Carleton University

Prof. M Reza Kholghy
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Directed Study on Mass Transfer

Course content:
This course covers some fundamental topics on mass transfer including Brownian diffusion, Fick's laws, and its application with some emphasis on diffusion in concentrated solutions and estimation of diffusivities in different solutions. Then, the concept of generalized mass balances and mass transfer coefficients are discussed and basic theories for mass transfer coefficients are introduced. Mass transfer in hetero/homogeneous chemical reactions and the boundary layer problem are also discussed.

Prerequisites:
You should dedicate at least 15 h/week (2 h lectures, 6 h reading and preparation, 7 h for the project) to it. You need to have a strong understanding of calculus and ordinary differential equations (MATH1004 & 1104) and chemistry (CHEM1101) and passed Computation and Programming, (ECOR1041), Fluid Mechanics I (MAAE2300), Thermodynamics & Heat Transfer (MAAE2400), with high marks. Having knowledge of Heat Transfer (MECH 4406) and Fluid Mechanics II -Differential relations for fluid flow- (MAAE3300) is a plus.

Course Plan:
Week of Jan. 10: Lect .1: Organization, Introduction, Brownian Diffusion
Week of Jan. 17: Lect. 2: Diffusion in Dilute Solutions: Fick's Laws
Week of Jan. 24: Lect. 3: Applications of Fick's Laws
Week of Jan. 31: Lect. 4: Diffusion in Concentrated Solutions
Week of Feb. 07: Lect. 5: Estimation of Diffusivities
Week of Feb. 14: Lect. 6: Generalized Mass Balances: Rotating Disk
Week of Feb. 28: Lect. 7: Mass Transfer Coefficients (MTC) 1 & 2
Week of Mar. 07: Dispersion
Week of Mar. 14: Lect. 8: Basic Theories for Mass Transfer Coefficients
Week of Mar. 21: Lect. 9: Hetero/Homogeneous Chemical Reactions
Week of Mar. 28: Lect. 10: Boundary Layers: Mass & Heat/Momentum Transfer
Week of Apr. 04: Lect. 11: Mass Transfer and Chemical Reactions
Week of Apr 11: Lect. 12: Review: Fick's laws, dilute/concentrated solutions, MTC & reactions

Exercises
Week of Jan. 10: Ex. 1: Brownian Diffusion and Fick's Laws
Week of Jan. 17: Ex. 2: Diffusion in Dilute Solutions: Fick's Laws
Week of Jan. 24: Ex. 3: Applications of Fick's Laws
Week of Jan. 31: Ex. 4: Diffusion in Concentrated Solutions
Week of Feb. 07: Ex. 5: Estimation of Diffusivities
Week of Feb. 14: Ex. 6: Generalized Mass Balances Rotating Disk
Week of Feb. 28: Ex. 7: Mass Transfer Coefficients 1
Week of Mar. 07: Ex. 8: Mass Transfer Coefficients 2
Week of Mar. 14: Ex. 9: Dispersion
Week of Mar. 21: Ex. 10: Basic Theories for Mass Transfer Coefficients
Week of Mar. 28: Ex. 11: Boundary Layers
Week of Apr. 04: Ex. 12: Chemical Reactions
Week of Apr. 11: Ex. 13: Mass Transfer and Chemical Reaction

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Grading:
Midterm Exam on March 28th: 25 %
The Midterm exam is going to be a take-home exam with 4 questions. Students should return their solutions to the instructor within a day.

Mini Project: 75%
For the mini project, students are to prepare a
a two-page proposal (10%, due Jan 31st),
planning presentation (10%, due Feb 7th),
and a final report (55, Due April 30th).

Required Reference:
1. E.L. Cussler. “Diffusion: Mass transfer in fluid systems”. 3rd Ed., Cambridge University Press (2009)

Recommended Additional Reference:
1. R. E.Treybal, "Mass transfer operations." McGraw-Hill, (1980).
2. R. B. Bird, W. E. Stewart, and E. N. Lightfoot. “Transport phenomena”. Vol. 1. John Wiley & Sons, (2006).

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Mass Transfer Mini-Projects WS2022

(E: experimental, T: theoretical, L: literature study)

1.
(L, T)

Modeling oxidation and combustion of single metal particles **AVAIL.**

Metals such as iron and aluminum can be used as carbon free energy carriers. This study aims to review literature models for oxidation and combustion of single spherical metal particles with oxygen, water vapor, carbon dioxide and carbon monoxide and investigate the impact of Stephan flow (diffusion induced convection) on heat and mass transfer during particle oxidation. The student should perform a thorough literature review and develop a model to explain single particle oxidation.

Supervisor: Prof. Reza Kholghy (CB 3202, reza.kholghy@carleton.ca)

Student: Mahsa Salehi

2.
(L, T)

A simple model for calculating carbon conversion flux during inception and surface growth **AVAIL.**

Inception and surface growth of carbonaceous nanoparticles is a complex chemical process with many intermediate species and reaction pathways. This study aims to develop a simple model to calculate carbon conversion flux during inception and surface growth. The student should perform a thorough literature review and develop a code to calculate carbon conversion flux as a function of temperature, pressure and precursor species concentrations.

Supervisor: Prof. Reza Kholghy (CB 3202, reza.kholghy@carleton.ca)
Student: Mo Adib

3.
(L, T)

Estimating Van der Waals interactions between fractal like agglomerates **AVAIL.**

Van der Waals forces impact how nanoparticle evolve during material synthesis and deposit on surfaces. This mini project aim to develop a simple model to predict Van der Waals interaction forces as a function of agglomerate morphology and composition.

Supervisor: Dr. Jose Moran (josec.moranc@gmail.com), Prof. Reza Kholghy (CB 3202, reza.kholghy@carleton.ca)

Student: Hossein Rahbar
