

Separation Process Engineering

The Definitive, Fully Updated Guide to Separation Process Engineering—Now with a Thorough Introduction to Mass Transfer Analysis
Separation Process Engineering, Third Edition, is the most comprehensive, accessible guide available on modern separation processes and the fundamentals of mass transfer. Phillip C. Wankat teaches each key concept through detailed, realistic examples using real data—including up-to-date simulation practice and new spreadsheet-based exercises. Wankat thoroughly covers each of today's leading approaches, including flash, column, and batch distillation; exact calculations and shortcut methods for multicomponent distillation; staged and packed column design; absorption; stripping; and more. In this edition, he also presents the latest design methods for liquid-liquid extraction. This edition contains the most detailed coverage available of membrane separations and of sorption separations (adsorption, chromatography, and ion exchange). Updated with new techniques and references throughout, Separation Process Engineering, Third Edition, also contains more than 300 new homework problems, each tested in the author's Purdue University classes. Coverage includes Modular, up-to-date process simulation examples and homework problems, based on Aspen Plus and easily adaptable to any simulator Extensive new coverage of mass transfer and diffusion, including both Fickian and Maxwell-Stefan approaches Detailed discussions of liquid-liquid extraction, including McCabe-Thiele, triangle and computer simulation analyses; mixer-settler design; Karr columns; and related mass transfer analyses Thorough introductions to adsorption, chromatography, and ion exchange—designed to prepare students for advanced work in these areas Complete coverage of membrane separations, including gas permeation, reverse osmosis, ultrafiltration, pervaporation, and key applications A full chapter on economics and energy conservation in distillation Excel spreadsheets offering additional practice with problems in distillation, diffusion, mass transfer, and membrane separation

This new book explains advanced and emerging technologies for removing heavy metals from wastestreams and contaminated sites. Separation processes of this type are critical for meeting stringent regulations of priority pollutants, especially arsenic, mercury, and lead, which the text treats in depth. After explaining the chemistry of heavy metals and their transport in various media, the work offers a comprehensive analysis of strategies for separating metals from groundwater, wastewater, contaminated soils, and industrial sludges. Both the basics and the applications of techniques such as ion-exchange, specialized sorbents, novel membranes, advanced precipitates, and electrokinetic processes are presented with a view to current use and potential for future applications such as resource reuse. Information in this volume enables engineers and other investigators to adapt and select the best means to remove and, in certain instances, recover heavy metals.

Engineering Aspects of Membrane Separation and Application in Food Processing presents an overview and introduction to a wide range of membrane processes, their unique characteristics and challenges. In the food industry, as in many industries, membranes have an environmental advantage over conventional processes that they displace, because they are less energy intensive. The processing at near-ambient conditions also retains flavors and nutritional value. These advantages, together with significant reductions in the cost of membrane modules, augers well for their future not only in the dairy industry but in other parts of the food industry, such as alcohol processing, animal product processing, and fruit and vegetable processing. Chapters address a wide range of membranes separations in the food and beverage industries, and applications are provided that will be of value not only to food engineers but also to process engineers working in other areas.

The processing of food is now a highly interdisciplinary science, and anyone concerned with food processing will benefit from reading this book and understanding what membrane processes of the twenty-first century have to offer.

This book describes, analyses and discusses the main principles, phenomena and design strategies of reactive separation processes with an emphasis on the intensification as a basis of the sustainability. Different reactive separation processes are explained in detail to show the phenomena and with the purpose of understanding when their use allows advantages based on the output results. Case examples are analysed and the perspective of these processes in the future is discussed. The overall sustainability of reactive separation processes in the industry is also explained separately.

The impending crisis posed by water stress and poor sanitation represents one of greatest human challenges for the 21st century, and membrane technology has emerged as a serious contender to confront the crisis. Yet, whilst there are countless texts on wastewater treatment and on membrane technologies, none address the boron problem and separation processes for boron elimination. Boron Separation Processes fills this gap and provides a unique and single source that highlights the growing and competitive importance of these processes. For the first time, the reader is able to see in one reference work the state-of-the-art research in this rapidly growing field. The book focuses on four main areas: Effect of boron on humans and plants Separation of boron by ion exchange and adsorption processes Separation of boron by membrane processes Simulation and optimization studies for boron separation Provides in one source a state-of-the-art overview of this compelling area Reviews the environmental impact of boron before introducing emerging boron separation processes Includes simulation and optimization studies for boron separation processes Describes boron separation processes applicable to specific sources, such as seawater, geothermal water and wastewater

The Definitive, Up-to-Date, Student-Friendly Guide to Separation Process Engineering With More Mass Transfer Coverage and a New Chapter on Crystallization Separation Process Engineering, Fourth Edition, is the most comprehensive, accessible guide available on modern separation processes and the fundamentals of mass transfer. In this completely updated edition, Phillip C. Wankat teaches each key concept through detailed, realistic examples using real data including up-to-date simulation practice and spreadsheet-based exercises. Wankat thoroughly covers each separation process, including flash, column, and batch distillation; exact calculations and shortcut methods for multicomponent distillation; staged and packed column design; absorption; stripping; and more. This edition provides expanded coverage of mass transfer and diffusion, so faculty can cover separations and mass transfer in one course. Detailed discussions of liquid-liquid extraction, adsorption, chromatography, and ion exchange prepare students for advanced work. Wankat presents coverage of membrane separations, including gas permeation, reverse osmosis, ultrafiltration, pervaporation, and applications. An updated chapter on economics and energy conservation in distillation adds coverage of equipment costs. This edition contains more than 300 new, up-to-date homework problems, extensively tested in undergraduate courses at Purdue University and the University of Canterbury (New Zealand). Coverage includes New chapter on crystallization from solution, including equilibrium, chemical purity, crystal size distribution, and pharmaceutical applications Thirteen up-to-date Aspen Plus process simulation labs, adaptable to any simulator Eight detailed Aspen Chromatography labs Extensive new coverage of ternary stage-by-stage distillation calculations Fraction collection and multicomponent calculations for simple batch distillation New mass transfer analysis sections on numerical solution for variable diffusivity Mass transfer to expanding or contracting objects, including ternary mass transfer Expanded coverage of pervaporation Updated Excel spreadsheets offering more practice with distillation, diffusion, mass transfer, and membrane separation problems

The present book contains a comparison of existing theoretical models developed in order to describe membrane separation processes. In general, the permeation equations resulting from these models give inaccurate predictions of the mutual effects of the permeants involved, due to the simplifications adopted in their derivation. It is concluded that an optimum description of transport phenomena in tight (diffusion-type) membranes is achieved with the "solution-diffusion" model. According to this model each component of a fluid mixture to be separated dissolves in the membrane and passes through by diffusion in response to its gradient in the chemical potential. A modified Flory-Huggins equation has been derived to calculate the solubility of the permeants in the membrane material. Contrary to the original Flory-Huggins equation, the modified equation accounts for the large effect on solubility of crystallinity and elastic strain of the polymer chains by swelling. The equilibrium sorption of liquids computed with this equation was found to be in good agreement with experimental results. Also, the sorption of gases in both rubbery and glassy polymers could be described quantitatively with the modified Flory-Huggins equation without any need of the arbitrary Langmuir term, as required in the conventional "dual-mode" sorption model. Furthermore, fewer parameters are required than with the at least identical accuracy.

Appropriate for one-year transport phenomena (also called transport processes) and separation processes course. First semester covers fluid mechanics, heat and mass transfer; second semester covers separation process principles (includes unit operations). The title of this Fourth Edition has been changed from Transport Processes and Unit Operations to Transport Processes and Separation Process Principles (Includes Unit Operations). This was done because the term Unit Operations has been largely superseded by the term Separation Processes which better reflects the present modern nomenclature being used. The main objectives and the format of the Fourth Edition remain the same. The sections on momentum transfer have been greatly expanded, especially in the sections on fluidized beds, flow meters, mixing, and non-Newtonian fluids. Material has been added to the chapter on mass transfer. The chapters on absorption, distillation, and liquid-liquid extraction have also been enlarged. More new material has been added to the sections on ion exchange and crystallization. The chapter on membrane separation processes has been greatly expanded especially for gas-membrane theory.

Membrane Separation Processes: Theories, Problems, and Solutions provides graduate and senior undergraduate students and membrane researchers in academia and industry with the fundamental knowledge on the topic by explaining the underlying theory that is indispensable for solving problems that occur in membrane separation processes. All major membrane processes are discussed, and an economic analysis is provided. Separation processes such as RO, UF, MF, RO, PRO and MD are thoroughly discussed. During the last two decades, the scope of the R&D of membrane separation processes has been significantly broadened. Other sections in the book cover membrane contactor and membrane adsorption. In addition, hybrid systems in which two or more membrane systems are combined are now being investigated for large-scale applications. Written by renowned experts with extensive experience with industry, education and R&D who have complementary expertise In-depth coverage of the most important conventional and emerging membrane processes Provides fundamental membrane theories for solving problems in separation processes without using complicated software

Synthetic Membranes and Membrane Separation Processes addresses both fundamental and practical aspects of the subject. Topics discussed in the book cover major industrial membrane separation processes, including reverse osmosis, ultrafiltration,

microfiltration, membrane gas and vapor separation, and pervaporation. Membrane materials, membrane preparation, membrane structure, membrane transport, membrane module and separation design, and applications are discussed for each separation process. Many problem-solving examples are included to help readers understand the fundamental concepts of the theory behind the processes. The book will benefit practitioners and students in chemical engineering, environmental engineering, and materials science.

Separation processes on an industrial scale account for well over half of the capital and operating costs in the chemical industry. Knowledge of these processes is key for every student of chemical or process engineering. This book is ideally suited to university teaching, thanks to its wealth of exercises and solutions. The second edition boasts an even greater number of applied examples and case studies as well as references for further reading.

Completely rewritten to enhance clarity, this third edition provides engineers with a strong understanding of the field. With the help of an additional co-author, the text presents new information on bioseparations throughout the chapters. A new chapter on mechanical separations covers settling, filtration, and centrifugation, including mechanical separations in biotechnology and cell lysis. Boxes help highlight fundamental equations. Numerous new examples and exercises are integrated throughout as well. In addition, frequent references are made to the software products and simulators that will help engineers find the solutions they need.

Edited to avoid duplication and favor comprehensiveness, 20 contributors detail the recovery, separation, and purification operations of bioprocess technology. Individual chapters in this classic yet still highly relevant work emphasize concepts that are becoming more and more important when applied to the large scale versions of techniques that are considered well established. Aside from fully discussing processes, Separation Processes in Biotechnology includes sections on concentration separation and operation, purification operations, and product release and recovery. It also discusses plant operation and equipment and delves into economic considerations

This concise and systematically organized text, now in its second edition, gives a clear insight into various membrane separation processes. It covers the fundamentals as well as the recent developments of different processes along with their industrial applications and the products. It includes the basic principles, operating parameters, membrane hardware, flux equation, transport mechanism, and applications of membrane-based technologies. Membrane separation processes are largely rate-controlled separations which require rate analysis for complete understanding. Moreover, a higher level of mathematical analysis, along with the understanding of mass transfer, is also required. These are amply treated in different chapters of the book to make the students comprehend the membrane separation principles with ease. This textbook is primarily designed for undergraduate students of chemical engineering, biochemical engineering and biotechnology for the course in membrane separation processes. Besides, the book will also be useful to process engineers and researchers. **KEY FEATURES** • Provides sufficient number of examples of industrial applications related to chemical, metallurgical, biochemical and food processing industries. • Focuses on

important biomedical applications of membrane-based technologies such as blood oxygenator, controlled drug delivery, plasmapheresis, and bioartificial organs. • Includes chapter-end short questions and problems to test students' comprehension of the subject. NEW TO THIS EDITION • A new section on membrane cleaning is included. Membrane fabrication methods are supplemented with additional information (Chapter 2). • Additional information on silt density index, forward osmosis and sea water desalination (Chapter 3). • Physicochemical parameters affecting nanofiltration, determination of various resistances using resistance in series model and few more industrial applications with additional short questions (Chapter 4). • Membrane cross-linking methods used in pervaporation, factors affecting pervaporation and few more applications (Chapter 9). • Membrane distillation, membrane reactor with different modules, types of membranes and reactions for membrane reactor (Chapter 13). Chemical Engineering Volume 2 covers the properties of particulate systems, including the character of individual particles and their behaviour in fluids. Sedimentation of particles, both singly and at high concentrations, flow in packed and fluidised beds and filtration are then examined. The latter part of the book deals with separation processes, such as distillation and gas absorption, which illustrate applications of the fundamental principles of mass transfer introduced in Chemical Engineering Volume 1. In conclusion, several techniques of growing importance - adsorption, ion exchange, chromatographic and membrane separations, and process intensification - are described. A logical progression of chemical engineering concepts, volume 2 builds on fundamental principles contained in Chemical Engineering volume 1 and these volumes are fully cross-referenced. Reflects the growth in complexity and stature of chemical engineering over the last few years. Supported with further reading at the end of each chapter and graded problems at the end of the book.

This book concentrates on the more recent methods and techniques for separating food components and products of the biotechnology industry. Each chapter deals with a specific type or area of application and includes information on the basic principles, industrial equipment available, commercial applications, and an overview of current research and development. Much of the emphasis is on extraction of macromolecules, increasing the added value of foods and recovering valuable components from by-products and fermentation media. Many of the methods discussed are now in commercial practice, while others are being vigorously researched. Separation and filtration technology is of major importance in food processing and biotechnology. This book provides a very detailed examination of the most important, advanced separation processes now in use.

You can maximize industrial profitability by choosing the right separation process with this authoritative guide. This book will help engineers, chemists, managers, and technicians in the chemical, petroleum, pharmaceutical, food, and paper industries maximize profitability by optimizing performance of separation processes. Focusing on the latest distillation, extraction, adsorption, and membrane processes, this up-to-the-minute guide helps you select a cost-effective process; choose a cost-cutting configuration; keep up with cutting-edge technology; and follow up on your choices. Written by two of the leading separation process chemical engineers in the world, this handbook is truly worth its weight in gold to anyone involved in separation process technology.

Gas Separation by Adsorption Processes provides a thorough discussion of the advancement in gas adsorption process. The book is comprised of eight chapters that emphasize the fundamentals concept and principles. The text first covers the adsorbents and adsorption

isotherms, and then proceeds to detailing the equilibrium adsorption of gas mixtures. Next, the book covers rate processes in adsorbers and adsorber dynamics. The next chapter discusses cyclic gas separation processes, and the remaining two chapters cover pressure-swing adsorption. The book will be of great use to students, researchers, and practitioners of disciplines that involve gas separation processes, such as chemical engineering.

This much-needed book presents a clear and very practice-oriented overview of thermal separation processes. An extensive introduction elucidates the physical and physicochemical fundamentals of different unit operations used to separate homogenous mixtures. This is followed by a concise text with numerous explanatory figures and tables referring to process and design, flowsheets, basic engineering and examples of separation process applications. Very helpful guidance in the form of process descriptions, calculation models and operation data is presented in an easy-to-understand manner thereby assisting the practicing engineer in the choosing and evaluation of separation processes and facilitating the modeling and design of innovative equipment. A comprehensive reference list provides further opportunity for the following up of special separation problems. Chemical and mechanical engineers, chemists, physicists and biotechnologists in research and development, plant design and environmental protection, as well as students in chemical engineering and natural sciences will find this all-embracing reference guide of tremendous value and practical use.

Originally published: New York: McGraw-Hill, 1971. 2nd ed. Includes a new introduction.

This textbook provides a comprehensive introduction to chemical process engineering, linking the fundamental theory and concepts to the industrial day-to-day practice. It bridges the gap between chemical sciences and the practical chemical industry. It enables the reader to integrate fundamental knowledge of the basic disciplines, to understand the most important chemical processes, and to apply this knowledge to the practice in the industry.

This work offers an accessible discussion of current and emerging separation processes used for waste minimization, showing how the processes work on a day-to-day basis and providing troubleshooting tips for equipment that doesn't function according to design specifications. It describes the fundamentals of over 30 processes, types of equipment available, vendors, and common problems encountered in operations with hazardous waste.

The development of computer-aided simulation programs for separation processes provides engineers with valuable tools to make more reliable qualitative and quantitative decisions in plant design and operation. Written by a specialist in modeling and optimization, *Multistage Separation Processes, Third Edition* clarifies the effective use of simulation

Surveys the selection, design, and operation of most of the industrially important separation processes. Discusses the underlying principles on which the processes are based, and provides illustrative examples of the use of the processes in a modern context. Features thorough treatment of newer separation processes based on membranes, adsorption, chromatography, ion exchange, and chemical complexation. Includes a review of historically important separation processes such as distillation, absorption, extraction, leaching, and crystallization and considers these techniques in light of recent developments affecting them.

In this volume, the third in a set specifically written for the industrial process and chemical engineer, the authors provide the detailed information on filtration equipment and media which allows the reader to then consider the pre-treatment of suspensions, selection of the most appropriate equipment for the task, data analysis and the subsequent design of the processes involved for particular separations. The result is a comprehensive book which is designed to be used frequently and referred to regularly in order to achieve better industrial

separations. Successful industrial-scale separation of solids from liquids requires not only a thorough understanding of the principles involved, but also an appreciation of which equipment to use for best effect, and a start-to-finish plan for the various processes involved in the operation. If these factors are all correct, then successful separations should result. Part of 3-volume set Unique approach to industrial separations Internationally-known authors

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key applications A full chapter on economics and energy conservation in distillation Excel spreadsheets offering additional practice with problems in distillation, diffusion, mass transfer, and membrane separation [Author bio] Phillip C. Wankat is Clifton L. Lovell Distinguished Professor of Chemical Engineering and director of undergraduate degree programs at Purdue University's School of Engineering Education. His current research interests include adsorption, large-scale chromatography, simulated moving bed systems, and distillation, as well as improvements in engineering education. He rece...

A modern separation process textbook written for advanced undergraduate and graduate level courses in chemical engineering.

This textbook is targeted to undergraduate students in chemical engineering, chemical technology, and biochemical engineering for courses in mass transfer, separation processes, transport processes, and unit operations. The principles of mass transfer, both diffusional and convective have been comprehensively discussed. The application of these principles to separation processes is explained. The more common separation processes used in the chemical industries are individually described in separate chapters. The book also provides a good understanding of the construction, the operating principles, and the selection criteria of separation equipment. Recent developments in equipment have been included as far as possible. The procedure of equipment design and sizing has been illustrated by simple examples. An overview of different applications and aspects of membrane separation has also been provided. 'Humidification and water cooling', necessary in every process industry, is also described. Finally, elementary principles of 'unsteady state diffusion' and mass transfer accompanied by a chemical reaction are covered. SALIENT FEATURES :

- A balanced coverage of theoretical principles and applications.
- Important recent developments in mass transfer equipment and practice are included.
- A large number of solved problems of varying levels of complexities showing the applications of the theory are included.
- Many end-chapter exercises.
- Chapter-wise multiple choice questions.
- An Instructors manual for the teachers.

Separation processes—or processes that use physical, chemical, or electrical forces to isolate or concentrate selected constituents of a mixture—are essential to the chemical, petroleum refining, and materials processing industries. In this volume, an expert panel reviews the separation process needs of seven industries and identifies technologies that hold promise for meeting these needs, as well as key technologies that could enable separations. In addition, the book recommends criteria for the selection of separations research projects for the Department of Energy's Office of Industrial Technology.

Separation Process Engineering Includes Mass Transfer Analysis Prentice Hall

Separation Process Essentials provides an interactive approach for students to learn the main separation processes (distillation, absorption, stripping, and solvent extraction) using material and energy balances with equilibrium relationships, while referring readers to other more complete works when needed. Membrane separations are included as an example of non-equilibrium processes. This book reviews and builds on material learned in the first chemical engineering courses such as Material and Energy Balances and Thermodynamics as applied to separations. It relies heavily on example problems, including completely worked and explained problems followed by "Try This At Home" guided examples. Most examples have accompanying downloadable Excel spreadsheet simulations. The book also offers a complementary website, <http://separationsbook.com>, with supplementary material such as links to YouTube tutorials, practice problems, and the Excel simulations. This book is aimed at second and third year undergraduate students in Chemical engineering, as well as professionals in the field of Chemical engineering, and can be used for a one semester course in separation processes and unit operations.

Novel Catalytic and Separation Process Based on Ionic Liquids presents the latest progress on the use of ionic liquids (ILs) in catalytic and

separation processes. The book discusses the preparation of ILs, the characterization of IL catalysts by spectroscopic techniques, catalytic reactions over IL catalysts, separation science and technology of ILs, applications in biomass utilization, and synthesis of fine chemicals. Scientists, engineers, graduate students, managers, decision-makers, and others interested in ionic liquids will find this information very useful. The book can be used as a springboard for more advanced work in this area as it contains both theory and recent applications, research conducted, and developments in separation techniques and catalysis using ionic liquids. Presents new preparation and advanced characterization of ionic liquids catalysts Outlines catalytic reactions using ionic liquid, thus showing higher yields and selectivity Presents novel separation science and technology based on ionic liquids and non-thermal processes

Thermal Separation Technology is a key discipline for many industries and lays the engineering foundations for the sustainable and economic production of high-quality materials. This book provides fundamental knowledge on this field and may be used both in university teaching and in industrial research and development. Furthermore, it is intended to support professional engineers in their daily efforts to improve plant efficiency and reliability. Previous German editions of this book have gained widespread recognition. This first English edition will now make its content available to the international community of students and professionals. In the first chapters of the book the fundamentals of thermodynamics, heat and mass transfer, and multiphase flow are addressed. Further chapters examine in depth the different unit operations distillation and absorption, extraction, evaporation and condensation, crystallization, adsorption and chromatography, and drying, while the closing chapter provides valuable guidelines for a conceptual process development.

Reviewing core concepts, such as equilibrium and unit operations, this title introduces a step-by-step process for solving separation problems. It looks at each leading processes, including advanced processes such as membrane separation, adsorption, and chromatography. For each process, it presents principles, techniques, equations, and examples.

Thermal Induced Membrane Separation Processes describes the fundamental and advanced areas associated with the field of thermal induced membrane separation processes. It includes extensive coverage of material selection, types, and theory of thermal induced membrane fabrication, characterization, and modification. This book focuses on the applications of various thermal induced membrane processes and discusses ancillary topics related to the subject, such as membrane modules, membrane contactors and reactors, preparation and characterization techniques, smart membranes, fouling and its mitigation, and economic analysis of the thermal induced membrane separation processes. Thermal Induced Membrane Separation Processes elaborates on every aspect on the thermal induced membranes in a simple and straightforward manner, helping readers ranging from students to researchers in academia and the industry to understand the processes for successful execution and implementation into their research. Covers entire field of thermal induced membranes, providing basic to advanced knowledge of thermal induced membranes in a single source Presents state-of-art research in the field Includes the most up-to-date examples of the fabrication, modification, and applications of thermal induced membranes

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