

Fall 2021

CHE 603-101: Separation Process Principles

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New Jersey Institute of Technology
Otto H. York Department of Chemical and Materials Engineering

ChE 603-101 Separation Process Principles (Fall 2021) (Tiernan 107)

Instructor: K.K. Sirkar (371 Tiernan, x 8447)

Prerequisites: Undergraduate ChE course in Separations

Course Content: Description of separation, separation indices, closed and open systems, binary, multicomponent and continuous mixtures, recycle, reflux, time-dependent processes. Physicochemical basis for separation in equilibrium, field and membrane separation processes, flux-force relations, chemical potential profiles, band broadening, phase equilibria. Closed systems: Separation factors in equilibrium, field and membrane processes, focusing techniques. Effect of chemical reaction on separation in equilibrium and membrane processes. Open stage analysis, role of bulk flow vis-a-vis force direction, bulk flow parallel to force, bulk flow(s) perpendicular to force, time-dependent systems. Distillation, absorption, extraction, crystallization, zone refining, capillary electrophoresis, ion exchange, chromatography, PSA, electrophoresis, dielectrophoresis, electrostatic precipitation, centrifugal separations, HGMS, reverse osmosis, ultrafiltration, dialysis, electrodialysis, liquid membranes, gas permeation, pervaporation, parametric pumping, etc. Stage and point efficiencies. Reaction-separation systems.

Textbook 1. "Separation of Molecules, Macromolecules and Particles: Principles, Phenomena and Processes". Kamalesh K. Sirkar, Cambridge University Press, New York, 2014.

Recommended References (LIBRARY, RESERVED SECTION)

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- 4b. Wankat, P.C., Separation Process Engineering, 2nd Ed., Prentice Hall, 2007.
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Developments in Separation Science, Vol. III, part A, N. N. Li (ed.), Chemical Rubber Co., Cleveland, OH, 1997.

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16. Progress in Separation and Purification, Vols. 1, 2, 3 and 4, E. S. Perry et al. (eds.), 1968 onwards, Interscience.
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21. Schoen, H. M., New Chemical Engineering Separation Techniques, Interscience, 1962.
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25. Pratt, H.R. C., Countercurrent Separation Processes, Elsevier, 1967.
26. Ladisch, M.R., Bioseparations Engineering: Principles, Practice, and Economics, Wiley-Interscience, New York, 2001.

Lecture Outline

<u>Week/s</u>	<u>Topic</u>
1.5	Description of Separation; Closed, Open Systems; Binary, Multicomponent, Continuous Mixtures; Recycle, Reflux, Time-dependent Processes.
1.5	Physicochemical Basis for Separation in Equilibrium, Field and Membrane Separation Processes; Fluxes-Forces; Chemical Potential Profiles; Band Broadening; Phase Equilibria; Interphase Transport.
1.5	Ideal Separation Factor in Equilibrium, Field and Membrane Processes; Isoelectric Focusing; Isopycnic Sedimentation.
1.5	Role of Chemical Reactions in Separations; Gas Absorption; Distillation; Solvent Extraction; Crystallization; Enzymatic Resolution; Chromatographic Separations. <u>FIRST EXAM</u> (Oct. 7 or 14).
2.0	Open Stage Analysis; Bulk Flow Parallel to Force; Elutriation, Capillary Electrophoresis; Centrifugal Elutriation; Depth Filtration; Flash Distillation; Solvent Extraction; Zone Melting; Drying; Filtration; RO, Continuous Stirred Tank Separator; Crystallization, UF.
2.5	Bulk Flow of One Phase Perpendicular to Force; Fixed Bed Processes (Adsorption; Ion Exchange; Chromatography); Crossflow Membrane Processes; Electrophoretic Processes; Centrifugal Separations. <u>SECOND EXAM</u> . (Nov. 11 or 18).
2.3	Bulk Flow of Two Phases Perpendicular to Force; Absorption, Distillation, Extraction; Moving Bed Processes; Simulated Moving Bed Processes; Membrane Processes: Dialysis, Electrodialysis, Gas Separation.
1.2	Bioseparations; Water Treatment; Chemical Separations; Hydrometallurgical Separations. <u>FINAL EXAM</u> .

GRADING INFORMATION

There will be three open-book written examinations: one on October 7 or 14 (Thursday), one on November 11 or 18 (Thursday) and then the final exam. The first two exams will last between 1.5-2 hours. The final exam will be for 2.5-3 hours. The grading of the examinations will be weighted based on the time allotted and the nature of the questions. In general, the distribution will be: 40% final exam; 30% for the other two exams.

OFFICE HOURS

I am available for discussions on Mondays, 4:00-5:30 pm. I can hold problem solving sessions 2-3 times during the course. It will probably be implemented on a Saturday.