B. Tech. Semester VI

Subject Name: Mass Transfer Operation-II **Subject Code: BTCH13601**

Type of course: Professional Core Course

Prerequisite: Material & Energy Balance Calculations, Chem. Eng. Thermodynamics-I &II, Momentum and Mass Transfer-I

Rationale: This is core Chem Engg. course. The principles learnt in this course are required in almost all the courses and throughout the professional career of Chemical Engineer for process operations and design.

Teaching and Examination Scheme:

TEACHING SCHEME				Theory Marks			Practical Marks		Total
L	T	P	C	TEE	CA1	CA2	TEP	CA3	150
3	0	2	4	60	15	25	30	20	

CA1: Continuous Assessment (assignments/projects/open book tests/closed book tests **CA2:** Sincerity in attending classes/class tests/ timely submissions of assignments/self-learning attitude/solving advanced problems **TEE:** Term End Examination **TEP:** Term End Practical Exam (Performance and viva on practical skills learned in course) **CA3:** Regular submission of Lab work/Quality of work submitted/Active participation in lab sessions/viva on practical skills learned in course

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1.	**Distillation:** Binary System: Introduction, Vapor-liquid Equilibria, *P-x-y T-x-y* diagrams, concept of volatility and effect of P and T on equilibrium data, Ideal solutions, Raoult's Law as applied to distillation operations, Deviation from ideality, Minimum and maximum boiling azeotropic mixtures, Enthalpy concentration diagrams, their characteristics. Flash distillation, steam distillation, simple distillation, continuous rectification, Batch fractionation. Determination of number of stages by Ponchon and Sevarit method and McCabe-Thiele method, Concept of minimum, total and optimum reflux ratio, Reboilers, Use of open steam, , Partial condensers, cold hot circulating reflux. Azeotropic Distillation, Extractive Distillation **Multicomponent distillation:** key components, minimum and total reflux, short cut method: FUG (Fenskey-Underwood-Gilliland) method, Rigorous methods: Lewis-Matheson calculations, Thiele and Geddes method.	20	45%
2.	**Liquid Extraction and Leaching of ternary systems**: Ternary diagrams, Hunter-Nash graphical method and Maloney–Schubert graphical equilibrium-stage method, Solvent Selection, Operating point, number of stages, maximum solvent	10	22%

	to feed ratios, minimum reflux, minimum number of stages, Design of extractor, Introduction to reactive extraction, aqueous two phase extraction, extraction of biomolecules, supercritical fluid extraction. **Solid-liquid extraction**: Solid - liquid equilibria, efficiency, performance evaluation, Equipment for extraction, leaching and their sizing, Design considerations.		
3.	**ADSORPTION AND ION-EXCHANGE:** Definitions and industrial applications, Types of adsorption, nature of commonly used adsorbents, Adsorption Equilibria, Single gases and vapors, Breakthrough Curves, Kinetic and transport considerations, Material balance and application of Freundlich's equation for single stage operation, multistage cross-current operation and multistage countercurrent operation, Correlations for Transport-Rate Coefficients, Equipment for sorption operations, Scale-Up and Process Alternatives, Equipments for adsorption such as fluidized bed & Teeter beds, steady state moving bed & unsteady state fixed - bed adsorbers, concepts of adsorption wave, break-through curve, Pressure swing adsorber, elution and chromatography. **Ion-Exchange** : Principles, Techniques, Applications, Equilibria and Rate of ion exchange	**8**	**18%**
4.	**DRYING** :Drying of solids: Mechanism of drying, drying rate curves, Estimation of drying time , Drying equipment, operation, Process design of dryers, Drying of bioproducts,Through-circulation drying, concept of Nto_G and Hto_G, Drying at low temperature, Freeze drying etc. Batch & continuous drying equipments-Tray dryer, Tunnel dryer, Rotary dryers, Spray dryers, Fluidized bed dryer.	**6**	**13%**

Suggested Specification table with Marks (Theory/Practical):

% Distribution of Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
30	**30**	**25**	**15**	**00**	**00**

Legends: R: Remembrance, **U:** Understanding; **A:** Application, **N:** Analyze, **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 Text Books:

Sr. No.	Title of book /article	Author(s)	Publisher and details like ISBN	Year of publication	Publication Edition
1	Mass-Transfer Operations	Treybal R.E.	McGraw-Hill, New York	1981	3rd Edition
2	Unit Operations in	McCabe W.L, Smith	Mc Graw Hill,	2001 &	6th & 7th

	Chemical Engineering,	J.C., Harriott P.	New York	2005	Edition.
3	Chemical Engineering Vol. 1, Backhurst J. R., Harker J.H.	Coulson J.M., Richardson J.F.	Elsevier, New Delhi.	2004	6th Edition
4	Mass Transfer	Sherwood, T.K., Pigford, R.L., Wilke, C.R.	Cambridge University Press, Cambridge.	1997	2nd Edition
5	Introduction to Process Engineering and Design	S B Thakore and B I Bhatt	Tata McGraw Hill	2007	2nd Edition
6	Perry's Chemical Engineers' Handbook,	Green D. and Perry R.	McGraw-Hill Professional, Edinburgh.	2007	Eighth Edition
7	Applied process design for chemical and petrochemical plants ,Vol-1, 2 &3	Ludwig, E.	Butterworth-Heinemam	1997	Third Edition

Course Outcome:

Sr. No.	CO Statement After learning this subject, students will be able to	Marks % weightage
CO-1	Explain concepts of mass transfer principles	25
CO-2	Describe the important mass transfer operations such as Distillation, Liquid-liquid extraction & Leaching, Drying and Adsorption	25
CO-3	Select optimum parameters effecting different mass transfer operations	25
CO-4	Design principles for the design of distillation column and list their types, accessories and applications	25

Mapping with POs:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO12	PSO 1	PSO 2	PSO 3
CO-1	2	2	2	1	1	2	3	3	3	2	2	3	3	3	3
CO-2	2	2	2	3	2	2	3	3	3	2	3	3	3	3	3
CO-3	3	3	2	2	3	2	3	3	3	3	2	3	3	3	3
CO-4	3	3	3	1	2	3	3	3	3	2	3	3	3	3	3
Rationale*	10	10	9	7	8	9	12	12	12	9	10	12	12	12	12

Rationale*: The principles learnt in this course are required in almost all the courses and throughout the professional career of Chemical Engineer for process operations and design.

LIST OF PRACTICALS: (Minimum 6-8 performed.)

Experiments need to be performed during the semester.

1. Leaching
2. $CaCO_3$ Leaching
3. Liquid-liquid extraction
4. Freundlich isotherm
5. Ternary diagram
6. Differential distillation
7. Steam distillation
8. Air oven dryer
9. VLE
10. Adsorption column
11. Multi component distillation
12. Simulation of the unit operation using process simulator should be included to study the behaviour of mass transfer operation in each experiment

Major Equipment:

1. VLE
2. Air oven dryer
3. CO_2 absorption
4. Liquid-liquid extraction
5. Adsorption column

List of Open Source/learning website:

- https://nptel.ac.in/courses/103/103/103103145/
  - Chapter-1 & 3
- https://nptel.ac.in/courses/103/103/103103035
  - Chapter-1,2,3 & 4
- https://nptel.ac.in/courses/103/103/103103154/
  - Chapter-1 & 3

List of Open Source Software:

- https://openfoam.org/
- https://www.smartdraw.com/process-flow-diagram/process-flow-diagram-software.htm
- https://dwsim.inforside.com.br/new/
- https://www.cocosimulator.org/index_download.html