balance. On the other hand, the treatment of branch points is less clear. For instance, the section on Coulomb scattering omits any specification of branch cuts, so that one must read equation (1.54) as an act of faith. In contrast, the discussion of the multivalued nature of fourth-order Runge–Kutta procedures is excellent. It is, perhaps, understandable that the complex angular-momentum and particle separation planes are neglected, as are such unifying concepts as unitarity, analyticity and symmetry.

Perhaps the reader should be warned that computer time is finite and that the art of heavy-particle, as against electron-atom, collision spectroscopy is often best served by first reducing the close-coupling equations from second to first order by judicious use of the JWKB approximation. Although much has been published in the two years since the most recent of the cited references, many should find the book valuable, if slightly expensive.

In the preface of his book on scattering theory Dr Taylor expresses the hope of bringing the student of atomic or nuclear physics to the point where he can begin reading the literature and tackling real problems, with a complete grasp of the underlying principles. Provided it is understood that literature in this context refers not only to the journal literature but also, with priority, to the specialist atomic or nuclear texts, some of which appear in the bibliography, then this hope would appear not unduly optimistic. The emphasis on formal scattering theory is certainly appropriate to the nuclear or elementary-particle physicist. The atomic-physics student will find the book complementary to that of Dr Smith and will probably wish to browse from chapter 10 onwards, omitting the formalities of time-dependent theory. The sections dealing with the complex linear- and angular-momentum planes should be found particularly rewarding, as should those on invariance principles. Perhaps the reader might have preferred discussion of uniform convergence in connexion with Gauss convergence factors and Coulomb scattering, of momentum transfer factors in heavy-particle charge-transfer rearrangement collisions, and so on. Indeed, he might even object to some statements, for instance in the introduction, that the computation of the scattered and incident fluxes completely ignores the interference of the two waves; in fact the total flux density is given by

$$\left\{p - \frac{4\pi}{r^2}\,\delta(\hat{x} - \hat{r})\,\mathrm{Im}\,f\,(E,0)\right\}\hat{x} + \frac{p}{r^2}\,|f\,(E,\theta)|^2\,\hat{r} + O\,(r^{-3})$$

from which the usual results follow. Despite such quibbles, the more mathematically minded will in general find this a challenging and scholarly treatise well worth the expense and the effort of working through the reinforcing problems appended to each of the twenty-two chapters.

D. S. F. CROTHERS

Reactions in Solution

Mechanisms of Homogeneous Catalysis from Protons to Proteins. By Myron L. Bender. Pp. x+686. (Wiley: New York and London, December 1971.) £11.75.

FROM a chemist's point of view, the processes of life are chemical reactions proceeding in aqueous or partly aqueous phases. The chemist's contribution to their understanding has therefore, in the first place, been directed towards the study of simpler reactions in aqueous solution, on the assumption of the apparently self-evident axiom that the behaviour of complex systems cannot properly be rationalized before that of simpler systems. It has been a part of this general approach to consider the mechanisms of reaction *in vivo* in terms of *in vitro* mechanisms of simple reactions of organic substrates in solution. Probably all reactions in solution are subject to catalytic effects, and the remarkable catalysis by proteins ("enzymes") is thus seen by the chemist as a complex problem of qualitatively the same type as simpler and less effective forms of catalysis.

Professor Myron Bender's new book is a masterly exposition of this point of view. It traces the developments which have taken students of reaction mechanisms from topics such as the saponification of ethyl benzoate to the investigation of acetylcholinesterase and lysozyme catalysis. There have been a number of interesting recent books devoted to the chemical approach to enzyme action. Professor Bender's contribution is remarkable for its careful treatment of the basic physical chemistry of simpler catalytic phenomena, which is clear without conveying the wrong idea that all simple problems have been "solved". It then guides the reader from the securely established basic phenomena to problems of obvious complexity. The progression is convincingly logical, with the aim of embracing the entire field and considering the treatment simply as an updating of R. P. Bell's classic monograph *Acid-Base Catalysis*. The main stream of the development is that from oxonium and hydroxide catalysis, *via* general acid-base, nucleophilic and electrophilic catalysis, metal ion effects, bifunctional and multifunctional catalytic phenomena and neighbouring-group effects in model compounds, to enzyme mechanisms. Confluent contributions, such as investigations of enzyme structure and of enzyme-substrate binding, are likewise traced. With his prodigious knowledge of organic and physical chemistry, Professor Bender is able to present an elegant and impressive chain of arguments. The reader may not agree in detail with every one of the examples adduced in this exposition, but he cannot fail to find stimulation and a clearer perspective of scientific development. The actual treatment of enzymes and their catalysis takes up about 260 of the approximately 660 pages of solid and well-documented text.

The book was written over a period of five years, with a lengthy interruption due to the author's illness. This extended period appears, if anything, to have resulted in a more mature balance of material, and has not produced the lack of unity often observed in such cases. The book will be studied with pleasure and profit by students of physical organic chemistry who are venturing into the rich country of enzyme action. It can also be recommended to biochemists and biophysicists who have approached enzymes from a more phenomenological or structural point of view and who may need more persuasion to see the essential unifying link of catalysis between simple reactions in solution and enzyme action.

I hope that a cheaper edition of this book will soon bring it within the reach of students' pockets.

V. GOLD

Turbulent Models

Turbulence Phenomena: An Introduction to the Eddy Transfer of Momentum, Mass and Heat. By J. T. Davies. Pp. xi+412. (Academic: New York and London, June 1972.) $19.50.

Mathematical Models of Turbulence. By B. E. Launder and D. B. Spalding. Pp. 169. (Academic: New York and London, July 1972.) £2.50; $7.50.

THE central problem of turbulence is the unclosed nature of the relations derived by statistical averaging of the Navier-Stokes equations. In the past, this difficulty has been avoided either by outright correlation or by closure at the lowest level. This is done by assuming that the Reynolds stress is a functional of the mean velocity gradient (e.g. the mixing length method). Correlations cannot be used to predict anything; the mixing length method is fundamentally wrong, and has been pushed for rather more than it is worth.

It has long seemed likely that raising the level of the closure would greatly improve the performance of turbulence models, but this possibility remained theoretical until large digital computers became generally available. The com-