Ceramic Engineering 259
Thermodynamics of Materials

Instructor: Dr. Bill Fahrenholtz
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Time: MWF 10:00 to 10:50 am, 216 McNutt

Office Hours: Drop by anytime or make an appointment by email if you want to be sure to find me. Email is also an excellent way to get questions answered.

Course Objective: The goal of this course to develop problem solving skills involving classical thermodynamics. The main focus will be on understanding basic thermodynamic functions as they apply to reaction equilibria. Students will also learn how to locate, understand, and use references such as tables, journals, and books.

Background: It is assumed that students have been introduced to enthalpy, entropy, Gibbs' free energy and equilibrium in Met 125 or Chem 3.

Text: D.R. Gaskell, Intro to the Thermodynamics of Materials, 5th Taylor and Francis, New York, 2008.

Lectures: Mathematical tools will be introduced and practical examples will be worked in lectures. Material will be covered in the same order as the text. Supplemental materials will be given in lectures and through assignments.

Homework: Homework assignments are given weekly. Students are encouraged to work together, but each individual must turn in his/her own work. If you have questions about homework, please work as much of the problem as possible so that you can ask specific questions. Students who fail to turn in two assignments or who do not maintain a 50% average on the homework may be dropped from the course. Solutions to homework and in-class problems will be posted on Blackboard. Helpful hints for solving homework problems are provided on page 3.

Reading: Reading assignments are listed in the syllabus. Homework, problems assigned in class, and unannounced quizzes will assume that you have done the reading.

Exams: Four in-class hour exams will be given during the semester. Missing an exam without prior notification and permission will result in a grade of zero. More information on exams is provided on page 3 of this handout.

Final Exam: A comprehensive final will be given during finals week. It is scheduled for on Thursday, May 3, 2012 from 10:30 am to 12:30 pm in room 216 McNutt.

Grading:

Homework/quizzes/in-class problems	25%
Hour exams	20% each (4 exams, low dropped if ≥0)
Final exam	15% comprehensive, mandatory final

A≥90>B≥80>C≥70>D≥60>F

Cheating: Campus policy on academic dishonesty (e.g. cheating, plagiarism) allows the instructor to make a judgment about the student's grade on the work in question and requires that alleged cases of academic dishonesty be reported.

Tentative Class Schedule

Class	Date	Topic	Reading
1	1/9	Overview and laws of thermodynamics	Ch. 1, 2, 3, 6
2	1/11	Standard state Gibbs' free energy and $\Delta G°$, K_{eq}	Sec 8.6, Ch 11
3	1/13	The equilibrium constant, K_{eq}	
	1/16	**No Class, MLK Holiday**	
4	1/18	Effects of H and S on equilibrium	
5	1/20	Effect of starting composition on reaction equilibrium	
6	1/23	Effect of temperature on equilibrium	
7	1/25	**No Class: Daytona Beach Meeting**	
8	1/27	Effect of pressure on equilibrium	
9	1/30	Control of oxygen partial pressure	
10	2/1	**Exam 1**	
11	2/3	Standard state and changes in Gibbs' free energy	Ch 7
12	2/6	Clapeyron equation	
13	2/8	Clausius Clapeyron equation	
14	2/10	Single component phase diagrams	
15	2/13	Gibbs' free energy as a function of temperature	
16	2/15	Gibbs' free energy as a function of pressure	
17	2/17	Effect of temperature changes on ΔH	
18	2/20	Effect of temperature changes on ΔS	
19	2/22	**Exam 2**	
20	2/24	Gas solid reactions	Ch 12
21	2/27	Ellingham diagram	
22	2/29	Phase stability diagrams: pO_2 and temperature	
23	3/2	Predominance diagrams	
24	3/5	Oxidation	
25	3/7	SiC stability	
26	3/9	Corrosion	
27	3/12	**Exam 3**	
28	3/14	Raoult's law and ideal solutions	
	3/16	**No Class: St. Pat's Break**	Ch 9
29	3/19	Non-ideal behavior and Henry's law	
30	3/21	Gas solubility in solids and liquids	
31	3/23	Graphical interpretation of G as a function of composition	
	3/26-3/30	**No Class: Spring Break**	
32	4/2	Phase separation	
33	4/4	Reactions with solutions	
34	4/6	G vs composition in eutectic systems	
35	4/9	G vs. composition in solution systems	
36	4/11	**Exam 4**	
37	4/13	Problem solving	Ch 5
38	4/16	Electrochemistry	Ch 15
39	4/18	Electrochemical sensors	
40	4/20	Fuel cells	
41	4/23	Energy functions	
42	4/25	Pourbaix diagrams	
43	4/27	Adiabatic flame temperature	
	5/10	**Final Exam, Thursday, May 3, 2012 10:30 am to 12:30 pm**	

Homework and In-Class Problems

Homework will be assigned weekly, except for weeks in which we have an hour exam. Each assignment will consist of 3 to 5 problems. You are expected to complete all of the problems that are assigned, but only 1 or 2 problems will be graded each week. The problems to be graded will be randomly selected from the assignments. Detailed solutions will be posted on Blackboard so that you can evaluate the problems that are not graded by me. The suggestions below are provided to help you get the most out of the homework assignments.

1. **Units:** Keep units with all of your numbers throughout your calculations. Points will be deducted when your drop units. For more complex problems, you will find that keeping track of units will provide insight into physical interpretation of the results and toward models for solving problems.

2. **Start with a fundamental relationship:** When solving a problem, don't look for a specialized equation that can solve the specific situation that you have encountered. You will be a better problem solver if you can start with a fundamental relationship or basic underlying equation that is generally applicable. After you identify the fundamental relationship, then you can modify that equation to solve your particular problem. For example, for problems involving work done by the system, the basic relationship is: $W = \int PdV$, which can be integrated for specific cases such as:

   Constant pressure $\quad W = P(V_{final} - V_{initial})$

   Constant volume $\quad W = 0$

   Isothermal ideal gas $\quad P = \frac{nRT}{V}$, so $W = \int \frac{nRT}{V} dV = nRT \ln\left(\frac{V_{final}}{V_{initial}}\right)$

3. **Show your steps and explain your logic:** Each of the problems that you encounter this semester will have several possible solutions. When I am grading them, I want to understand how you went from the problem statement, to an initial set of conditions, a reaction model, and a final answer. More importantly, you will want to be able to understand what you did and why when you go back to your homework to study for the exams. Simple sketches or drawings are often the first step in conceptualizing a solution to a problem, so I encourage you to include one on each problem.

4. **Problem solving suggestions:** Developing a standard process for solving problems will benefit you on both the homework assignments and exams in this class and in others. The best way to develop your process is to practice using the daily example problems and homework problems. The worked examples and homework solutions posted on Blackboard for this class will follow this methodology. Some suggested steps in a problem solving methodology include:
   a) Read the problem carefully.
   b) Identify the key aspects of the problem statement and paraphrase it. What are you trying to determine?
   c) List the data that are provided in the problem.
   d) Develop a model for solving the problem. This could be based on a flow chart, sketch, drawing, or diagram.
   e) Identify the key variables and fundamental thermodynamic relationships in your model.
   f) Determine the data that are needed to solve the problem. For problems from the text book, the data needed to solve them are somewhere in the book. For problems that I write, data will be provided or you will be instructed as to where to find it.
   g) Solve the problem by modifying the fundamental relationship to your particular problem.
   h) Evaluate your answer. Does it make sense with what you know?