LOK JAGRUTI UNIVERSITY (LJU)

INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Chemical Engineering (708)

Bachelor of Engineering (B.E.) - Semester – IV

Course Code:	**017083402**
Course Name:	**Mass Transfer -I**
Category of Course:	Professional Core Course (PCC)
Prerequisite Course:	Thermodynamics II

Teaching Scheme				
Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Credit**	**Total Hours**
5	**0**	**2**	**6**	**50**

Syllabus

Unit No.	Topic	Prerequisite Topic	Successive Topic	Teaching Hours
01	**Introduction of Mass Transfer**			**5 (10%)**
	1.1 Classification of Mass Transfer Operation			
	1.2 Choice of Separation Method			
	1.3 Methods of Conducting Mass Transfer Operations			
	1.4 Design Principles			
02	**Molecular Diffusion in Fluids**			**6 (12.5%)**
	2.1 Definition of Molecular and Eddy Diffusion		Introduction to Mass Transport (017083501-Unit 8), Mass and Molar Transport by Convection (017083501-Unit 10)	
	2.2 Fick's First Law			
	2.3 Concept of N and J Flux			
	2.4 Steady State Molecular Diffusion in Fluids at Rest and in Laminar Flow			
	2.5 Concept of Effective Diffusivity, Diffusivity of Gases		Diffusion Through Stagnant Gas Film (017083501-Unit 9.2)	
	2.6 Diffusivity of Liquids		Heterogeneous Non-Catalytic Systems (017083601 Unit 6)	
	2.7 Diffusivity in Solids, Knudsen Diffusivity			
03	**Mass Transfer Coefficients**			**4 (7.5%)**
	3.1 Mass Transfer in Laminar and Turbulent Regions			
	3.2 F and K Type Mass Transfer Coefficients			
	3.3 Film, Penetration and Surface Renewal Theories			
04	**Inter Phase Mass Transfer**			**5 (10%)**
	4.1 Concept of Equilibrium		Concept of Vapor-Liquid Equilibria (017083503- Unit 2.1) Equilibrium concept (017083701- Unit 2.7)	
	4.2 Diffusion Between Phases			
	4.3 Two Resistance Theory			
	4.4 Local Overall Mass Transfer Coefficient			
	4.5 Controlling Mass Transfer Resistances		Concentration dependent term of rate equation (017083601 Unit 1.3), Heterogeneous Non-Catalytic Systems (017083601 Unit 6)	
05	**Gas Absorption**			**6 (12.5%)**
	5.1 Equilibrium Solubility of Gases in Liquids			
	5.2 Ideal and Non-Ideal Solution		Ideal Solutions (017083503- Unit 3.1)	
	5.3 Choice of Solvent for Absorption			
	5.4 Material Balance and Liquid-Gas Ratio for Absorption and Stripping		Mass and energy balances for steady state and unsteady state reactor (017083601 Unit 3.1)	
	5.5 Counter Current Multi Stage Operation (Isothermal)			
	5.6 Absorption Factor			
	5.7 Concept of Ideal Stage			
	5.8 Continuous Contact Equipments	Batch and Continuous Processing (017083304 Unit 1.2)		
	5.9 Overall Coefficient and Transfer Units			
	5.10 Concept of HETP and HTU			
	5.11 NTU and J_h Factor			
	5.12 Industrial Absorbents			

06	**Gas Dispersed Equipment for Gas Liquid Operations**			**5 (10%)**
	6.1 Sparged Vessels			
	6.2 Mechanically Agitated Vessels			
	6.3 Tray Tower		Simple Distillation (017083503- Unit 1.4)	
	6.4 Tray Tower Internals			
	6.5 Different Types of Trays			
	6.6 Flooding, Loading, Coning, Weeping and Dumping in Tray Tower			
07	**Liquid Dispersed Equipment for Gas Liquid Operations**			**4 (7.5%)**
	7.1 Venturi Scrubber			
	7.2 Wetted Wall Towers			
	7.3 Spray Towers			
	7.4 Packed Towers		Packed bed catalytic reactors (017083701- Unit 10.1)	
	7.5 Different Types of Packings and their Selection Criteria			
	7.6 Tray Tower Vs. Packed Tower			
08	**Liquid-Liquid Extraction**			**5 (10%)**
	8.1 Ternary Liquid- Liquid Equilibrium			
	8.2 System of Three Liquids-One Pair Partially Soluble			
	8.3 System of Two Partially Soluble Liquids-One Solid			
	8.4 Multi-Component System			
	8.5 Single Stage and Multistage Extraction		Models in Mass-Transfer Operations (017083701- Unit 3)	
	8.6 Co-Current and Cross Current Extraction			
	8.7 Continuous Counter Current Multistage Extraction with and Without Reflux			
	8.8 Single Stage and Multistage Equipment – overview			
09	**Leaching**			**5 (10%)**
	9.1 Steady State and Unsteady State Leaching Operations			
	9.2 Single Stage Leaching			
	9.3 Multistage Cross Current and Counter Current Leaching			
	9.4 Rate of Leaching			
	9.5 Application of Leaching			
	9.6 Leaching Equipment – Bollman extractor, Rotocel extractor			
10	**Crystallization**			**5 (10%)**
	10.1 Supersaturation			
	10.2 Nucleation			
	10.3 Principle of Crystallization			
	10.4 Crystallization Rate			
	10.5 Application of Crystallization	Manufacturing of sugar (017083304- Unit 7.1)		
	10.6 Crystallization Equipment – vaccum crystallizer, Draft tube-baffle crystallizer			

Sr. No.	Practical Title	Link to Theory Syllabus
1	Vapour - Gas diffusivity using Stefan tube:-To determine the diffusivity of Acetone vapour (A) in stagnant air (B).	Unit 2
2	Wetted Wall Column: To study the rate and phenomena of diffusion into gas flowing through pipe and also verify the Sherwood and Gilliland correlation	Unit 3
3	Liquid-Liquid Extraction: To determine the percentage recovery of acetic acid using water as a solvent for three stage of batch extraction.	Unit 8
4	Leaching: - To study the effects of quantity of solvent used and time of contact between solid and liquid phase for cross current leaching operation	Unit 9
5	Crystallization: - To calculate the percentage yield of crystal obtained with and without seeding of the soluble in its super saturation solution.	Unit 10

Major Components/ Equipment

Sr. No.	Component/Equipment
1	Wetted Wall Column
2	Packed Bed
3	Three neck flasks
4	Crystallizer
5	Condenser
6	Liquid- Liquid Extraction Column
7	Magnetic Stirrer with heating plate
8	Heating bath Oil and Water
9	Weight Balance machine

Proposed Theory + Practical Evaluation Scheme by Academicians (% Weightage Category Wise and it is Marks Distribution)					
L:	**5**	**T:**	**0**	**P:**	**2**
Note: In Theory Group, Total 4 Test (T1+T2+T3+T4) will be conducted for each subject. Each Test will be of 25 Marks. Each Test Syllabus Weightage: Range should be 20% - 30%					
Group (Theory or Practical)	**Group (Theory or Practical) Credit**	**Total Subject Credit**	**Category**	**% Weightage**	**Marks Weightage**
Theory	**5**	**6**	MCQ	33%	40
Theory			Theory Descriptive	17%	20
Theory			Formulas and Derivation	8%	10
Theory			Numerical	25%	30
Expected Theory %	**83%**		**Calculated Theory %**	**83%**	**100**
Practical	**1**		Individual Project	0%	0
Practical			Group Project	9%	50
Practical			Internal Practical Evaluation (IPE)	4%	25
Practical			Viva	4%	25
Practical			Seminar	0%	0
Expected Practical %	**17%**		**Calculated Practical %**	**17%**	**100**
Overall %	**100%**			**100%**	**200**

Course Outcome	
	Upon completion of the course students will be able to
1	Develop a foundational understanding of mass transfer mechanisms and molecular diffusion in fluids, including Fick's law of diffusion and the concepts of concentration gradients and flux.
2	Develop a thorough understanding of mass transfer coefficients and the factors influencing interphase mass transfer in gas-liquid systems, including surface area, concentration gradients, and fluid properties.
3	Apply their knowledge of gas dispersed equipment, liquid dispersed equipment, and liquid-liquid extraction to solve engineering problems, including separation and purification processes in industries such as petrochemicals, pharmaceuticals, and environmental engineering.
4	Develop a comprehensive understanding of leaching and crystallization processes, including principles of mass transfer, kinetics, and thermodynamics governing these operations.
Suggested Reference Books	
1	Mass transfer operation by R.E. Treybal, McGraw-Hill international, 3rd edition
2	Principles of mass transfer and separation processes by B.K. Dutta, Eastern Economy Edition.
3	Principles and fundamentals of mass transfer operation-I, Volume-I, by Kiran D Patil, Nirali Prakashans
4	Unit Operations of Chemical Engg. By W.L. McCabe, J.C. Smith and Harriott, McGraw-Hill international, 6^{th} edition
5	Chemical Engineering, Volume-2, by Coulson and Richardson, 4^{th}edition
List of Open-Source Software/Learning Website	
1	https://nptel.ac.in/courses/103/103/103103154/
2	https://nptel.ac.in/courses/103/103/103103145/
3	https://nptel.ac.in/courses/103/103/103103035/

Practical Project/Hands on Project		
Sr. No.	**Project List**	**Linked with Unit**
1	Entrapment of Particulate matter of the cigarette with the help of Whatman filter paper.	Unit 1
2	Gasoline vapor diffusion in atmosphere with respect to Temperature as varying parameter.	Unit 2
3	Compare Analytically One Component Diffusion and EMCD	Unit 2
4	Calculate Overall Mass Transfer Coefficient and Compare it With Individual MTC Analytically for Film Theory	Unit 3
5	Derive Reynolds's Analogy	Unit 3
6	Derive Fractional Offered by Gas and Liquid Phase	Unit 4
7	Explain HTU and NTU Graphically for Absorption Without and With Reaction	Unit 5
8	Calculate Analytically Effect of L/V Ratio on % Solute Removal in Absorption	Unit 5
9	Compare Bubble Cap, Sieve, Valve Tray	Unit 6
10	Compare Different Types of Packing Materials	Unit 7
11	Study Effect of Temperature on L-L Extraction	Unit 8
12	Temperature effect on Liquid-Liquid phase and Aniline point explanation.	Unit 8
13	Leaching of Salts from Soil into the Solvent (Water).	Unit 9
14	Crystallization with respect to Temperature as varying parameter.	Unit 10
15	Calculate Yield of Crystals of Given Salt Using Duhring's Plot	Unit 10