BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

SECOND SEMESTER 2020-21
COURSE HANDOUT

Date: 18.01.2021

In addition to part I (General Handout for all courses appended to the Time table) this portion gives further specific details regarding the course.

Course No : **CHE F244**
Course Title : **Separation Process I**
Instructor-in-Charge : **SURESH GUPTA**
Tutorial/Practical Instructors : **Arkaprovo Ghosal, Anil Kumar**

1. Course Description:
Molecular diffusion in fluids, Interphase mass transfer, mass transfer coefficient, Theories for interphase mass transfer, overall mass transfer coefficient and correlations, mass transfer with chemical reaction, analogy between momentum, heat and mass transfer, Absorption, Distillation including azeotropic and extractive distillation, Liquid-Liquid extraction, Leaching, Equipment for absorption, distillation, extraction and leaching.

2. Scope and Objective of the Course:

This course deals with the basic knowledge of mass transfer fundamentals and separations by phase addition or creation. The primary objective of this course is to encapsulate the important technical fundamentals for designing the mass transfer equipments.

3. Text Book:
Seader, J.D., Henley, E.J., "Separation Process Principles," 2nd Edition, W iley India Pvt. Ltd., New Delhi, 2006.

4. Reference Books:
R1. Treybal, R.E., "Mass Transfer Operations," 3rd Ed. (International Edition), McGraw-Hill Book Company, Singapore, 1980.
R2. Dutta, B. K., "Principles of Mass Transfer and Separation Processes," Prentice-Hall of India Pvt. Ltd., New Delhi, 2007.

5. Course Plan:

Module	Lecture session/Tutorial session	References	Learning outcomes
Introduction to separation processes	L1. Mechanism of separation, Separation by phase addition or creation, Separation by barrier, Separation by solid agent, Separation by external field or gradient, component recoveries and product purities, Selection of feasible separation processes.	Ch. 1 (T1)	• Role of separation operations in the chemical and biochemical industries. • What constitutes the separation of a mixture and how each of the five basic separation techniques works. • Component material balances around a separation operation based on specifications of component recovery • (split ratios or split fractions) and/or product purity. • Concept of key components and separation factor to

			measure separation between two key components.
Mass transfer and diffusion	L2-L10. Molecular diffusion, Diffusion coefficients, One-dimensional molecular diffusion through stationary media, Molecular diffusion in laminar flow, Two-film theory and overall mass transfer coefficients.	Ch. 3 (T1)	• Relationship between mass transfer and phase equilibrium, and why models for both are useful. • Mechanisms of mass transfer, including bulk flow. • Fick's law of diffusion for binary mixtures and discuss its analogy to Fourier's law of heat conduction. • Diffusivities for gas, liquid, and solid mixtures. • Rates of mass transfer by molecular diffusion in laminar flow for three common cases. • Mass-transfer coefficient and explain its analogy to the heat-transfer coefficient. • Rates of mass transfer across fluid–fluid interfaces using two-film theory and penetration theory.
Absorption and Stripping of dilute mixtures	L11-L20. Equipment, General design considerations, Graphical equilibrium stage method for tray towers, Algebraic method for determining the number of equilibrium stages, Stage efficiency, Rate-based method for packed columns, Efficiency of packed columns.	Ch. 6 (T1)	• Differences among physical absorption, chemical absorption, and stripping. • Different types of trays. • Difference between random and structured packings and cite examples of each. • Estimation of minimum MSA flow rate to achieve a specified key-component recovery. • Graphically, estimation of the required number of equilibrium stages in a countercurrent cascade • Overall stage efficiency • Operation problems in tray columns. • Understand the height equivalent to a theoretical (equilibrium) stage or plate (HETP or HETS) • Estimation of packed height, and packed-column diameter.

Distillation of binary mixtures	L21–L32. Equipment and design considerations, McCabe-Thiele graphical equilibrium stage method for tray towers, Estimation of stage efficiency, Diameter of tray towers and reflux drums, Rate-based method for packed columns, Ponchon-Savarit graphical equilibrium stage method for tray towers.	Ch. 7 (T1)	• Need in distillation for a condenser to produce reflux and a reboiler to produce boilup. • Five possible phase conditions of the feed. • McCabe–Thiele method for determining minimum reflux ratio, minimum equilibrium stages, number of stages • Murphree vapor-stage efficiency to determine the number of actual stages (plates) from the number of equilibriumstages.
Liquid-Liquid extraction with ternary systems	L33-L37. Ternary liquid-liquid systems, Equipment, General design considerations, Hunter-Nash graphical equilibrium-stage method, Maloney-Schubert graphical equilibrium stage method.	Ch. 8 (T1)	• Why and when liquid–liquid extraction might be preferred to distillation. • Selection of equipment for liquid-liquid extraction. • Distribution coefficient and its relationship to activity coefficients and selectivity of a solute • between carrier and solvent. • Use of a triangular diagram to estimate minimum • solvent requirement, and equilibrium stages for ternary liquid–liquid extraction in a cascade.
Leaching and washing	L38-L40. Equilibrium-stage model for leaching and washing, Rate-based model for leaching, Equipment for leaching.	Ch. 16 (T1)	• Equipment used for batch and continuous leaching. • Differences between leaching, washing, and expression. • Calculation for the recovery of a solute for a continuous, countercurrent leaching and washing system. • No. of stages for the continuous counter-current leaching operation for the design recovery of solute.

6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Mid-Semester Test	90 Min.	30		CB
Comprehensive Examination	120 min	40		CB/OB
$Tutorials/ Surprise test		15		CB/OB
Assignment(s)		15		OB

$Four tutorials (each 10 marks) will be conducted out of which best three tutorials will be considered for final grading. During tutorial and surprise quizzes, the students will be asked to solve problems (numerical/objective/multiple choice type) and submit the answer sheet to the instructor.

7. Chamber Consultation Hour: To be announced in the class.

8. Notices: All notices concerning this course will be displayed in IntraBITS Portal and on the Chemical Engineering Notice Board.

9. Make-up Policy:

Make-up is granted only for genuine cases with valid justification and prior permission of Instructor-in-charge.

10. Note (if any):

Instructor-in-charge

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