**CHEN 3660 - CHEMICAL ENGINEERING SEPARATIONS (3)**

**Required Core Course**

**2015-2016 Catalog Data Lec (3).** Separations processes including distillation, extraction, membrane separation, and other separation operations.

**Prerequisites** Pr: Completion of CHEN 3370 and CHEN 3620 with a grade of C or better.

**Schedule** Three one-hour class sessions per week.

**Course Objectives** The goal of this course is to introduce the principles and calculation methods required to solve industrial problems involving staged unit operations including application of multiphase equilibrium data and the analysis and design of single stage flash separations, binary distillation columns, multicomponent distillation columns, and liquid-liquid extraction columns. Theory and design of other separation processes are also considered.

**Textbook**

Wankat, Separation Process Engineering, 3e, 2011, Prentice Hall

**Topics Covered**

1. Introduction to separation processes (0.67 weeks)
2. Vapor-liquid equilibrium (0.67 weeks)
3. Non-ideal thermodynamic property models (0.67 weeks)
4. Single equilibrium stages and flash calculations (1 week)
5. Cascades, Strippers, Absorbers (2 weeks)
6. Distillation of binary mixtures (3 weeks)
7. Liquid-Liquid extraction with ternary systems (2.33 weeks)
8. Enhanced Distillation (O.33 weeks)
9. Supercritical extraction (0.33 weeks)
10. Membrane separations (2 weeks)
11. Adsorption, ion exchange, chromatography separations (1 week)
12. Tests (1 week)

**Course Outcomes:** Upon successful completion of this course, students should be able to:

1. Explain the following equilibrium concepts: K value, relative volatility, equilibrium, azeotrope, bubble point, dew point and Gibbs phase rule.
2. Identify the state of a system, the composition of its phases, the temperature dependences (bubble point, dew point, superheat temperature) using binary equilibrium diagrams (e.g., x-y, T-x-y, H-x-y).
3. Calculate the bubble point and dew point of multicomponent systems using DePriester charts (aka K charts) or appropriate equations.
4. Derive and plot the operating line for binary flash distillation on a x-y diagram.
5. Solve binary and multicomponent flash problems using sequential and simultaneous solution methods as appropriate.
6. Employ the Rachford-Rice equation to determine the solution to multicomponent flash problems.
7. Explain the basic concepts (e.g., equilibrium diagram, operating line, individual and overall driving forces, HTU, NTU) as they apply in the unit operations of gas absorption and stripping. Apply these concepts to solve mass transfer problems involving staged gas absorption or stripping operations. Determine the impact of temperature, pressure and solvent rate on these operations.
8. Sketch and identify the internal features of a distillation column and its external auxiliaries. Explain how a distillation column functions to separate chemical species.
9. Explain the following single feed distillation column concepts: total and partial condenser, total and partial reboilers, constant molal overflow, optimum feed stage, reflux liquid, reboiled vapor, rectification (enriching), stripping, stage efficiencies and flooding. Derive the operating equations for the rectification section, stripping section, and feed stage(s). Solve binary distillation problems.
10. Calculate feed quality and explain its effect on vapor and liquid flow rates above and below the feed stage including the cases of superheated and subcooled feeds.
11. Use the McCabe-Thiele method to design and rate distillation columns. Employ stage efficiency data to determine actual number of stages. Correctly differentiate between internal stages and equilibrium situations in column externals. Utilize appropriate methods to size columns (column diameter, tray spacing, height of packed bed columns) and to estimate pressure drop.
12. Understand the concept of limiting operating conditions including total reflux, minimum reflux, other pinch conditions.
13. Explain multicomponent distillation concepts such as key and non-key components, distributing components and optimum feed stage.
14. Explain the general procedure for stage-by-stage analysis of multicomponent distillation. Solve multicomponent distillation problems for situations where constant relative volatility can be assumed as well as systems where bubble point and dew point calculations must be performed on each stage.
15. Explain liquid-liquid extraction concepts including solubility envelope, plait point, extract, raffinate, solvent, solute, conjugate line, solvent to feed ratio, delta point, and delta composition.
16. Solve problems involving single contact extractions, cross-current extractions and counter-current extractions.
17. Design membrane-based separation processes.

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| **Contribution of Course to Meeting ABET Criteria 5 (Curriculum)** |
| **Math and Basic Sciences** | **Engineering Topics** | **General Education** |
| 0 Credits | 3 Credits | 0 Credits |

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| **Relationship of Course to Student Outcomes (PO’s)** |
| **Student Outcome** | **A** | **B** | **C** | **D** | **E** | **F** | **G1** | **G2** | **H** | **I** | **J** | **K** |
| **Level of Coverage** | **S** | **S** | **S** |  | **R** |  |  |  |  |  |  | **R** |

**Date of Preparation and Person(s) Preparing This Description**January 3, 2016: Joseph Shaeiwitz, William Josephson, Steve Duke