

Chemical Reaction Engineering Fogler Solutions

The 18th European Symposium on Computer Aided Process Engineering contains papers presented at the 18th European Symposium of Computer Aided Process Engineering (ESCAPE 18) held in Lyon, France, from 1-4 June 2008. The ESCAPE series brings the latest innovations and achievements by leading professionals from the industrial and academic communities. The series serves as a forum for engineers, scientists, researchers, managers and students from academia and industry to: - present new computer aided methods, algorithms, techniques related to process and product engineering, - discuss innovative concepts, new challenges, needs and trends in the area of CAPE. This research area bridges fundamental sciences (physics, chemistry, thermodynamics, applied mathematics and computer sciences) with the various aspects of process and product engineering. The special theme for ESCAPE-18 is CAPE for the Users! CAPE systems are to be put in the hands of end users who need functionality and assistance beyond the scientific and technological capacities which are at the core of the systems. The four main topics are: - off-line systems for synthesis and design, - on-line systems for control and operation, - computational and numerical solutions strategies, - integrated and multi-scale modelling and simulation, Two general topics address the impact of CAPE tools and methods on Society and Education. *

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CD-ROM that accompanies the book contains all research papers and contributions * International in scope with guest speeches and keynote talks from leaders in science and industry * Presents papers covering the latest research, key top areas and developments in Computer Aided Process Engineering This covers chemical reactions and kinetics for engineers and increased emphasis has been placed on numerical solutions to reaction engineering problems. Although computer technology has dramatically improved the analysis of complex transport phenomena, the methodology has yet to be effectively integrated into engineering curricula. The huge volume of literature associated with the wide variety of transport processes cannot be appreciated or mastered without using innovative tools to allow comprehension

Interest in ozonation for drinking water and wastewater treatment has soared in recent years due to ozone's potency as a disinfectant, and the increasing need to control disinfection byproducts that arise from the chlorination of water and wastewater. *Ozone Reaction Kinetics for Water and Wastewater Systems* is a comprehensive reference that

Successful industrial heterogeneous catalysts fulfill several key requirements: in addition to high catalytic activity for the desired reaction, with high selectivity where appropriate, they also have an acceptable commercial life and are rugged enough for transportation and charging into plant reactors. Additional requirements include the need to come online smoothly in a short time and reproducible manufacturing procedures that involve

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convenient processes at acceptable cost. The development of heterogeneous catalysts that meet these (often mutually exclusive) demands is far from straightforward, and in addition much of the actual manufacturing technology is kept secret for commercial reasons-thus there is no modern text that deals with the whole of this important subject. Principles of Catalyst Development, which deals comprehensively with the design, development, and manufacture of practical heterogeneous catalysts, is therefore especially valuable in meeting the long-standing needs of both industrialists and academics. As one who has worked extensively on a variety of catalyst development problems in both industry and academia, James T. Richardson is well placed to write an authoritative book covering both the theory and the practice of catalyst development. Much of the material contained in this book had its origin in a series of widely acclaimed lectures, attended mainly by industrial researchers, given over many years in the United States and Europe. All those in industry who work with catalysts, both beginners and those of considerable experience, should find this volume an essential guide. This is the second edition of the text "Bioreaction Engineering Principles" by Jens Nielsen and John Villadsen, originally published in 1994 by Plenum Press (now part of Kluwer). Time runs fast in Biotechnology, and when Kluwer Plenum stopped reprinting the first edition and asked us to make a second, revised edition we happily accepted. A text on bioreactions written in the early 1990's will not reflect the enormous development of experimental as well as theoretical aspects of cellular

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reactions during the past decade. In the preface to the first edition we admitted to be newcomers in the field. One of us (JV) has had 10 more years of job training in biotechnology, and the younger author (IN) has now received international recognition for his work with the hottest topics of "modern" biotechnology. Furthermore we are happy to have induced Gunnar Liden, professor of chemical reaction engineering at our sister university in Lund, Sweden to join us as co-author of the second edition. His contribution, especially on the chemical engineering aspects of "real" bioreactors has been of the greatest value. Chapter 8 of the present edition is largely unchanged from the first edition. We wish to thank professor Martin Hjortso from LSU for his substantial help with this chapter.

Chemical reaction engineering is concerned with the exploitation of chemical reactions on a commercial scale. It's goal is the successful design and operation of chemical reactors. This text emphasizes qualitative arguments, simple design methods, graphical procedures, and frequent comparison of capabilities of the major reactor types. Simple ideas are treated first, and are then extended to the more complex.

Artificial organs may be considered as small-scale process plants, in which heat, mass and momentum transfer operations and, possibly, chemical transformations are carried out. This book proposes a novel analysis of artificial organs based on the typical bottom-up approach used in process engineering. Starting from a description of the fundamental physico-chemical phenomena involved in the process, the whole system is rebuilt as an interconnected ensemble of elemental unit operations. Each artificial organ is

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presented with a short introduction provided by expert clinicians. Devices commonly used in clinical practice are reviewed and their performance is assessed and compared by using a mathematical model based approach. Whilst mathematical modelling is a fundamental tool for quantitative descriptions of clinical devices, models are kept simple to remain focused on the essential features of each process. Postgraduate students and researchers in the field of chemical and biomedical engineering will find that this book provides a novel and useful tool for the analysis of existing devices and, possibly, the design of new ones. This approach will also be useful for medical researchers who want to get a deeper insight into the basic working principles of artificial organs.

"The fourth edition of Elements of Chemical Reaction Engineering is a completely revised version of the book. It combines authoritative coverage of the principles of chemical reaction engineering with an unsurpassed focus on critical thinking and creative problem solving, employing open-ended questions and stressing the Socratic method. Clear and organized, it integrates text, visuals, and computer simulations to help readers solve even the most challenging problems through reasoning, rather than by memorizing equations."--BOOK JACKET.

While mathematically sophisticated methods can be used to better understand and improve processes, the nonlinear nature of food processing models can make their dynamic optimization a daunting task. With contributions from a virtual who's who in the food processing industry, Optimization in Food Engineering evaluates the potential uses and limitations of optimization techniques for food processing, including classical methods, artificial intelligence-genetic algorithms, multi-objective optimization procedures, and computational fluid dynamics. The book begins by delineating the

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fundamentals and methods for analytical and numerical procedures. It then covers optimization techniques and how they specifically apply to food processing. The final section digs deep into fundamental food processes and provides detailed explanation and examples from the most experienced and published authors in the field. This includes a range of processes from optimization strategies for improving the performance of batch reactors to the optimization of conventional thermal processing, microwave heating, freeze drying, spray drying, and refrigeration systems, to structural optimization techniques for developing beverage containers, optimization approaches for impingement processing, and optimal operational planning methodologies. Each chapter presents the required parameters for the given process with the optimization procedure to apply. An increasing part of the food processor's job is to optimize systems to squeeze more dollars out of overhead to offset rising utility and transportation costs. Logically combining optimization techniques from many sources into a single volume focused on food production processes, this book provides real solutions to increases in energy, healthcare, and product liability costs that impact the bottom line in food production. The role of the chemical reactor is crucial for the industrial conversion of raw materials into products and numerous factors must be considered when selecting an appropriate and efficient chemical reactor. Chemical Reaction Engineering and Reactor Technology defines the qualitative aspects that affect the selection of an industrial chemical reactor and couples various reactor models to case-specific kinetic expressions for chemical processes. Offering a systematic development of the chemical reaction engineering concept, this volume explores: Essential stoichiometric, kinetic, and thermodynamic terms needed in the analysis of

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chemical reactors Homogeneous and heterogeneous reactors Residence time distributions and non-ideal flow conditions in industrial reactors Solutions of algebraic and ordinary differential equation systems Gas- and liquid-phase diffusion coefficients and gas-film coefficients Correlations for gas-liquid systems Solubilities of gases in liquids Guidelines for laboratory reactors and the estimation of kinetic parameters The authors pay special attention to the exact formulations and derivations of mass energy balances and their numerical solutions. Richly illustrated and containing exercises and solutions covering a number of processes, from oil refining to the development of specialty and fine chemicals, the text provides a clear understanding of chemical reactor analysis and design.

A proper understanding of diffusion and mass transfer theory is critical for obtaining correct solutions to many transport problems. Diffusion and Mass Transfer presents a comprehensive summary of the theoretical aspects of diffusion and mass transfer and applies that theory to obtain detailed solutions for a large number of important problems. Particular attention is paid to various aspects of polymer behavior, including polymer diffusion, sorption in polymers, and volumetric behavior of polymer-solvent systems. The book first covers the five elements necessary to formulate and solve mass transfer problems, that is, conservation laws and field equations, boundary conditions, constitutive equations, parameters in constitutive equations, and mathematical methods that can be used to solve the partial differential equations commonly encountered in mass transfer problems. Jump balances, Green's function solution methods, and the free-volume theory for the prediction of self-diffusion coefficients for polymer-solvent systems are among the topics covered. The authors then use those elements to analyze a wide variety of mass transfer problems, including

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bubble dissolution, polymer sorption and desorption, dispersion, impurity migration in plastic containers, and utilization of polymers in drug delivery. The text offers detailed solutions, along with some theoretical aspects, for numerous processes including viscoelastic diffusion, moving boundary problems, diffusion and reaction, membrane transport, wave behavior, sedimentation, drying of polymer films, and chromatography. Presenting diffusion and mass transfer from both engineering and fundamental science perspectives, this book can be used as a text for a graduate-level course as well as a reference text for research in diffusion and mass transfer. The book includes mass transfer effects in polymers, which are very important in many industrial processes. The attention given to the proper setup of numerous problems along with the explanations and use of mathematical solution methods will help readers in properly analyzing mass transfer problems.

Based on the popular course of the same title, *Concepts of Chemical Engineering 4 Chemists* outlines the basic aspects of chemical engineering for chemistry professionals. It clarifies the terminology used and explains the systems methodology approach to process design and operation for chemists with limited chemical engineering knowledge. The book provides practical insights into all areas of chemical engineering, including such aspects as pump design and the measurement of key process variables. The calculation of design parameters, such as heat and mass transfer coefficients, and reaction scale-up are also discussed, as well as hazard analysis, project economics and process control. Designed as a reference guide, it is fully illustrated and includes worked examples as well as extensive reference and bibliography sections. *Concepts of Chemical Engineering 4 Chemists* is ideal for those who either work alongside chemical engineers or who are embarking on chemical

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engineering-type projects.

Today's Definitive, Undergraduate-Level Introduction to Chemical Reaction Engineering Problem-Solving For 30 years, H. Scott Fogler's Elements of Chemical Reaction Engineering has been the #1 selling text for courses in chemical reaction engineering worldwide. Now, in Essentials of Chemical Reaction Engineering, Second Edition, Fogler has distilled this classic into a modern, introductory-level guide specifically for undergraduates. This is the ideal resource for today's students: learners who demand instantaneous access to information and want to enjoy learning as they deepen their critical thinking and creative problem-solving skills. Fogler successfully integrates text, visuals, and computer simulations, and links theory to practice through many relevant examples. This updated second edition covers mole balances, conversion and reactor sizing, rate laws and stoichiometry, isothermal reactor design, rate data collection/analysis, multiple reactions, reaction mechanisms, pathways, bioreactions and bioreactors, catalysis, catalytic reactors, nonisothermal reactor designs, and more. Its multiple improvements include a new discussion of activation energy, molecular simulation, and stochastic modeling, and a significantly revamped chapter on heat effects in chemical reactors. To promote the transfer of key skills to real-life settings, Fogler presents three styles of problems: Straightforward problems that reinforce the principles of chemical reaction engineering Living Example Problems (LEPs) that allow students to rapidly explore the issues and look for optimal solutions Open-ended problems that encourage students to use inquiry-based learning to practice creative problem-solving skills About the Web Site (umich.edu/~elements/5e/index.html) The companion Web site offers extensive enrichment opportunities and additional content, including Complete PowerPoint slides for lecture

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notes for chemical reaction engineering classes Links to additional software, including Polymath, MATLAB, Wolfram Mathematica, AspenTech, and COMSOL Multiphysics Interactive learning resources linked to each chapter, including Learning Objectives, Summary Notes, Web Modules, Interactive Computer Games, Computer Simulations and Experiments, Solved Problems, FAQs, and links to LearnChemE Living Example Problems that provide more than 75 interactive simulations, allowing students to explore the examples and ask “what-if ” questions Professional Reference Shelf, containing advanced content on reactors, weighted least squares, experimental planning, laboratory reactors, pharmacokinetics, wire gauze reactors, trickle bed reactors, fluidized bed reactors, CVD boat reactors, detailed explanations of key derivations, and more Problem-solving strategies and insights on creative and critical thinking Register your product at informit.com/register for convenient access to downloads, updates, and/or corrections as they become available.

This book covers a number of topics in heat and mass transfer processes for a variety of industrial applications. The research papers provide advances in knowledge and design guidelines in terms of theory, mathematical modeling and experimental findings in multiple research areas relevant to many industrial processes and related equipment design. The design of equipment includes air heaters, cooling towers, chemical system vaporization, high temperature polymerization and hydrogen production by steam reforming. Nine chapters of the book will serve as an important reference for scientists and academics working in the research areas mentioned above, especially in the aspects of heat and mass

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transfer, analytical/numerical solutions and optimization of the processes.

This comprehensive, well organized and easy to read book presents concepts in a unified framework to establish a similarity in the methods of solutions and analysis of such diverse systems as algebraic equations, ordinary differential equations and partial differential equations. The distinguishing feature of the book is the clear focus on analytical methods of solving equations. The text explains how the methods meant to elucidate linear problems can be extended to analyse nonlinear problems. The book also discusses in detail modern concepts like bifurcation theory and chaos. To attract engineering students to applied mathematics, the author explains the concepts in a clear, concise and straightforward manner, with the help of examples and analysis. The significance of analytical methods and concepts for the engineer/scientist interested in numerical applications is clearly brought out. Intended as a textbook for the postgraduate students in engineering, the book could also be of great help to the research students.

Chemical Reaction Engineering: Essentials, Exercises and Examples presents the essentials of kinetics, reactor design and chemical reaction engineering for undergraduate students. Concise and didactic in its approach, it features over 70 resolved examples and many exercises. The work is organized in two parts: in the first part kinetics is presented

Enables readers to apply core principles of environmental engineering to analyze environmental

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systems Environmental Process Analysis takes a unique approach, applying mathematical and numerical process modeling within the context of both natural and engineered environmental systems. Readers master core principles of natural and engineering science such as chemical equilibria, reaction kinetics, ideal and non-ideal reactor theory, and mass accounting by performing practical real-world analyses. As they progress through the text, readers will have the opportunity to analyze a broad range of environmental processes and systems, including water and wastewater treatment, surface mining, agriculture, landfills, subsurface saturated and unsaturated porous media, aqueous and marine sediments, surface waters, and atmospheric moisture. The text begins with an examination of water, core definitions, and a review of important chemical principles. It then progressively builds upon this base with applications of Henry's law, acid/base equilibria, and reactions in ideal reactors. Finally, the text addresses reactions in non-ideal reactors and advanced applications of acid/base equilibria, complexation and solubility/dissolution equilibria, and oxidation/reduction equilibria. Several tools are provided to fully engage readers in mastering new concepts and then applying them in practice, including: Detailed examples that demonstrate the application of concepts and principles Problems at the end of each chapter challenging readers to apply their newfound knowledge to analyze environmental processes and systems MathCAD worksheets that provide a powerful platform for constructing process models Environmental Process

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Analysis serves as a bridge between introductory environmental engineering textbooks and hands-on environmental engineering practice. By learning how to mathematically and numerically model environmental processes and systems, readers will also come to better understand the underlying connections among the various models, concepts, and systems.

The leading resource on ozone technology, this book contains everything from chemical basics to technical and economic concerns. The text has been updated to include the latest developments in water treatment and industrial processes. Following an introduction, the first part looks at toxicology, reaction mechanisms and full-scale applications, while Part B covers experimental design, equipment and analytical methods, mass transfer, reaction kinetics and the application of ozone in combined processes.

A comprehensive introduction to chemical reactor engineering from an industrial perspective In *Fundamentals of Chemical Reactor Engineering: A Multi-Scale Approach*, a distinguished team of academics delivers a thorough introduction to foundational concepts in chemical reactor engineering. It offers readers the tools they need to develop a firm grasp of the kinetics and thermodynamics of reactions, hydrodynamics, transport processes, and heat and mass transfer resistances in a chemical reactor. This textbook describes the interaction of reacting molecules on the molecular scale and uses real-world examples to illustrate the principles of chemical reactor analysis and heterogeneous catalysis at every scale. It includes a

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strong focus on new approaches to process intensification, the modeling of multifunctional reactors, structured reactor types, and the importance of hydrodynamics and transport processes in a chemical reactor. With end-of-chapter problem sets and multiple open-ended case studies to promote critical thinking, this book also offers supplementary online materials and an included instructor's manual. Readers will also find: A thorough introduction to the rate concept and species conservation equations in reactors, including chemical and flow reactors and the stoichiometric relations between reacting species A comprehensive exploration of reversible reactions and chemical equilibrium, including the thermodynamics of chemical reactions and different forms of the equilibrium constant Practical discussions of chemical kinetics and analysis of batch reactors, including batch reactor data analysis In-depth examinations of ideal flow reactors, CSTR, and plug flow reactor models Ideal for undergraduate and graduate chemical engineering students studying chemical reactor engineering, chemical engineering kinetics, heterogeneous catalysis, and reactor design, Fundamentals of Chemical Reactor Engineering is also an indispensable resource for professionals and students in food, environmental, and materials engineering. This book addresses primarily the engineer in industrial process development, the research chemist in academia and industry, and the graduate student intending to become a reaction engineer. In industry, competitive pressures put a premium on scale-up by large factors to cut development time. To be safe, such development

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should be based on "fundamental" kinetics that reflect the elementary steps of which the reaction consists. The book forges fundamental kinetics into a practical tool by presenting new, effective methods for elucidation of mechanisms and reduction of complexity without unacceptable sacrifice in accuracy: fewer equations (lesser computational load), fewer coefficients (fewer experiment to determine them). For network elucidation, new rules relating network configurations to observable kinetic behaviour allow incorrect networks to be ruled out by whole classes instead of one by one. For modelling, general equations and algorithms are given from which equations for specific networks can be recovered by simple substitutions. The procedures are illustrated with examples of industrial reactions including, among others, paraffin oxidation, ethoxylation, hydroformylation, hydrocyanation, shape-selective catalysis, ethane pyrolysis, styrene polymerization, and ethene oligomerization. Many of the rate equations have not been published before. The expanded edition of the 2001 title, *Kinetics of Homogeneous Multistep Reactions* includes new chapters on heterogeneous catalysis and periodic and chaotic re-actions; new sections on adsorption, statistical methods, and lumping; and other new detail. * Contains new chapters on heterogeneous catalysis, oscillations and chaos * Includes new sections on statistical methods, lumping adsorption and software and databases * Provides a better understanding of complex reaction mechanisms

This book describes the various advanced treatment methods for removal of multiple types of dyes from

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effluent stream. It pays particular attention to the economic aspects of treatment of textile waste-water. The different technologies illustrated in the book include adsorption, nanofiltration, advanced oxidation, micellar enhanced ultrafiltration, cloud-point extraction, and electrocoagulation. The book presents in-depth analyses of the removal mechanisms and performance optimization of the processes involved therein. This book will be useful to chemists, chemical engineers, environmental engineers, and health and pollution control professionals. The contents have been presented in a manner that they can be easily understood and applied by a wide variety of readers including researchers, students, and practicing engineers. The Maple Summer Workshop and Symposium, MSWS '94, reflects the growing community of Maple users around the world. This volume contains the contributed papers. A careful inspection of author affiliations will reveal that they come from North America, Europe, and Australia. In fact, fifteen come from the United States, two from Canada, one from Australia, and nine come from Europe. Of European papers, two are from Germany, two are from the Netherlands, two are from Spain, and one each is from Switzerland, Denmark, and the United Kingdom. More important than the geographical diversity is the intellectual range of the contributions. We begin to see in this collection of works papers in which Maple is used in an increasingly flexible way. For example, there is an application in computer science that uses Maple as a tool to create a new utility. There is an application in abstract algebra where Maple has been

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used to create new functionalities for computing in a rational function field. There are applications to geometrical optics, digital signal processing, and experimental design.

The publication of the third edition of "Chemical Engineering Volume" marks the completion of the re-orientation of the basic material contained in the first three volumes of the series. Volume 3 is devoted to reaction engineering (both chemical and biochemical), together with measurement and process control. This text is designed for students, graduate and postgraduate, of chemical engineering.

Appropriate for a one-semester undergraduate or first-year graduate course, this text introduces the quantitative treatment of chemical reaction engineering. It covers both homogeneous and heterogeneous reacting systems and examines chemical reaction engineering as well as chemical reactor engineering. Each chapter contains numerous worked-out problems and real-world vignettes involving commercial applications, a feature widely praised by reviewers and teachers. 2003 edition.

"This book provides a college-level overview of chemical processing of metals in water-based solutions, in the field that is known as hydrometallurgy"--

This book discusses and illustrates practical problem solving in the major areas of chemical and biochemical engineering and related disciplines using the novel software capabilities of POLYMATH, Excel, and MATLAB. Students and engineering/scientific professionals will be able to develop and enhance their

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abilities to effectively and efficiently solve realistic problems from the simple to the complex. This new edition greatly expands the coverage to include chapters on biochemical engineering, separation processes and process control. Recent advances in the POLYMATH software package and new book chapters on Excel and MATLAB usage allow for exceptional efficiency and flexibility in achieving problem solutions. All of the problems are clearly organized and many complete and partial solutions are provided for all three packages. A special web site provides additional resources for readers and special reduced pricing for the latest educational version of POLYMATH.

Learn Chemical Reaction Engineering through Reasoning, Not Memorization Essentials of Chemical Reaction Engineering is the complete, modern introduction to chemical reaction engineering for today's undergraduate students. Starting from the strengths of his classic Elements of Chemical Reaction Engineering, Fourth Edition, in this volume H. Scott Fogler added new material and distilled the essentials for undergraduate students. Fogler's unique way of presenting the material helps students gain a deep, intuitive understanding of the field's essentials through reasoning, using a CRE algorithm, not memorization. He especially focuses on important new energy and safety issues, ranging from solar and biomass applications to the avoidance of runaway reactions. Thoroughly classroom tested, this text reflects feedback from hundreds of students at the University of Michigan and other leading universities. It also provides new resources to help students discover

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how reactors behave in diverse situations-including many realistic, interactive simulations on DVD-ROM. New Coverage Includes Greater emphasis on safety: following the recommendations of the Chemical Safety Board (CSB), discussion of crucial safety topics, including ammonium nitrate CSTR explosions, case studies of the nitroaniline explosion, and the T2 Laboratories batch reactor runaway Solar energy conversions: chemical, thermal, and catalytic water spilling Algae production for biomass Steady-state nonisothermal reactor design: flow reactors with heat exchange Unsteady-state nonisothermal reactor design with case studies of reactor explosions About the DVD-ROM The DVD contains six additional, graduate-level chapters covering catalyst decay, external diffusion effects on heterogeneous reactions, diffusion and reaction, distribution of residence times for reactors, models for non-ideal reactors, and radial and axial temperature variations in tubular reactions. Extensive additional DVD resources include Summary notes, Web modules, additional examples, derivations, audio commentary, and self-tests Interactive computer games that review and apply important chapter concepts Innovative "Living Example Problems" with Polymath code that can be loaded directly from the DVD so students can play with the solution to get an innate feeling of how reactors operate A 15-day trial of Polymath(tm) is included, along with a link to the Fogler Polymath site A complete, new AspenTech tutorial, and four complete example problems Visual Encyclopedia of Equipment, Reactor Lab, and other intuitive tools More

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than 500 PowerPoint slides of lecture notes Additional updates, applications, and information are available at www.umich.edu/~essen and www.essentialsofcre.com.
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This book addresses primarily the chemist and engineer in industrial research and process development, where competitive pressures put a premium on scale-up by large factors to cut development time. To be safe, such scale-up should be based on "fundamental" kinetics, that is, mathematics that reflect the elementary steps of which the reactions consist. The book forges fundamental kinetics into a practical tool by presenting new effective methods for elucidation of mechanisms and reduction of mathematical complexity without unacceptable sacrifice in accuracy.

Master the principles of thermodynamics, and understand their practical real-world applications, with this deep and intuitive undergraduate textbook. *Chemical Degradation Methods for Wastes and Pollutants* focuses on established and emerging chemical procedures for the management of pollutants in industrial wastewater and the environment. This reference offers an in-depth explanation of the degradation process, mechanisms, and control factors affecting each method, as well as issues crucial to the application of these approaches in real-world treatment sites. It examines ten of the most common and useful chemical technologies for environmental remediation and sanitation of industrial waste streams and offers implementation guidelines and examples of remediation

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strategies that are crucial to effective wastewater
cleansing.

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