

GUJARAT TECHNOLOGICAL UNIVERSITY

BIO-TECHNOLOGY (04)
PRINCIPLES OF PROCESS ENGINEERING-II
SUBJECT CODE: 2150404
B.E. 5thSEMESTER

Type of course: Chemical Engineering.

Prerequisite: None.

Rationale: The objective of this course is to study the principles of mass transfer and their application to separation and purification processes. The course integrates fluid dynamics and thermodynamics and proceeds to develop rate expressions for mass transfer in gases, liquids and solids.

Teaching and Examination Scheme:

| Teaching Scheme | | | Credits | Examination Marks | | | | | | Total Marks |
|-----------------|---|---|---------|-------------------|-----|---------|-----------------|--------|----|-------------|
| L | T | P | | Theory Marks | | | Practical Marks | | | |
| | | | ESE (E) | PA (M) | | ESE (V) | | PA (I) | | |
| | | | | PA | ALA | ESE | OEP | | | |
| 3 | 0 | 3 | 6 | 70 | 20 | 10 | 20 | 10 | 20 | 150 |

Content:

| Sr. No. | Topic | Teaching Hours | Module Weightage (%) |
|---------|--|----------------|----------------------|
| 1. | Introduction: Classification of mass transfer operation, choice of separation method, Methods of conducting mass transfer operations, Design principles | 06 | 11 |
| 2. | Molecular and eddy Diffusion in Fluids: Estimation of diffusivities and mass transfer coefficient, Their correlations, Analogies in transfer process, Simultaneous heat and mass transfer, Phase relationship for absorption, Distillation, Drying & crystallization, Applications of diffusion. | 12 | 22 |
| 3. | Inter Phase Mass Transfer: Concept of equilibrium, diffusion between phases, Two resistance theory, Local overall mass transfer coefficient, controlling mass transfer resistances. | 05 | 09 |
| 4. | Diffusion in Solids Fick's law in Diffusion, Types of Solid Diffusion | 02 | 04 |
| 5. | Gas Absorption: Equilibrium Solubility of gases in liquids, Ideal and non-ideal solution, Counter current multi stage operation (isothermal), Absorption factor, Continuous contact equipments, Overall coefficient and Transfer units, Concept of HETP and HTU, NTU and j_H factor, Industrial absorbers. | 10 | 18 |
| 6. | Liquid-Liquid Extraction: | 11 | 20 |

| | | | |
|----|---|----|----|
| | Ternary liquid-liquid equilibrium and tie line data, choice of solvent, Single stage & multistage extraction, Co - current and cross current extraction, Continuous counter current multistage extraction with and without reflux, theory & performance of continuous contact equipments, Single stage & multistage equipments, Applications of liquid extraction | | |
| 7. | Leaching: Steady state and unsteady state leaching equipments, Single stage leaching, Multistage cross current and counter current leaching, Rate of leaching recovery of solvent vapours, Application of leaching. | 05 | 10 |
| 8. | Mass Transfer with Chemical Reactions: Mass transfer with chemical reaction in case of adsorption, Extraction, leaching, Introduction to back mixing in various contacting devices. | 03 | 06 |

Suggested Specification table with Marks (Theory):

| Distribution of Theory Marks | | | | | |
|------------------------------|---------|---------|---------|---------|---------|
| R Level | U Level | A Level | N Level | E Level | C Level |
| 15 | 25 | 15 | 10 | 05 | - |

Reference Books:

1. "Mass transfer operation" by R.E.Treybal, Mc-Graw Hill international, 3rd edition
2. "Mass Transfer" by Sherwood, Pigford & Wilke, Mc-Graw Hill international.
3. "Chemical Engineering", Volume-2, by Coulson & Richardson, 4th edition
4. Perry's Chemical Engineers handbook, by Perry & Green, Mc-Graw. Hill international, 7th edition
5. Unit Operations of Chemical Engg. By W.L. McCabe, J. C. Smith & Harriott, Mc-Graw Hill international, 6th edition

Course Outcome: After learning the course students should be able to:

1. To build a basic knowledge of mass transfer operations and separation processes carried out in industries.
2. To understand the designing of mass transfer equipments used in the chemical industries.
3. To utilize the technological methods in problem solving of mass transfer operations in industries.
4. To review the practical importance and relevance of mass transfer in industries.
5. To understand the applications of different mass transfer processes.
6. To recognize the selection criteria for mass transfer process and equipments required by the industries.

List of Experiments and Open Ended Projects:

Minimum 5 practicals to be performed and remaining time should be allotted to open-ended projects / study reports / latest outcomes in technology study :-

1. In the beginning of the academic term, faculties will have to allot their students at least one Open-ended Project / Study Report / Latest outcome in technology.
2. Literature survey including patents and research papers of fundamental process
 - Design based small project **or**
 - Study report based on latest scientific development **or**
 - Technology study report/ modeling/ simulation/collection report **or**
 - Computer based simulation/ web based application/ analysis presentations of basic concept field which may help them in chemical engineering.

3. These can be done in a group containing maximum **three** students in each.
4. Faculties should cultivate problem based project to enhance the basic mental and technical level of students.
5. Evaluation should be done on **approach of the student on his/her efforts** (not on completion) to study the design module of given task.
6. In the semester student should perform **minimum 5** set of experiments and complete **one small open ended dedicated project** based on engineering applications. This project along with any performed experiment should be **EVALUATED BY EXTERNAL EXAMINER.**

PRACTICALS (ANY FIVE):

| | |
|----|--|
| 1. | To determine the percentage extraction for the benzoic acid from dilute aqueous solution using toluene as solvent. |
| 2. | To determine the diffusion co-efficient of CCl_4 in air & variation with temperature. |
| 3 | Determine mass transfer co-efficient of liquid (water) evaporation to atmospheric air at elevated temperature. |
| 4. | To determine the efficiency of single stage leaching operation for leaching of NaOH aqueous solution & CaCO_3 . |
| 5. | To find out the liquid side mass transfer coefficient K_{La} for the absorption of CO_2 in NaOH in the packed column. |
| 6. | To prepare the ternary diagram for a system of three liquid one pair partially soluble i.e. acetic acid, benzene and water system. |
| 7. | To study the (cross current) liquid-liquid extraction for extracting acetic acid from benzene using water as solvent. |
| 8. | To determine the mass transfer coefficient in a stirred cell. |

Major Equipments:

Packed column, Stirred cell, Diffusion apparatus.

Open Ended Project fields:-

Students are free to select any area of science and technology based on chemical engineering applications to define Projects.

Some suggested projects are listed below:

- Absorption of two compounds by using packed column.
- Separation of compounds using Liquid-liquid extraction.
- Separation of compounds using leaching.

List of Open Source Software/learning website:

- 1) Literature available in any laboratory manual of Mass Transfer Operation-I.
- 2) Mass Transfer Operations for the Practicing Engineer by Louis Theodore, Francesco Ricci, Wiley Publishers
- 3) NPTEL videos
- 4) Website: academia.edu for Laboratory view based e-learning portal for virtual mass transfer operations laboratory

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will

allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.