GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: MASS TRANSFER-I
(Course Code: 3340502)

Diploma Programmes in which this course is offered	Semester in which offered
Chemical Engineering	4th Semester

1. RATIONALE

The operations which involve changes in composition of solutions, are known as the mass-transfer operations. Mass transfer operations are required for preliminary purification of raw materials or final separation of products from by-products. Mass transfer operations are major and important activity in most of the chemical plants. Hence the course has been designed to develop the following competency and its associated cognitive, practical and affective domain learning outcomes.

2. COMPETENCY

The course should be taught and curriculum should be implemented with the aim to develop required skills so that students are able to acquire following competency:

- **Supervise operation of various equipments for, the mass-transfer operations in chemical process plants.**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Discuss fundamentals of mass transfer operation.
ii. Evaluate diffusivity of gases by using empirical equation and explain effect of pressure and temperature on diffusivity.
iii. Explain Equilibrium and resistance concept related to mass transfer at fluid surface
iv. Calculate numerical for absorption based on material balance
v. Solve problem based on material balance with different condition on ternary diagram
vi. Explain various equipment uses for liquid extraction
vii. Explain different states of operation and equipment used for leaching.
viii. Discuss various membrane types and membrane modules

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	200
4	0	4	8	70	30	40	60	

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE DETAILS

Unit	Major Learning Outcomes (Outcomes in cognitive domain)	Topics and Sub-topics
Unit – I **Fundamental of Mass Transfer**	1a. Describe Importance of ass transfer operation	1.1 Introduction of Mass transfer operations
	1b. Classify mass transfer operations based on direct contact of two immiscible phases 1c. Explain Membrane separation operations	1.2 Operations based on direct contact of two immiscible phases 1.3 Membrane separation operations
	1d. Distinguish direct and indirect operations 1e. Describe selection of appropriate separation method	1.4 Direct and indirect operations 1.5 Choice of separation method
	1f. Explain fundamental design principles of Mass Transfer	1.6 Fundamental design principles of Mass Transfer
Unit – II **Molecular Diffusion in Fluids**	2a. Differentiate Molecular and Eddy diffusion 2b. Calculate the rate of diffusion in Fluids 2c. Distinguish Molar flux, diffusivity and concentration gradient in Fluids 2d. Apply the diffusion principal in Fluids	2.1 Molecular and Eddy diffusion 2.2 Rate of diffusion in Fluids 2.3 Molar flux, diffusivity and concentration gradient in Fluids 2.4 Applications of diffusion in Fluids.
	2e. Derive diffusivity equation 2f. Describe the effect of various factors on diffusivity 2g. Explain molecular diffusion in fluids for laminar flow	2.5 Derivation of diffusivity equation ($D_{AB}=D_{BA}$) 2.6 Effect of concentration, Temperature and pressure 2.7 on diffusivity 2.8 General equation for steady state molecular diffusion in fluids for laminar flow
	2h. Describe Molecular diffusion in gases 2i. Derive Equation for Steady state diffusion 2j. Evaluate diffusivity of gases using empirical equation	2.9 Molecular diffusion in gases 2.10 Derive Equation for Steady state diffusion of (a) Component A through non diffusing B and simple numerical (b) Equimolar counter current diffusion of A and B with simple numerical Empirical equation of diffusivity of gases
Unit – III **Interphase Mass Transfer**	3a. Explain Equilibrium 3b. Describe Diffusion between phases 3c. Describe various mass transfer coefficients using resistance concept 3d. Distinguish mass transfer co-efficients	3.1 Concept of equilibrium 3.2 Diffusion between phases (two resistance concept) 3.3 Local and overall two phases mass transfer co-efficient and their uses 3.4 Average overall mass transfer co-efficient
	3e. Define stage, stage efficiency and cascade	3.5 Stage and stage efficiency and types of Cascade
Unit – IV	4a. Apply concept of absorption	4.1 Industrial application of Absorption

Unit	Major Learning Outcomes (Outcomes in cognitive domain)	Topics and Sub-topics
Gas Absorption	4b. Describe the physical properties of gases 4c. Explain Raoults law	4.2 Equilibrium solubility of gases in liquids and effect of temperature and pressure. 4.3 Ideal solution and Raoult's law
	4d. Select appropriate solvent	4.4 Solvent for absorption
	4e. Explain Material balance in different condition 4f. Select liquid-gas ratio for absorber	4.5 Material balance for one component transfer 1. counter current flow 2. co-current flow 3. counter current multistage operation 4.6 Minimum liquid-gas ratio for absorber
	4g. Define various Efficiencies	4.7 Real Tray & Tray efficiency- point efficiency, Murphy efficiency, Overall Tray efficiency
	4h. Explain tray tower and packed tower 4i. Evaluate various packing	4.8 Tray tower and packed tower 4.9 HETP
	4j. Calculate absorption based on material balance	4.10 Raoult's law and material balance applied in gas absorption
Unit – V **Liquid Extraction**	5a. Apply the liquid extraction	5.1 Industrial application of Liquid Extraction
	5b. Describe the three component system 5c. Explain equilibrium using triangular co-ordinates 5d. Describe the effect of temperature and pressure	5.2 Equilibrium for three component system 5.3 Equilateral triangular co-ordinates system 5.3.1 System of three liquids-one pair partially Soluble 5.3.2 System of three liquids-two pair partially Soluble 5.4 Effect of temperature and pressure on solubility
	5e. Select appropriate solvent	5.5 Criteria for choice of solvent
	5f. Distinguish various types of extraction 5g. Describe the material balance for various stages 5h. Calculate Material balance in different conditions	5.6 Single stage extraction and multistage cross current extraction on ternary diagram 5.7 Material balance for single stage, multistage- cross current/counter current system 5.8 Problems based on material balance
	5i. Define Various equipment use in liquid extraction	5.9 Equipment Single stage extractor, agitated vessel, flow mixer and settler, spray tower, packed tower and centrifugal extractor
Unit – VI **Leaching**	6a. Describe Industrial applications	6.1. Industrial applications of leaching
	6b. Prepare solids Explain the factors affecting leaching	6.2. Preparation of solid 6.3. Temperature of leaching
	6c. Describe different states of operation and equipments	6.4. Methods of operation and equipment for (a) Unsteady state operation I. In place operation II. Heap leaching III. Percolation tanks

Unit	Major Learning Outcomes (Outcomes in cognitive domain)	Topics and Sub-topics
		IV. Filter press leaching V. Agitated vessel VI. Leaching by Shanks system (b) Steady state operation I. Leaching during grinding II. Leaching in door type agitator III. Leaching in door balanced tray thickener IV. Continues counter current decantation with flow sheet V. Leaching of vegetable seeds 1. Rotacel 2. Kennedy extractor 3. Bollman extractor 4. Continuous horizontal extractor
	6d. Explain Material balance	6.5. Material balance for single stage system
Unit – VII **Membrane Separation**	7a. Describe Membrane Separation Process	7.1 Introduction and Basic Principle of Membrane Separation
	7b. Classify membrane process	7.2 Types of Membrane Processes
	7c. Describe advantages and disadvantages 7d. Uses membrane separation processes	7.3 Advantages and disadvantages of membrane processes 7.4 Various applications of membrane separation.
	7e. Draw the diagram of various membrane modules	7.5 Various types of membrane and membrane Modules with diagram a. Plate and frame b. Tubular c. Spiral wound d. Hollow fiber

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of Mass Transfer	04	03	02	00	05
II	Molecular Diffusion in Fluids	07	02	04	03	09
III	Interphase Mass Transfer	05	02	02	02	06
IV	Gas Absorption	11	02	04	08	14
V	Liquid Extraction	10	02	03	08	13
VI	Leaching	11	02	03	08	13
VII	Membrane Separation	08	02	04	04	10
Total		**56**	**15**	**22**	**33**	**70**

Legends: R = Remember; U= Understand; A= Apply and above levels (Bloom's revised taxonomy)
Note: This specification table shall be treated as only as a guideline for students and teachers. The actual distribution of marks in the question paper may vary from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

***Note**: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Approx. Hrs. Required
1	II	Determine diffusivity of gas-liquid system at room temperature	4
2	II	Determine diffusivity of gas-liquid system with respect to temperature	4
3	II	Determine diffusivity of liquid-liquid system at room temperature	4
4	II	Determine diffusivity of liquid-liquid system at different temperature	4
5	IV	Find out rate of absorption in a tray or packed tower	4
6	V	Determine the efficiency of single stage extraction	4
7	V	Determine the efficiency of two stage cross current extraction	4
8	V	Determine the efficiency of continuous counter current extraction	4
9	V	Prepare ternary diagram for a system of three liquids	4
10	VI	Obtain tie-line data for Acetic Acid, Benzene and water	4
11	VI	Measure recovery of salt using sand-salt mixture in single stage leaching	4
12	VI	Measure recovery of salt using sand-salt mixture in two stage leaching	4
13	VI	Calculate efficiency of Leaching by shanks system	4
14	VII	Study and Compare different types of membrane module with detailed diagram.	4
Total Hrs			**56**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Visit nearby industries and observe the working of mass transfer equipments and collect their specifications

ii. Visit the website of reputed mass transfer equipment manufacturers and prepare a report on these equipments.

9. SPECIAL INSTRUCTIONAL STRATERGY (if any)

i. Show animated videos and drawings of mass transfer equipment

10. SUGGESTED LEARNING RESOURCES

A. List of Books:

Sr. No.	Title of Books	Author	Publication
1	Mass Transfer Operations	Robert E. Treybal	Mc Graw- Hill, 3rd Edition, 1981
2	Unit Operation of Chemical Engineering	McCabe, Warren L., Julian C. Smith	McGraw Hill Publication, New York 2004, 7th Edition
3	Separation Process Principles	Ernest J. Henley, J. D. Seader, D. Keith Roper	Wiley India, 2nd Edition, 2005
4	Unit Operations-II	K. A. Gavhane	Nirali Prakashan, Pune, 2009
5	Unit Operations of Chemical Engineering, Volume-1	P. Chattopadhyay	Khanna Publishers, New Delhi, 1995
6	Chemical Engineering, Volume-2	Coulsion and Richardson	Butterworth-Heinemann; 5th Edition, 2002
7	Introduction to Chemical Engineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York, 7th Edition, 2004

B. List of Major Equipment/ Instrument with Broad Specifications

i. **Gaseous diffusion system:**
Thermostatic bath 2 litre; Temperature controller 0-100 ^{0}C; Vernier 0-100 mm(0.1 mm resolution); Magnetic stirrer with heater 2 MLH; Air blower 0.25 HP

ii. **Liquid diffusion system:**
1 liter glass beaker, Magnetic stirrer 1 MLH, electrical conductivity sensor & meter to measure conductivity in MHO

iii. **Packed column absorber :**
75 mm ID, 1 m Glass column, Rasching ring packing; CO_2 cylinder with pressure regulator and rotameter; NaOH circulation system with pump, sump and rotameter

iv. **Continuous extractor :**
Glass column ID 75mm, OD 87mm, Height 1000mm; Supply tanks(three)-SS 304, 40 litre; Rotameters(two)-0.3 to 3 lpm-Glass tube, SS316 float; 0.25 HP motor with SS 304/316 shaft and blades

v. **Leaching apparatus :**
Leaching bag-Polypropylene; Glass column Dia. 40 mm, height 400mm with SS 304 cap at both end; Solvent tank SS304-25 litre with 1 KW immersion heater; Collection tank SS 304, 30 litre; Pump- MOC-Polypropylene, 15 lpm flow rate

vi. **Glass Separating funnels**
-250ml, 500ml ; **Burettes**-25 ml, 50 ml; **Pipettes** - 10 ml, 25 ml; **Conical flasks**- 250 ml, 500 ml; **Beakers** - 250 ml, 500 ml

C . List of Software/Learning Websites

i. www.unitoperation.com
ii. www.nptel.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Harsh B. Shukla**, Lecturer in Chemical Engineering, Shri K.J. Polytechnic, Bharuch
- **Prof. Upasana T. Singh**, Lecturer in Chemical Engineering, Shri K.J. Polytechnic, Bharuch
- **Prof. Jatin. R. Vadher**, Lecturer in Chemical Engineering, Govt. Polytechnic, Gandhinagar.

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Abhilash Thakur**. Associate Professor, Department of Applied Sciences
- **Dr. Bashirullah Shaikh**, Assistant Professor, Department of Applied Sciences