Mass Transfer Operations

Lecture 01: *Overview of the course*

Jamin Koo

2019. 9. 2

Class information

- **Class code: 130517-002**
- **Instructor: Jamin Koo (jaminkoo@hongik.ac.kr)**
- **Time & place**
  - ✓ Monday 1:00 – 1:50 & 2:00 – 2:50 PM @ Room 405
  - ✓ Thursday 5:00 – 5:50 PM @ Room 405
- **Language: English** (Korean in limited cases)

Proposed schedule

5. 강의 내용 및 일정 Course Schedule			
Week	강의 및 실습내용 Topics, Assignments, Required Studies	교재내 범위 Readings	기타 Other Objectives
1	Introduction, Mass Transfer Theory		Assignment #1 out
2	Equilibrium Stage		
3	Distillation: Flash and Continuous Distillation		Assignment #1 due Assignment #2 out
4	Distillation: McCabe–Thiele Method		
5	Distillation: Enthalpy Balances, Stage Efficiency		Assignment #2 due Assignment #3 out
6	Distillation: Batch Distillation		
7	Leaching and Extraction		Assignment #3 due
8	Midterm exam		
9	Diffusion and Mass Transfer between Phases Equilibrium		Assignment #4 out
10	Diffusion and Mass Transfer between Phases Equilibrium		
11	Gas Absorption_packed bed		Assignment #4 due Assignment #5 out
12	Gas Absorption_packed bed		
13	Humidification Operations		Assignment #5 due Assignment #6 out
14	Humidification Operations		
15	Final exam		Assignment #6 due
참고사항 Note	The proposed schedule may be subject to change. For example, a team project may be assigned instead of homework #5–6.		

Teaching style and philosophy

- **Proactive learning**
  - ✓ You are expected to have read the lecture slide **BEFORE** coming to the class.
  - ✓ I will be teaching you what to study, not how to study; you have to STUDY IN YOUR OWN to learn concepts.
  - ✓ Ask questions DURING the lecture if you have come up with any while studying in your own or listening in class.
- **Understand rather than memorize**
- **Use of online lectures and video clips**

Grading & homework

- **Homework**
  - ✓ Assigned bi-weekly, due at the beginning of the class
  - ✓ 50% penalty will be given for late (~24 hrs) submission.
  - ✓ The assignment w/ the lowest score will not be counted.

- **Grading:** Homework (30%), midterm (30%), final (40%)
  - ✓ Entire homework or exam will be re-graded upon request **but may not be to your advantage**!
  - ✓ 90% or above will be guaranteed of at least A.
  - ✓ 80% or above will be guaranteed of at least B.
  - ✓ The exact grading scale will depend on the entire class's performance (average, and standard deviation).

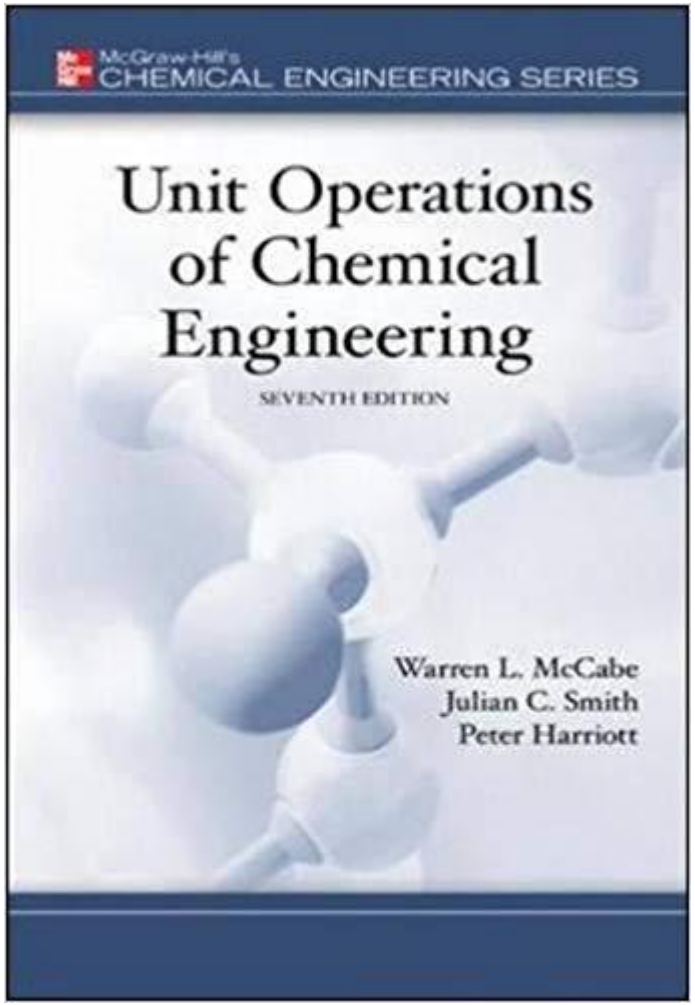
Office hours & rules

- **Office hours**
  - ✓ **Mon/Tues/Fri 5 – 6 PM**
  - ✓ ***Please write an email first to confirm the schedule!***
- **Rules regarding the office hours**
  - ✓ Can ask about lecture and class materials
  - ✓ Can ask only ***clarifying*** questions on homework
  - ✓ Can ask for regrading homework and/or exams
  - ✓ Cannot ask about items not covered in the above list

Additional rules

- **Maximum achievable grade for *re-takers***
  - ✓ How many re-takers are in the class?
  - ✓ The school limits this to B+.
- **Accommodation for students w/ disabilities**
  - ✓ How many students have disabilities?
  - ✓ Class consensus on how to accommodate
- **Conflicts w/ the exam schedules**
  - ✓ Need to notify the instructor ***at least 1 week in advance*** unless due to medical or other type of emergency

Materials



- **Textbook**

Unit operations of Chemical Engineering 7th ed

price? eng vs kor? how many?

- **Supplementary mat'l**
  - ✓ PPT slides
  - ✓ Will be uploaded on the ClassNet before the lecture.
  - ✓ Lectures will be given based on the textbook.
  - ✓ Homework and exams will be based on the textbook.

Learning objectives

- **Design and analyze unit operations that involve mass transfer between and across phases.**
- **Become familiar with theoretical concepts on diffusion & transfer, as well as key vocabulary.**
- **Evaluate and compare economics of various mass transfer operations**
- **(*Optional*) Feel more comfortable about communicating in English.**

Today’s outline

- **Introduction**
  - ✓ Who you are, and why you enrolled in the class.
- **Brief introduction to mass transfer**
  - ✓ Mass transfer
  - ✓ Separation processes
- **Future outlook of the field**
  - ✓ Industry outlook
  - ✓ R&D needs, and industry outlook

1.1 Introduction

- **Let's introduce ourselves.**
  - ✓ Name, major, and one fun fact about yourself
  - ✓ eg., Jamin Koo, Chemical Engineering, gained 6 kg in weight since working here

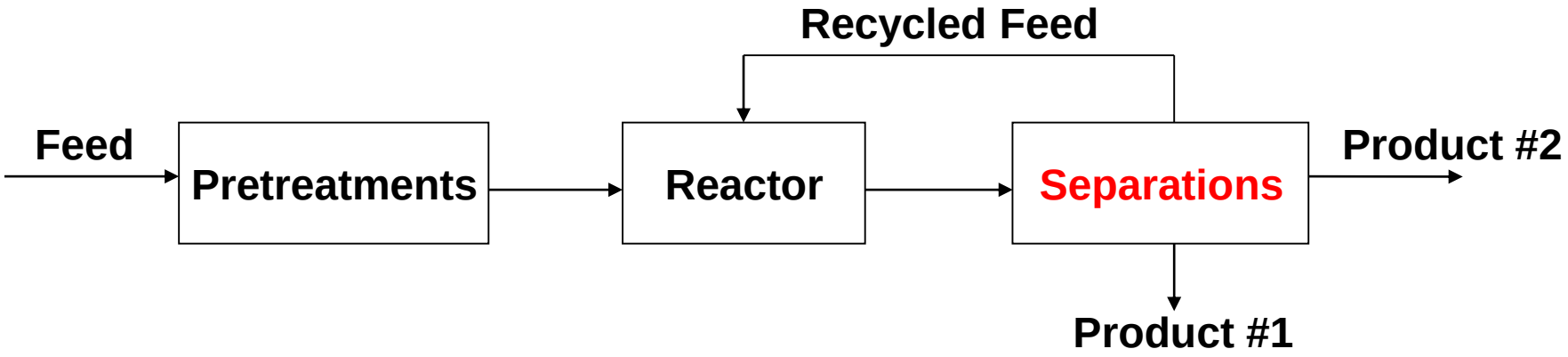
1.2 Mass transfer

- **It is motion of molecules or fluid elements caused by some form of potential or driving force such as the concentration difference (or difference in activity).**

- **It forms the basis for separation processes.**
  - ✓ mass transfer operation = separation operation

- **It occurs between phase boundaries. Examples include:**
  - ✓ Gas absorption in liquid
  - ✓ Evaporation
  - ✓ Drying
  - ✓ Dehumidification
  - ✓ Crystallization

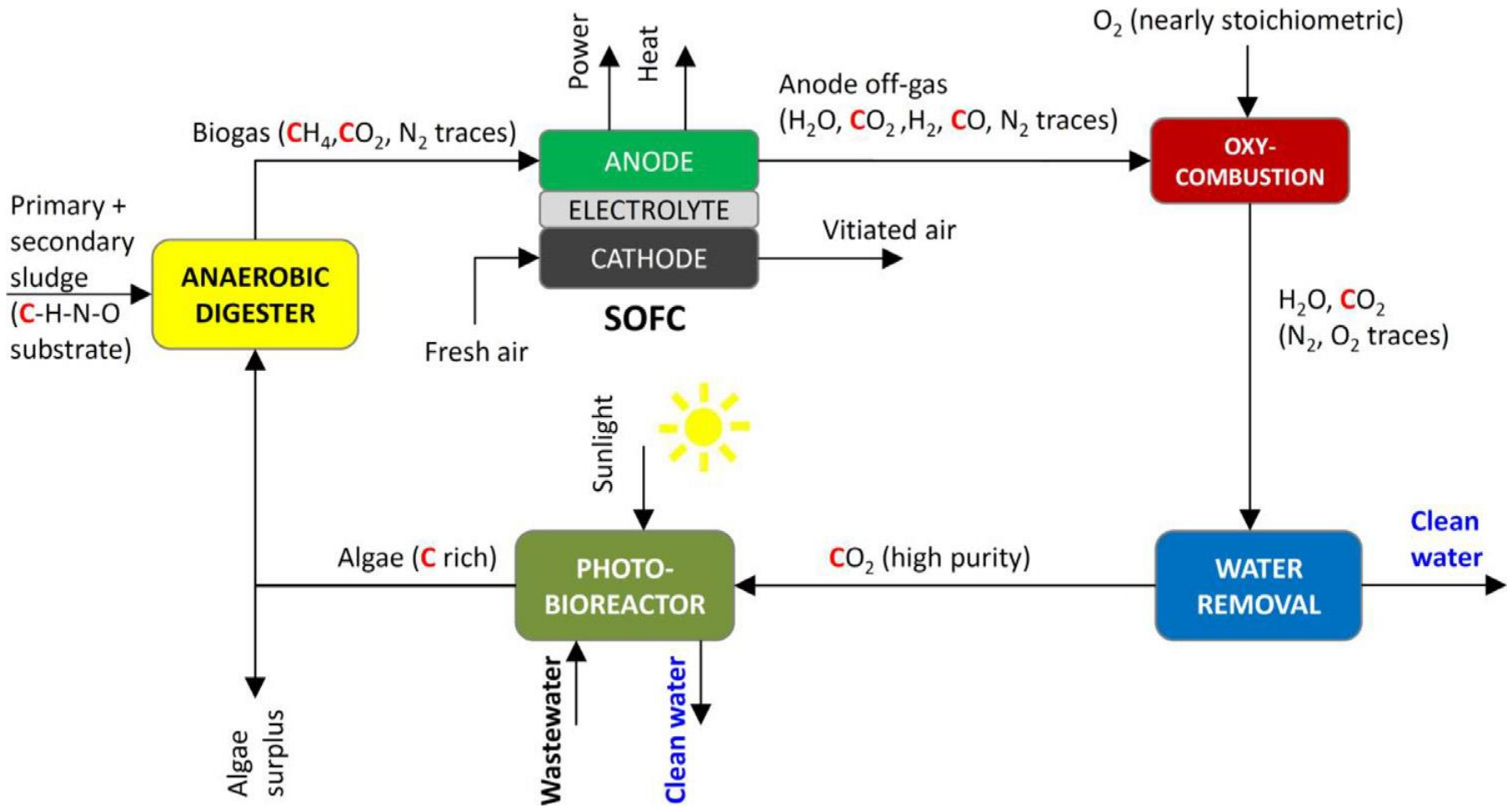
1.2 Typical chemical processes



- **They are large-scale and must be economically sound.**

- **Mass transfer occurs in most of the unit operations:**
  - ✓ Distillation
  - ✓ Absorption
  - ✓ (Liquid-liquid) extraction
  - ✓ Adsorption
  - ✓ Crystallization

Ongoing research project w/ SNU



1.2 Separation processes

- **They are crucial to the commercialization of the overall process.** **Why?**

- **Many do not involve biological and/or chemical rxns:**
  - ✓ Air separation into O_2 and N_2
  - ✓ Removal of impurities and unused raw materials

- **They are usually difficult and expensive.**
  - ✓ Mixtures are in general stable. Why?
  - ✓ Separation is thermodynamically unfavorable. Why?
  - ✓ One thus needs to add XXX ($$$) to separate molecules.

1.2 Mechanisms for separation

- **Phase creation or addition**
  - ✓ e.g., distillation, absorption, crystallization
- **Mass-separating agent(s)**
  - ✓ analogous to energy separating agent
  - ✓ frequently used in absorption and stripping
- **Barrier**
  - ✓ selective transport across membrane based on size, hydrophobicity,..
- **Force field and gradient**
  - ✓ e.g., ion exchange chromatography, electrophoresis, HPLC

1.2 Mechanics vs equilibrium

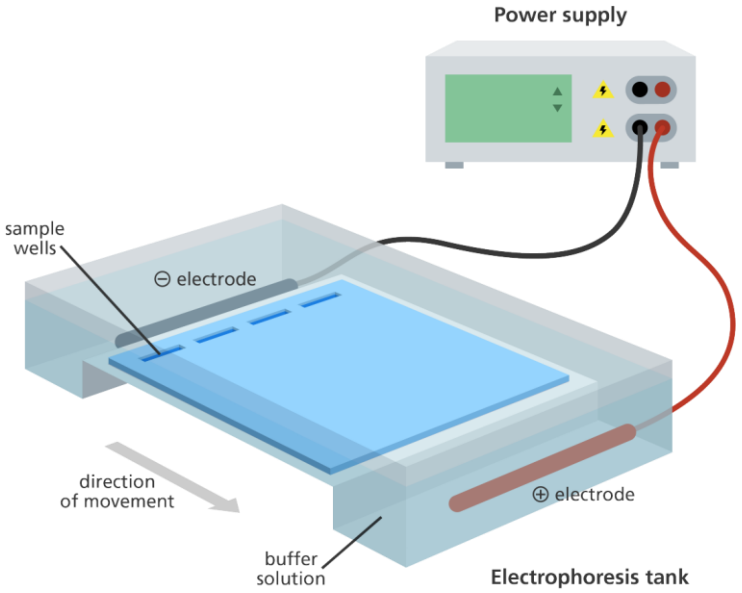
- **Mechanical separation**
  - ✓ filtration
  - ✓ sieving
  - ✓ settling

- **Equilibrium-based separation**
  - ✓ evaporation
  - ✓ distillation (Ch. 21)
  - ✓ leaching – solid/liquid extraction (Ch. 23)
  - ✓ liquid-liquid extraction (Ch. 23)
  - ✓ drying solids (Ch. 24)
  - ✓ humidification (Ch. 19)
  - ✓ gas absorption/desorption (Ch. 20)
  - ✓ crystallization

1.2 Rate vs equilibrium-limited

- **Rate of mass transfer ∝ driving force**
  - ✓ examples of driving force?

- **Dimension(s) of separation unit ∝ mass transfer rate**
  - ✓ size of gel for DNA electrophoresis
  - ✓ height of the column in gas absorption



1.2 Diffusion & transfer theory

- **Diffusion (Ch. 17)**
  - ✓ Fick's law
  - ✓ diffusivities
  - ✓ Schmidt number

- **Mass transfer (Ch. 17)**
  - ✓ film theory
  - ✓ boundary-layer theory
  - ✓ mass-transfer coefficients

1.3 Where do ChemEs work

- **The industry sectors where we work are becoming more diverse.**

1.3 Separation processes

- **It is a sub-field of chemical engineering focused on developing separation & purification technologies for use in industry**.
  - ✓ Three professors have expertise in this field at Hongik.



  - ✓ **Professor Seo & Ryu** conduct research in this field.

1.4 Future outlook

- **Industry & research trends**
  - ✓ Artificial intelligence: semiconductor & microelectronics
  - ✓ Global warming: carbon capture and storage (CCS)
  - ✓ Urbanization: water purification, smart building
  - ✓ Fuel diversification: biofuel, H_2, solar, smart grid
  - ✓ Electrification: electric vehicle, ultra-batteries

World is changing ***at an increasingly faster rate***, so update your perspective frequently by reading and watching.

Class etiquette

- **Avoid acts that can disturb others' learning.**
  - ✓ eg., speaking over the phone
- **Make minimal noise while going in/out of the rm.**
  - ✓ No permission needed.
- **Raise your hand if you would like to speak.**
- What else?

  ***Treat others as you would like to be treated*.**

Honor system

- **I have first encountered this at Stanford Univ.**
- **It is the set of rules & norms based on *trust*.**
- **For this class, I will trust students as follows:**
  - ✓ Do not copy/plagiarize homework; discussing problems is okay and in fact encouraged.
  - ✓ Do not cheat during exams.
  - ✓ Do not lie (to gain advantages).
- **In return, I will do minimal overwatching.**
  - ✓ attendance, grading, exam hours, etc.