begin with Michaelis-Menten enzyme kinetics, which is done well here. Unlike inorganic catalysis, the "site" is a tangible, specific, and unambiguous location for many enzymes, thanks to experiments and molecular modeling (*e.g., Science,* **253**, 872, 1991). Fogler also treats multiphase reactors more effectively by treating both classical slurry reactors and aerobic bioreactors where air is bubbled through aqueous "slurries" of cell mass.

Student use of O.D.E.-solvers in this course is promoted through the book's examples and problems. POLYMATH (CACHE Corporation) is used in most cases, but other packages are also used or cited (*Chem. Eng. Ed.,* **24**, 54, 1991). Simple codes for some computer solutions are still provided, but the equation solvers allow a quicker transition for the students to explore solutions and effects of parameters. Fogler's approach forces emphasis on concepts over techniques, in the spirit that to use an equation solver effectively, you only need to know how it works—not how to make one. In this text, reaction engineering is the focus, while analytical or numerical methods are important tools to be used.

A strong point of the examples and problems is that real reactants and reactions are generally used. The types of chemistries involved are not structured beyond homogeneous versus heterogeneous, but it isn't (and shouldn't be) the purpose of this book to organize the suite of chemical engineering chemistry. Many students enter chemical engineering because they like chemistry, and the reaction engineering course is often the one place in the chemical engineering sequence where they seem to realize the connection with their chemistry courses. (Paradoxically, the curriculum is full of non-reaction chemistry, too, from chemical thermodynamics to materials to molecular bases of transport properties. We need to do a better job of pointing out the balance of physics and chemistry that go into the chemical engineering profession.)

Some worthwhile material has been omitted to meet space restrictions, but not always seamlessly. For example, analysis of trickle-bed reactors was eliminated, apparently to allow inclusion of bioreactors as multiphase reactors (certainly a defensible choice) but, unfortunately, trickle-bed problems are left unchanged from the first edition, as if the relevant text material was still in place. Other sources may be easily consulted, though, because references for trickle-bed analysis and design are retained in the "Supplementary Reading" section. Other topics which are mentioned only briefly include fluidized-bed and transport reactors.

Of course, not every topic can or should be included in an undergraduate course on reaction engineering. Fogler describes an excellent, semester-long sequence using about 60% of the book. Its coverage and timeliness make it today's *de facto* standard text for undergraduate kinetics and reaction engineering. ❐

ChE book review

HAZOP and HAZAN: Identifying and Assessing Process Industry Hazards, 3rd Edition

by Trevor Kletz

Published by the Institution of Chemical Engineers, United Kingdom; distributed in the US and Canada by Hemisphere Publishing Corporation, Bristol, PA; 150 pages, $49.50 (1992)

Reviewed by
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This book is a significant improvement over the last release, a soft-bound edition published in 1986. This issue includes a hard cover (in standard book size), redrawn and updated figures, new references, and new content. It is divided into seven chapters, with several chapter appendices and supplemental material.

Chapter 1 provides a brief introduction to hazard identification and assessment, including a discussion of why it is important, how far one must be prepared to go to eliminate hazards, and when in the design of a chemical plant these methods should be applied.

Chapter 2 presents the concept of hazard and operability studies (HAZOP), a hazard identification procedure which has become increasingly important to the chemical industry. A detailed example using the feed section to an olefin dimerization plant is provided. The chapter also includes discussion on why HAZOPs are important, who carries out the HAZOP, and the limitations to HAZOPs. An interesting appendix to the chapter describes nine accidents which could have been prevented by a proper HAZOP and one accident which most likely could not have been prevented.

Chapter 3 introduces hazard analysis, which Professor Kletz (and perhaps the British) is determined to call HAZAN, for hazard analysis. As Kletz points out, the United States prefers the term "quantita-

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FREE ENERGY OF WETTING

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in free energy, the total path represents a minimum in free energy, and Young's angle is the result.

In summary, when a liquid contacts a solid, either partial or complete wetting occurs. The extent of wetting is determined by a simple thermodynamic rule familiar to all students: the system will move to the state of lowest free energy. Although the rules are simple, the implications of the rules are profound and can have important consequences in many areas of applied chemistry.

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tive risk assessment" (QRA) or "probabilistic risk assessment" (PRA). This chapter includes very introductory material on calculating human risks and equipment reliability. There is an interesting section on calculating the cost of saving a life, demonstrating a huge range of cost values for various activities.

Chapter 4 is a manager's guide to hazard analysis and discusses the problems associated with hazard analysis in a managerial environment.

Chapter 5 discusses the most common objections raised against HAZOP and HAZAN, and the author provides a convincing case for applying these techniques.

Chapter 6 is a very short chapter which discusses sources of data and confidence limits, and Chapter 7 presents an interesting history of HAZOP and HAZAN.

I am a considerable fan of the author, Trevor Kletz, and buy all of his books as soon as they are published. He uses a powerful technique of mixing case histories with discussion to provide convincing cases for his material. Furthermore, he has a unique way of looking at things and often arrives at an "obvious" result that no one else even thought of.

The content of this book is introductory in nature and would be suitable for anyone with an interest in learning about basic HAZOP and HAZAN methods. It does not discuss techniques for decomposing large process units into suitable subunits for HAZOP analysis, a major problem for industrial practitioners, nor does it include some of the more recent organizational methods for managing a large HAZOP. There are some simple calculations related to equipment reliability, but nothing particularly difficult for chemical engineering students.

This book, along with Trevor's other books, would be a suitable reference or supplemental material for a chemical engineering design course or a course in chemical process safety. The students would be most responsive to the case histories and examples that are provided. ❐