GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (05)
MASS TRANSFER OPERATION-I
SUBJECT CODE:2150501
B.E. 5th SEMESTER

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	C	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.	Content	Total Hrs	% Weightage
1	**Introduction:** Classification of mass transfer operation, choice of separation method, Methods of conducting mass transfer operations, Design principles	04	07
2	**Molecular Diffusion in Fluids:** Definition of molecular and eddy diffusion, Ficks first law, Concept of N & J Flux, Steady state molecular diffusion in fluids at rest and in laminar flow, concept of effective diffusivity. Diffusivity of gases, Diffusivity of liquids.	10	18
3	**Mass Transfer Coefficients:** Mass transfer in laminar and turbulent regions, F and k type mass transfer coefficients, Film, Penetration and surface renewal theories.	04	08
4	**Inter Phase Mass Transfer:** Concept of equilibrium, diffusion between phases, Two resistance theory, Local overall mass transfer coefficient, controlling mass transfer resistances.	04	08
5	**Gas Absorption:** Equilibrium Solubility of gases in liquids, Ideal and non-ideal solution, Choice of solvent for absorption, Material balance and liquid-gas ratio for absorption and stripping, 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. Dilute solutions, Absorption with chemical reaction	08	15

6	**Equipments for Gas Liquid Operations:** Gas Dispersed: Sparged vessels, Mechanically agitated vessels, Gas-Liquid contact, Tray Tower, Tray tower internals, Different types of trays, Weirs, Downcomers and criteria of their selection, Flooding, Loading, Coning, Weeping & dumping in tray tower; Liquid Dispersed: Ventury scrubber, Wetted wall towers, spray towers, Packed Towers, Packed tower internals, Different types of packings and their selection criteria, mass transfer coefficient for packed towers, Co-current flow of gas & liquid, End effects and axial mixing, Tray tower vs. Packed tower.	08	15
7	**Liquid-Liquid Extraction:** Ternary liquid- liquid equilibrium and tie line data, system of three liquids-one pair partially soluble, system of two partially soluble liquids-one solid, multi-component system, stage wise contact, 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-liquid extraction.	07	13
8	**Leaching:** Steady state and unsteady state leaching operations, Single stage leaching, Multistage cross current and counter current leaching, Rate of leaching, Recovery of solvent vapors, Application of leaching, Leaching equipments	04	08
9	**Crystallization:** Saturation, Nucleation, Principle of crystallization, Crystallization rate, Equilibria and yields, Nucleation, Crystal growth, Caking of crystals, Application of crystallization, Crystallization equipments, Crystallization from melts	05	08

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**	**--**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. "Masstransferoperation" byR.E.Treybal,Mc-GrawHillinternational, 3rd edition
2. "MassTransfer"bySherwood, Pigford&Wilke,Mc-GrawHillinternational.
3. "ChemicalEngineering",Volume-2,byCoulson&Richardson, 4th edition
4. Perry'sChemicalEngineers handbook,byPerry&Green,Mc-Graw.Hill international, 7th edition
5. UnitOperationsofChemicalEngg.ByW.L.McCabe,J.C.Smith&Harriott,Mc-GrawHillinternational, 6th edition

Course Outcome:

After learning the course the students should be able to:

1. To build a basic knowledge of mass transfer operations and separation processes carried out in chemical industries.
2. To understand the designing of mass transfer equipments used in the chemical industries.
3. To utilizethe technological methods in problem solving of mass transfer operations in industries.
4. To reviewthe practical importance and relevanceof mass transfer in chemical industry.
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:

Minimum**5**practicalstobeperformedandremaining time should be allotted to open-endedprojects/study reports/latest outcomes in technologystudy**:-**

1. Inthebeginning oftheacademicterm,facultieswillhavetoallottheirstudentsatleastone Open-ended Project / StudyReport /Latest outcome in technology.
2. Literaturesurveyincludingpatents and research papers offundamental process

- Design based smallproject**or**
- Studyreport based on latest scientificdevelopment**or**
- Technologystudyreport/modeling/ simulation/collection report**or**
- Computerbasedsimulation/webbasedapplication/analysispresentationsofbasic conceptfieldwhich mayhelp them in chemical engineering.

3. Thesecan bedoneinagroup containingmaximum**three** students in each.
4. Facultiesshouldcultivateproblembasedprojecttoenhancethebasicmentalandtechnical level of students.
5. Evaluation should be done on **approach of the student on his/her efforts** (not on completion) to studythedesign moduleofgiven task.
6. Inthesemesterstudentshouldperform **minimum** 5 setofexperimentsandcomplete **<u>one smallopenendeddedicatedproject</u>**basedonengineeringapplications.Thisprojectalong with anyperformedexperiment should be **<u>EVALUATED BY EXTERNAL EXAMINER.</u>**

<u>PRACTICALS (ANYFIVE):</u>

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.
9.	To carry out crystallization with & without seeding
10.	To determine the stage efficiency and the overall recovery of NaOH for multistage cross current leaching operation for leaching NaOH from mixture of NaOH and $CaCO_3$ using water as a solvent.

Design based Problems (DP)/Open Ended Problem:

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

Some suggested projectsarelisted below:

- Absorption of two compounds by using packed column
- To carry out crystallization by using crystallizer
- Separation of compounds using Liquid-liquid extraction and leaching.

Major Equipment:

Packed column, Stirred cell, crystallizer, Diffusion apparatus.

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
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.