

# Material and Energy Balances

ChE 2800 - Winter 2008

Department of Chemical Engineering and Materials Science

Wayne State University

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<b>Lecture:</b>	8:30am-10:20am M W, 0020 Manoogian 8:30am-9:25am F, 0020 Manoogian
<b>Instructor:</b>	Jeffrey J. Potoff Room 1127 Engineering (313) 577-9357 jpotoff@chem1.eng.wayne.edu
<b>Web Site:</b>	<a href="http://www.blackboard.wayne.edu">http://www.blackboard.wayne.edu</a>
<b>Office Hours:</b>	Monday and Wednesday 10:30am-12:00pm or by appointment
<b>Pre-reqs:</b>	CHM 1225, 1230, 1240, 1250 MAT 2010, 2020 PHY 2170/2175
<b>Textbook:</b>	Felder, R. M., and Rousseau, R. W., "Elementary Principles of Chemical Processes," 3rd ed., John Wiley and Sons (1999); ISBN 0-471-53478-1
<b>Objectives:</b>	The primary objective of this course is to teach students basic problem solving skills required for future studies in chemical engineering. This course includes instruction on the use of the TI-83 calculator. <b>Topics include:</b> An introduction to units, curve fitting, material balances for (a) non-reactive and (b) reactive processes, energy balances for (a) non-reactive and (b) reactive processes, reaction stoichiometry, combined energy and material balances, phase equilibria, and psychrometric charts.
<b>Grading:</b>	Homework: <b>10%</b> Class participation and quizzes: <b>5%</b> Exam #1 (material balances, chemical reactions): <b>15%</b> Exam #2 (material balances + phase equilibria): <b>20%</b> Exam #3 (energy and material balances): <b>20%</b> Final Exam (comprehensive): <b>30%</b>
<b>Scale:</b>	A: 100-85%, B: 84-70%, C: 69-55%, D: 54-35% <b>FINAL GRADES ARE NOT CURVED!</b>

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Homework:	All homework is assigned at the beginning of the semester. Students may turn in homework any time before the due date listed on the schedule to receive full credit. Homework sets are expected to be neat, and written on only one side of “engineering paper.” Homework submitted on loose leaf notebook paper and/or “double-sided” solutions will be returned to the student without grade.
Add/Drop	Students requesting a withdrawal from the course may do so for a documented medical condition that prevents the completion of the course. Students failing the course at the time of withdrawal will be given a mark of “WF”.
Missed Exams	Students who must miss an exam for any reason are expected to contact the course instructor before the date of the exam. Valid excuses for missing an exam are: illness, car crash, death in the immediate family, and jury duty. Students must provide documentation (doctor’s note, police report, death certificate, etc), before make-up examinations will be administered.
Attendance	Students are expected to attend all classes. Missed classes will result in a reduced “Class Participation” grade. Rain, snow, etc. are not valid excuses for missing class if the university is open.
Cheating	Students caught cheating on any assignment will receive a grade of 0 on that assignment and be subject to further disciplinary action. Students who cheat on any exam components, including extra credit problems, will receive a failing grade for the course. The student due process policy and information regarding academic dishonesty can be found at

<http://www.doso.wayne.edu/judicial/index.htm>

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# 1 Expectations and Student Responsibilities

## 1.1 General

- Past surveys indicate 10-15 hours per week are needed to complete each homework assignment.
  - Students are urged to start their homework assignments on the day they are assigned.
- Homework is assigned on Monday and due the following Monday. In the event of a holiday where the university is closed, homework is due on Wednesday when classes resume.
- Students are expected to consult other sources of information for help in completing the homework assignments. This includes, but is not limited to:
  - The course text.
  - Office hours.
  - Classmates.
  - The library.
- For exams, students are responsible for all material covered by the lecture and homework assignments.

## 1.2 Calculator

- Students are expected to own and know how to use a TI-83 or equivalent calculator (TI-84, HP48GX).
- This course will make extensive use of the equation solving capabilities of the TI-83 calculator.
- Students who own a calculator besides a TI-83, TI-84 or HP48GX will be responsible for self-teaching themselves how to use it.
- Although the TI-83 calculator is capable of solving complex problems, students are required to write detailed solutions on all exams and homework assignments.

## 1.3 Computer

- Students are expected to be familiar with MS Excel.
- All course information will be posted at

<http://www.blackboard.wayne.edu>

- Electronic communication with students will be through their WSU access ID.

## 1.4 Math

- Students are expected to be proficient in algebra, trigonometry, and basic calculus.

## 2 Problem Solving

ChE 2800 is most likely a course that is quite different from any other you have taken in the past because the solution of most chemical engineering problems requires *global knowledge*, ie. knowledge of many different things (algebra, chemistry, physics, material balances, etc), which are then synthesized in the creation of a solution. Unlike courses where it is possible to skip a difficult topic and still pass the course, to do so in this course is very risky.

It is expected that everyone in this course knows how to use typical engineering tools, such as a calculator or a computer. The focus of this course is not in how to plug numbers into equations. It is instead in the derivation of the material and energy balance equations that will lead to a successful solution to the problem(s) of interest. Once these equations have been derived, the numerical solution is usually relatively easy to perform.

- The biggest problem for most students is moving from the stage of “I don’t know where to start,” to generating a preliminary solution.
- How does one generate ideas?
- One can think of problem solving as having 4 distinct stages - Moshe F. Rebenstein Univ of Cal.
  1. **Preparation:** Go over all elements of a problem and study their relationships.
  2. **Incubation:** Unless you have been able to solve the problem quickly, you sleep on it.
  3. **Inspiration:** You feel a spark of excitement as a possible solution suddenly appears.
  4. **Verification:** You check your solution to see if it really works.

### 2.1 Application to ChE2800

Listed below is a checklist for solving material and energy balance problems. For some of you, this may be intuitive, and for others it may not. Following this checklist will increase your chances of successfully solving a problem.

1. Read the available information thoroughly and understand what is required for an answer.
2. Determine what additional data, if any, are needed and obtain this information.
3. Draw a simplified picture of what is taking place. Label streams as appropriate. Use boxes to indicate equipment and lines to denote flow streams.
4. Pick a basis to start the problem (if none is given).

5. If a chemical reaction is involved, write it down and verify that it is balanced.
6. Decide what formulas or principles are governing this specific case and what types of calculations need to be performed.
7. Write the material and/or energy balance equations. Solve the equations for the quantity of interest before putting numbers into the equations.
8. Make the necessary calculations in good form. Check arithmetic and units as you proceed.
9. Determine whether the answer seems reasonable.