Phase Chemical Equilibrium
ECH4123

Class Periods: MWF | period 9 (4:05 PM - 4:55 PM)
Location: MCCBG086

Instructor:
Tony Ladd
Email Address: tladd@che.ufl.edu
Office Hours: Tuesday 4-6 PM ChE 226/230

Course Description
Application of thermodynamic principles to systems of variable composition including the study of phase and chemical equilibria (3 credits).

Course Pre-Requisites
ECH 3101 Process Thermodynamics, ECH 3203 Fluid and Solid Operations, ECH 3223 Energy Transfer Operations

Course Objectives
Formulate problems involving phase and reaction equilibria as minimizations of the Gibbs free energy
Relate thermodynamic properties of mixtures to properties of pure components using activity coefficients
Calculate composition diagrams for VLE, LLE, and VLLE
Calculate equilibrium compositions of reactive species (primarily gases)
Solve equations for phase and reaction equilibria using numerical methods.

Materials and Supply Fees
N/A

Relation to Program Outcomes (ABET):

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.</td>
<td>High</td>
</tr>
<tr>
<td>2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.</td>
<td></td>
</tr>
<tr>
<td>3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.</td>
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<tr>
<td>4. An ability to communicate effectively with a range of audiences</td>
<td></td>
</tr>
<tr>
<td>5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.</td>
<td></td>
</tr>
<tr>
<td>6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge</td>
<td>Medium</td>
</tr>
</tbody>
</table>

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An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty

Coverage is given as high, medium, or low. An empty box indicates that this outcome is not part of the course.


**Additional Materials**
Chemical, Biochemical, and Engineering Thermodynamics by S. I. Sandler (any edition)

**Course Schedule (approximate)**

<table>
<thead>
<tr>
<th>Week</th>
<th>Week begins</th>
<th>Topic</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8/23</td>
<td>Introduction and Review</td>
<td>AZP: 5.1, 5.2, 5.5</td>
</tr>
<tr>
<td>2</td>
<td>8/30</td>
<td>Equilibrium and stability</td>
<td>AZP: 6.1, 6.2</td>
</tr>
<tr>
<td>3</td>
<td>9/6</td>
<td>Phase Equilibrium</td>
<td>AZP: 6.3 – 6.5</td>
</tr>
<tr>
<td>4</td>
<td>9/13</td>
<td>EOS, chemical potential, and fugacity</td>
<td>AZP: 7.3, 7.4</td>
</tr>
<tr>
<td>5</td>
<td>9/20</td>
<td>Mixture thermodynamics</td>
<td>AZP: 8.2-8.4</td>
</tr>
<tr>
<td>6</td>
<td>9/27</td>
<td>Ideal mixtures and VLE</td>
<td>AZP: 8.6, 9.1</td>
</tr>
<tr>
<td>7</td>
<td>10/4</td>
<td>Colligative properties</td>
<td>AZP: 9.5, 9.6</td>
</tr>
<tr>
<td>8</td>
<td>10/11</td>
<td>Chemical equilibria</td>
<td>AZP: 10.2</td>
</tr>
<tr>
<td>9</td>
<td>10/18</td>
<td>Standard states and use of tables</td>
<td>AZP: 10.3</td>
</tr>
<tr>
<td>10</td>
<td>10/25</td>
<td>Mixing functions</td>
<td>AZP: 8.1</td>
</tr>
<tr>
<td>11</td>
<td>11/1</td>
<td>Excess properties and activity</td>
<td>AZP: 8.7, 8.8</td>
</tr>
<tr>
<td>12</td>
<td>11/8</td>
<td>Liquid-liquid equilibrium</td>
<td>AZP: 9.2</td>
</tr>
<tr>
<td>13</td>
<td>11/15</td>
<td>VLE for non-ideal mixtures</td>
<td>AZP: 9.1, 9.3</td>
</tr>
<tr>
<td>14</td>
<td>11/26</td>
<td>Example problems</td>
<td>AZP: 10.4, 10.5</td>
</tr>
</tbody>
</table>

**Policies for Assignments, Make-Ups, and Privacy**

a Students will be assigned homework on Wednesday, which should be completed by Wednesday of the following week. The deadline for homework submissions is 10pm. Late homework will be penalized at 10% per day – starting at 10:01 pm. **Students can have up to 3 one-day extensions over the course of the semester, where homework can be submitted without penalty.** The extensions are granted automatically – no need to contact the instructor.

b **Homework more than 2 days late (i.e. after Friday at 10pm) will not be graded.**

c Homework assignments will be posted at least 1 week ahead of the due date. They are designed to supplement and reinforce the lectures from the same week (typically W, F, M). Students are strongly encouraged to work on assignments during the week, making use of office hours as needed. You may
choose to wait until the last minute to look at the homework, but any adverse consequences, such as late or inadequate submissions, are then your responsibility.

d  Homework submissions must be on Canvas as a scanned pdf or (for programs) a .py file. No bitmapped images or screenshots will be accepted for grading.

e  Discussion of homework is encouraged, but the submitted solutions must be your own work. Copying homework solutions from any source is an academic honesty violation for all parties involved.

f  Partial solutions to some homework problems will be posted with the assignment. These are designed to enable students to self check their work. If you have problems getting the correct solution you need to ask questions or come to office hours. Complete solutions will not be provided in general.

g  You may use ChatGPT4 to help with your homework; it may suggest useful ideas and approaches. However the submitted solution must be your own. Copying from ChatGPT4 or other AI systems will be treated as an academic honesty violation.

h  Suspected incidents of academic dishonesty will be referred to SCCR for possible disciplinary action. Check out the orange book for UF policies on student’s responsibilities and rights.

i  Assigned reading and videos will be included in each week’s homework. Students are expected to be familiar with these materials, as well as material from lectures and homework.

j  Students can also access the notes I prepare (see Files/Notes on Canvas). They will usually be posted over the weekend and cover the previous week’s classes.

k  The homework assignments are listed in the table above with the material they will relate to – the week’s lectures are scheduled for WFM this semester. Homework’s will cover material up to Monday’s class and will be due on Wednesday. Office hours are on Tuesday (4-6pm) if you need help.

l  Tests are scheduled in the Assignments section on Canvas.

m  All tests are open book and open notes. You may not access internet web sites during these tests or use any AI aids on your computer. All work on tests and quizzes must be individual unless collaboration is explicitly authorized for that test. Failure to comply with instructions is an academic honesty violation.

n  Homework and tests may require the use of Python to compute solutions to numerical problems. Students may bring programs to these tests as well as notes and books.

o  There will be 4 scheduled quizzes during the semester. These are closed book, in class tests. It is possible that I may authorize some limited discussion and/or collaboration in a specific quiz. Any such authorization will be for that quiz only – it does not carry over. Tests are always entirely individual.

p  Requests for re-grading of assignments and exams will only be considered within a one-week period from the time graded work is returned.

q  Grades for individual assignments and tests will be posted on the web throughout the semester, You should ensure that they are entered correctly. Corrections will be considered only within a two-week period after the grades have been posted on the web.

r  Students may request a makeup for any activity sponsored by the university, for health reasons, and for family emergencies. Other reasons at the instructor’s discretion, but will typically not be allowed. Makeup tests and quizzes will be given at the end of the semester. There will be no make up for the final test, except for health or family reasons. In such cases the student will receive an Incomplete grade, with a makeup to be given the following semester. Request for a make up of any assignment must be made at least 1 week in advance of the assignment (emergency health issues aside).

s  You are responsible for all announcements made in class and on Canvas.

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**Evaluation of Grades**

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Percentage of Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1 (M1, M2, M3)</td>
<td>30%</td>
</tr>
<tr>
<td>Test 2 (M4)</td>
<td>30%</td>
</tr>
<tr>
<td>Quizzes (4)</td>
<td>10%</td>
</tr>
<tr>
<td>Homework</td>
<td>30%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

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### Grading Policy (approximate – subject to modification)

<table>
<thead>
<tr>
<th>Percent</th>
<th>Grade</th>
<th>Grade Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;90</td>
<td>A</td>
<td>4.00</td>
</tr>
<tr>
<td>85-90</td>
<td>A-</td>
<td>3.67</td>
</tr>
<tr>
<td>80-85</td>
<td>B+</td>
<td>3.33</td>
</tr>
<tr>
<td>75-80</td>
<td>B</td>
<td>3.00</td>
</tr>
<tr>
<td>70-75</td>
<td>B-</td>
<td>2.67</td>
</tr>
<tr>
<td>65-70</td>
<td>C+</td>
<td>2.33</td>
</tr>
<tr>
<td>60-65</td>
<td>C</td>
<td>2.00</td>
</tr>
<tr>
<td>55-60</td>
<td>C-</td>
<td>1.67</td>
</tr>
<tr>
<td>50-55</td>
<td>D+</td>
<td>1.33</td>
</tr>
<tr>
<td>45-50</td>
<td>D</td>
<td>1.00</td>
</tr>
<tr>
<td>40-45</td>
<td>D-</td>
<td>0.67</td>
</tr>
<tr>
<td>0 - 40</td>
<td>E</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Schedule of Homework, Quizzes, Tests

<table>
<thead>
<tr>
<th></th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>Electronic submission – see Canvas pages for due dates and times</td>
</tr>
<tr>
<td>Quizzes</td>
<td>Paper submission – see Canvas pages for dates and time (in class)</td>
</tr>
<tr>
<td>Module tests</td>
<td>Paper and electronic submission – see Canvas pages for dates and times</td>
</tr>
</tbody>
</table>

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

### Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

### Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluerca.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

### In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor; as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons),

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including but not limited to another student within the same class section. Additionally, a recording, or transcript of
a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform,
including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services.
A student who publishes a recording without written consent may be subject to a civil cause of action instituted by
a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student
Conduct Code.

**University Honesty Policy**

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida
community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by
the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is
either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this
assignment.” The Conduct Code ([https://sccr.dso.ufl.edu/process/student-conduct-code/](https://sccr.dso.ufl.edu/process/student-conduct-code/)) specifies a number of
behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns,
please consult with the instructor or TAs in this class.

**Commitment to a Safe and Inclusive Learning Environment**

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to
individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every
person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age,
socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please
contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpenacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

**Software Use**

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements
governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual
violator. Because such violations are also against University policies and rules, disciplinary action will be taken as
appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to
the highest standards of honesty and integrity.

**Student Privacy**

There are federal laws protecting your privacy with regards to grades earned in courses and on individual
assignments. For more information, please see: [https://registrar.ufl.edu/ferpa.html](https://registrar.ufl.edu/ferpa.html)

**Campus Resources:**

**Health and Wellness**

**U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to
creating a culture of care on our campus by encouraging members of our community to look out for one
another and to reach out for help if a member of our community is in need. If you or a friend is in distress,
please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A
nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team
can help connect students to the many other helping resources available including, but not limited to, Victim
Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a
sign of strength. In case of emergency, call 9-1-1.
Counseling and Wellness Center: [https://counseling.ufl.edu](https://counseling.ufl.edu), 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

**Sexual Discrimination, Harassment, Assault, or Violence**
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](https://care.dso.ufl.edu), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

**Sexual Assault Recovery Services (SARS)**
Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or [http://www.police.ufl.edu/](http://www.police.ufl.edu/)

**Academic Resources**
- **E-learning technical support**, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. [https://lss.at.ufl.edu/help.shtml](https://lss.at.ufl.edu/help.shtml).

- **Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling; [https://career.ufl.edu](https://career.ufl.edu).

- **Library Support**, [http://cms.uflib.ufl.edu/ask](http://cms.uflib.ufl.edu/ask). Various ways to receive assistance with respect to using the libraries or finding resources.

- **Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. [https://teachingcenter.ufl.edu/](https://teachingcenter.ufl.edu/)

- **Writing Studio, 302 Tigert Hall**, 846-1138. Help brainstorming, formatting, and writing papers. [https://writing.ufl.edu/writing-studio/](https://writing.ufl.edu/writing-studio/)


*Computing support*: [https://helpdesk.ufl.edu/](https://helpdesk.ufl.edu/)

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