalid when it is applied to molecules, atoms, and electrons.

9.1 The emergence of the quantum theory

The structure of biological matter cannot be understood without understanding the nature of electrons. Moreover, because many of the experimental tools available to biochemists are based on interactions between light and matter, we also need to understand the nature of light. We shall see, in fact, that matter and light have a lot in common.

Quantum theory emerged from a series of observations made during the late nineteenth century, from which two important conclusions were drawn. The first conclusion, which countered what had been supposed for two centuries, is that energy can be transferred between systems only in discrete amounts. The second conclusion is that light and particles have properties in common: electromagnetic radiation (light), which had long been considered to be a wave, in fact behaves like a stream of particles, and electrons, which since their discovery in 1897 had been supposed to be particles, in fact behave like waves. In this section we review the evidence that led to these conclusions, and establish the properties that a valid system of mechanics must accommodate.

(a) Atomic and molecular spectra

A spectrum is a display of the frequencies or wavelengths (which are related by $\lambda = c/\nu$, see Fundamentals 1.3) of electromagnetic radiation that are absorbed or emitted by an atom or molecule. Figure 9.1 shows a typical atomic emission spectrum and Fig. 9.2 shows a typical molecular absorption spectrum. The obvious feature of both is that radiation is absorbed or emitted at a series of discrete frequencies. The emission or absorption of light at discrete frequencies can be understood if we suppose that

- the energy of the atoms or molecules is confined to discrete values, for then energy can be discarded or absorbed only in packets as the atom or molecule jumps between its allowed states (Fig. 9.3)
- the frequency of the radiation is related to the energy difference between the initial and final states.

These assumptions are brought together in the Bohr frequency condition, which relates the frequency ν (and of radiation to the difference in energy ΔE between two states of an atom or molecule:

$$\Delta E = h\nu$$

where h is the constant of proportionality. The additional evidence that we describe below confirms this simple relation and gives the value $h = 6.626 \times 10^{-34}$ J s. This constant is now known as Planck's constant, for it arose in a context that had been suggested by the German physicist Max Planck.

At this point we can conclude that one feature of nature that any system of mechanics must accommodate is that the internal modes of atoms and molecules

Review from previous edition
An excellent textbook - fun to read and crystal clear.
Dr Hans A. Heus, Radboud University Nijmegen

Chemistry for the Biosciences

The Essential Concepts

Second Edition

Jonathan Crowe and Tony Bradshaw, Oxford Brookes University

Chemistry for the Biosciences leads students through the essential concepts that are central to understanding biological systems, using everyday examples and analogies to build their confidence in an often daunting subject. Placing an emphasis on clear, straightforward explanations, it fosters understanding as opposed to rote learning; by using relevant biological examples throughout, it illustrates just how integral chemistry is to the biosciences.

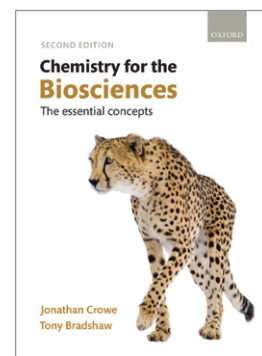
With scientific research placing more emphasis on the interface of chemistry and biology than ever before, few cannot argue that mastering some essential chemical concepts is central to fully understanding biology itself. *Chemistry for the Biosciences* is the ideal teaching and learning resource to ensure today's biology students grasp these concepts, and appreciate their importance throughout the subject.

Readership: Foundation level and first year undergraduate bioscience students, particularly those without A-level chemistry.

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“The text is clear and precise, and at times utterly delightful, with fantastic analogies that have remained in my head for weeks after reading it.”

**Kirsty MacLeod, 4th year Zoology student,
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Principles and Problems in Physical Chemistry for Biochemists

Third Edition

Nicholas C. Price, University of Glasgow, Raymond A. Dwek, University of Oxford, R. G. Ratcliffe, University of Oxford, Mark Wormald, Glycobiology Institute and University of Oxford

Principles and Problems in Physical Chemistry for Biochemists starts by introducing the laws of thermodynamics, and then uses these laws to derive the equations relevant to the student in dealing with chemical equilibria (including the binding of small molecules to proteins), properties of solutions, acids and bases, and oxidation-reduction processes. The student is thus shown how a knowledge of thermodynamic qualities makes it possible to predict whether, and how, a reaction will proceed.

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INTRODUCTION; The consequences of physics and chemistry for life; **THE ENERGETICS OF CHEMICAL REACTIONS;** Basic thermodynamics; Chemical potential and multiple component systems; Binding of ligands to macromolecules; Acids, bases and pH regulation; Oxidation-reduction reactions and electrochemistry; Properties of solutions; Ideal and non-ideal systems; **THE RATES OF CHEMICAL REACTIONS;** Basic chemical kinetics and single-step reactions; Applications of chemical kinetics to multi-step reactions; Catalysis and enzyme kinetics; Multi-substrate enzyme kinetics and enzyme inhibition; Coupled reactions and biochemical pathways; **ATOMIC AND MOLECULAR STRUCTURE;** Quantum mechanics: particles, waves and the quantization of energy; Electrons in atoms; Bonding in molecules; Introduction to atomic and molecular spectroscopy; Non-covalent interactions and macromolecular structure; Appendices; Note on units and constants; Mathematical tools needed for this text; Answers to problems

Readership: Undergraduates in biological sciences and biochemistry

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“Remarkably efficient [at] putting across conceptually difficult material ... *Principles and Problems* will continue to be essential reading for biochemistry undergraduates.”

The Biochemist

