Course Name: Mass Transfer - I

Course Number: CH31001

Instructor: Prof. Swati Neogi

**Lecture Topics:** Detail course module is available in Appendix A

**Marks Distribution**:

* Total marks: 50

O Marks for mid-sem exam: 30 o Marks for End sem:10

O Internal assessment: 10

**Class schedule:**

Monday: 10:00-10:55 am

Wednesday: 8:00-9:55 am

Thursday: 10:00-10:55 am

**Venue:** Vikramshila complex Hall V3

**Assignments and Class Test:**

* Home assignments will be provided regularly to cover all the topics discussed in the class and will be expected to be tried at home.
* Assignments to be submitted/checked on scheduled dates.
* Assignments will be discussed in the class.
* A notebook containing assignments will be maintained and will be brought in the class regularly.
* Class tests will be taken.

**Tentative Lecture Schedule:** Appendix B

**Text books & reference books:**

1. Mass-Transfer Operations, by Robert E. Treybal
2. Principles of Mass Transfer and Separation Processes, by Binay K. Dutta.

**References:**

1. Diffusion: Mass Transfer in Fluid Systems by by E. Cussler

2. Separation Process Principles by [J. D. Seader](http://as.wiley.com/WileyCDA/Section/id-302477.html?query=J.+D.+Seader), [Ernest J. Henley](http://as.wiley.com/WileyCDA/Section/id-302477.html?query=Ernest+J.+Henley), [D. Keith Rope](http://as.wiley.com/WileyCDA/Section/id-302477.html?query=D.+Keith+Roper)r

**Attendance Policy**: 100% attendance is desirable.

**TA Contacts:**

1. SangeetaSankhla: [sangeeta7sankhla@gmail.com](mailto:sangeeta7sankhla@gmail.com), +91 7728881981
2. Yashwanth Padarthi: [yashwanth.padarthi790@gmail.com](mailto:yashwanth.padarthi790@gmail.com) 9486595432
3. Proma Bhattacharya: promabhattacharya31@gmail.com, +91 9432152489

**Class leaders contacts:**

**TA and Prof. Swati Neogy Contact Timings:**

* Only on Thursday at **4.00PM to 5.00PM**
* TA’s will be available at Composite Testing laboratory.

**Extra help for Category I and Category II students**

* It will be desirable for category I and category II students to come to Composite Testing Laboratory on every Thursday at 4:00 PM to 5:00 PM for or any extra help with the course.

**Tentative Lecture schedule**

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Instructor** | **No of hours** | **Course Content** |
| 15-Jul-19 | SWN | 1 | General Introduction, class orientation, guidelines |
| 17-Jul-19 | SWN | 2 | Intro to mass transfer |
| 18-Jul-19 | SWN | 1 | Intro to separation process |
|  |  |  |  |
| 22-Jul-19 | SWN | 1 | Molecular diffusion |
| 24-Jul-19 | SWN | 2 | Molecular diffusion/Issue Assignment 1,2 |
| 25-Jul-19 | SWN | 1 | Molecular diffusion/Tutorial -review of Assignment 1 |
|  |  |  |  |
| 29-Jul-19 | SWN | 1 | Molecular diffusion |
| 31-Jul-19 | SWN | 2 | Molecular diffusion/Issue Assignment 3 |
| 1-Aug-19 | SWN | 1 | Convective MT/Tutorial -review of assignment 2 |
|  |  |  |  |
| 5-Aug-19 | SWN | 1 | Convective mass transfer |
| 7-Aug-19 | SWN | 2 | convective mass transfer/Issue Assignment 4 |
| 8-Aug-19 | SWN | 1 | Convective MT/Tutorial-review of assignment 3 |
|  |  |  |  |
| 12-Aug-19 |  | 1 | **Holiday(Id-ul-Zuha)** |
| 14-Aug-19 | SWN | 2 | Convective mass transfer/Issue of assignment 5 |
| 15-Aug-19 |  | 1 | **Holiday(Independence day)** |
|  |  |  |  |
| 19-Aug-19 | SWN | 1 | Interphase mass transfer/stagewise operation |
| 21-08-2019 | SWN | 2 | Interphase mass transfer |
| 22-Aug-19 | SWN | 1 | Stagewise operation/Tutorial review of assignment 4 and 5 |
|  |  |  |  |
| 26-Aug-19 | SWN | 1 | Crystallization |
| 28-Aug-19 | SWN | 2 | Crystallization/issue of Assignment 6 |
| 29-Aug-19 | SWN | 1 | Crystallization |
|  |  |  |  |
| 2-Sep-19 | NCP | 1 |  |
| 4-Sep-19 | NCP | 2 |  |
| 5-Sep-19 | NCP | 1 |  |
|  |  |  |  |
| 9-Sep-19 | NCP | 1 |  |
| 11-Sep-19 | NCP | 2 |  |
| 12-Sep-19 | NCP | 1 |  |
|  |  |  |  |
| 16-Sep-19 | **Mid Sem** | | |
| 18-Sep-19 |
| 19-Sep-19 |
|  |
| 24-Sep-19 |
| 25-Sep-19 | NCP | 2 |  |
| 26-Sep-19 | NCP | 1 |  |
|  |  |  |  |
| 30-Sep-19 | NCP | 1 |  |
| 2-Oct-19 |  | 2 | **Gandhi Jayanti Holiday** |
| 3-Oct-19 | NCP | 1 |  |
|  |  |  |  |
| 7-Oct-19 |  | 1 | **Dusshera Holiday** |
| 9-Oct-19 |  | 2 | **Dusshera(Additional) Holiday** |
| 10-Oct-19 | NCP | 1 |  |
|  |  |  |  |
| 14-Oct-19 | NCP | 1 |  |
| 16-Oct-19 | NCP | 2 |  |
| 17-Oct-19 | NCP | 1 |  |
|  |  |  |  |
| 21-Oct-19 | NCP | 1 |  |
| 23-Oct-19 | NCP | 2 |  |
| 24-Oct-19 | NCP | 1 |  |
|  |  |  |  |
| 28-Oct-19 | NCP | 1 |  |
| 30-Oct-19 | NCP | 2 |  |
| 31-Oct-19 | NCP | 1 |  |
|  |  |  |  |
| 4-Nov-19 | NCP | 1 |  |
| 6-Nov-19 | NCP | 2 |  |
| 7-Nov-19 | NCP | 1 |  |
|  |  |  |  |
| 11-Nov-19 | NCP/SWN | 1 |  |
| 13-Nov-19 | NCP/SWN | 2 |  |
| 14-Nov-19 | NCP/SWN | 1 |  |
|  |  |  |  |
| 18-Nov-19 | **End Sem** | | |
|  |
|  |

**MT1-Lecture Topics**

**Instructor: Swati Neogi**

1. Introduction
   1. Examples of separation processes
   2. Difference of separation processes using mechanical operation and mass transfer operation
   3. Introduction to mass transfer principles: molecular diffusion and convective mass transfer: collision of molecules, bulk flow, speed of mass transfer, examples
2. Definition of terms
   1. Mass concentration and mass fraction
   2. Molar concentration and molar fraction
   3. Velocity such as
      1. Molecular velocity/bulk velocity
      2. Mass average and molar average velocity
   4. Different types of flux w.r.t different reference frames
      1. Mass flux, n, i, j
      2. Molar flux, N, I, J
      3. Relationship between J and N
3. Molecular Diffusion
   1. Fick’s Law w.r.t binary system
      * 1. Basic definition of law
        2. Fick’s law in terms of other flux
        3. Concept of diffusivity, dimension and unit
        4. Analogy of Fick’s law with heat and momentum equation

Analogy of mass diffusivity with heat and momentum diffusivity

* + - 1. Prove: DAB = DBA
  1. Diffusivity
     1. Factors affecting gas phase diffusivity and correlations for estimating gas phase diffusivity
     2. Factors affecting liquid phase diffusivity and correlations for estimating liquid phase diffusivity
     3. Multicomponent diffusion in gas phase
     4. Knudsen and surface Diffusivity
  2. Conservation of mass in terms of flux
     1. General unsteady state with chemical reaction equation for a single component
     2. Steady state without chemical reaction.: NA. area= constant
     3. Derivation of Fick’s second law
  3. Steady state molecular diffusion in binary gas/liquid mixtures
     1. Examples
     2. Steady state binary diffusion across constant area

3.4.2.1.Diffusion of A through non diffusing B

3.4.2.2. Equimolar counter diffusion

3.4.2.3.Non-equimolar counter-diffusion

* + 1. Steady state binary diffusion across variable area 3.4.3.1.Diffusion of A through non diffusing B-spherical geometry

3.4.3.2.Diffusion of A through non diffusing B-cylindrical geometry

* 1. Experimental measurements of Diffusivity
     1. Gas Phase
     2. Liquid Phase

1. Convective Mass Transfer and Mass Transfer Coefficients
   1. Introduction
      1. Turbulent or eddy diffusion
      2. Concept of convective mass transfer
      3. Concept of mass transfer coefficients
   2. Analytical expressions for mass transfer coefficients
      1. based on the units of the driving force
      2. for molecular diffusion of gas and liquid when fluids are stationary or in laminar flow
   3. Mass transfer theories
      1. Film Theory: mass transfer from solid surface to flowing liquid
      2. Penetration Theory: mass transfer from liquid to gas in rising

bubble

* + 1. Surface renewal theory: improvement of surface renewal

theory

* + 1. Boundary layer theory: incorporating flow field of the fluid
  1. Correlations for the convective mass transfer for real situation
     1. Dimensionless groups in mass transfer
     2. Development of Correlations using experimental data
     3. Correlations using analogy
     4. Common correlations available in the Literature

1. Interphase mass transfer
   1. Phase equilibrium
   2. Two resistance/Film theory
   3. Local MTC
   4. Overall MTC
   5. Average overall MTC
2. Material balance in contacting equipments: Stagewise operations
   1. Steady state concurrent operations
   2. Steady state counter current operations: Kremsor Equation
   3. Steady state crosscurrent operations
3. Crystallization
   1. Introduction
      1. Overview of crystallization process
   2. Solid Liquid equilibria
   3. Definition and concept of degree of supersaturation
   4. Method of creating Supersaturation
4. Crystallization Dynamics
   1. Nucleation: Different types and rate equations
   2. Crystallization growth

7.2.2.1. Concept, definition

7.2.2.2. Mechanism and growth rate expression 7.2.2.3.McCabe ΔL law

1. Crystal Size Distribution
   1. Concept of N(L) and n(L)
   2. Relationship between Nucleation rate, Growth rate and n(L)
   3. Moments of Distribution
2. Analysis of Crystallisers
   1. Batch Crystallizers: Evaporative and cooling types
   2. Continuous Crystallizers: MSMPR type
   3. Commercial Crystallizer