ChEE 201
Elements of Chemical Engineering I
Fall 2015
University of Arizona

Instructors: Dr. Anthony Muscat and Dr. Paul Blowers
108 Harshbarger and 128 Harshbarger
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Ph: 520-626-5319

Office Hours: To Be Determined

Active Learning Environment: MWF 1:00 – 1:50 pm Biosciences West 301

Supplemental Hours: M 3-4 pm
W 4-5 pm
Th 2-3 pm
Sat 10-11 am
Sat 1-2 pm

Students are required to enroll in one of the supplemental hour sessions and to attend each week. Credit will be given for preparing for the supplemental hour of active instruction for attempting the problems and being ready to work on them.

TA: Jaewook Choi - jaewookchoi@email.arizona.edu

Undergraduate Preceptors:
Abdullah Aleidan
Darien Bakas
Marisa Gonzalez
Esteban Jimenez
Jazmin Jurkiewicz
Megan McGuckin
Jose Rodriguez
Morgan Skillman

Course Description:
This course will introduce you to the fundamental principles of chemical process analysis. It will equip you with problem solving techniques and will give you experience in the application of these techniques to a wide variety of process-related problems. This course will also begin demonstrating how mathematics and spreadsheets can be a fundamental tool for solving complex engineering problems.

Text: Custom Text Available on D2L, 1st Edition, Muscat, 2015.

Elementary Principles of Chemical Processes, 3rd edition, Special Printing
R. M. Felder and R. W. Rousseau, John Wiley and Sons, 1998 or 2005.

Course Objectives:
Upon completion of this course, students should:
1) be able to comfortably use unit conversions while solving problems
2) be able to confidently transfer a verbal problem statement into its mathematical representation
3) be able to write and solve mass balances for a process
4) be able to use the appropriate gas law while solving mass and energy balances
5) be able to use phase diagrams to solve mass and energy balances
6) be able to apply Raoult's law in mass and energy balances
7) be able to identify and use formulas for the different energy terms
8) be able to use heat capacities correctly in energy balances
9) be able to integrate material and energy balance solution techniques to solve complex problems

10) be able to investigate transient behaviors where variables change over time

Other metaconcepts the students should be proficient at:
1) be able to identify personal difficulties during problem solving and to take corrective action
2) be able to knowledgeably think of everyday examples where material and energy balances are important
3) be able to conceptually link levels of information and ideas in a problem solving framework
4) begin to use the library and electronic resources effectively to find high quality information

Course Prerequisites:
The courses you must have taken before this course are:
MATH 124 or MATH 125; CHEM 151, CHEM 152, ENGR 102. You should have also completed ECE 175 or AME 105 and be concurrently in AME 205. If you have not fulfilled the co- or prerequisite courses you may be dropped from the course at the instructor's discretion since you may not succeed based on past student performance.

If the class becomes too large for the classroom it is scheduled in, students who do not meet the 2.0 U of A GPA may be dropped from the course. 2.0 is the minimum GPA to be a student at U of A.

Course Website: D2L website for ChEE 201

Important Dates to Keep in Mind:
8-31-15: Last day to use UAccess for adding classes, changing section, or changing to/from pass/fail grade
9-1-14: Late drop fee of $25.00/class starts.
Change of Schedule form is needed with instructor's signature to drop or add a class.
9-6-15: Last day to drop without a W.
9-14-15: Last day to increase number of units without $250 fee.
9-50-15: Last day to file for Grade Replacement Option.
9-20-15: Last day to use UAccess to drop; course will not appear on your transcript.
Last day to change to pass/fail or grade using the instructor's signature only
10-19-15: Last day to drop the class, requiring both the instructor's signature and the dean's signature

Course Grading Policies:
Homework: (10 % of grade for individual problems + 5% for group team problems)
Individual homework is due at the ***beginning*** of the class on the day it is due. Late homework will not be accepted. The toughest problem each week is a group mastery problem that you will solve together in your learning teams, and this problem will be clearly marked so you know which one this problem is. Your group will submit all homework in one stack with your table number on it and include the mastery problem at the front. Clips will be provided for this submission.

To eliminate confusion and difficulties in staying current, students will have 1 week from the date homework, quizzes, or exams are returned to discuss grading criteria and scores. After the 1 week time limit has passed, students will not be able to petition for changes to their grade.

Pre-class Quizzes on D2L: (10 % of grade)
There are many elements of being ready for new topics and part of that is to do the class readings and to consider that information prior to attending class. The online quizzes developed to help you be ready for class will make up 10 % of the grade and you will have three attempts to achieve a grade.

In Class Quizzes (10% of grade)
Quizzes will be given regularly at the beginning of class on the homework and pre-class activities/recordings. These quizzes will be created to make sure students are personally responsible for completing materials when they are due. At this point, students are getting closer to being a fully functioning professionals in the workforce and the expectation will be that you meet your timelines and get your work done as required. This is practice for those scenarios of the future.

Attendance and Participation (5% of grade)
An active learning environment involves everyone working together to help master the content. Attendance will be taken through a variety of measures and will be recorded soon after each class.

Exams (four exams, 7.5 % each, 30 % of grade total).
These in-class exams are **comprehensive** and are scheduled for 9-14, 10-5, 10-26, and 11-23.
Unless otherwise announced, these exams will be open book. Don't get too excited about this fact since you will need to know how to problem solve.

Make-up exams: A make-up exam may be arranged if you notify the instructor before the regularly scheduled exam. A makeup exam will be scheduled only if the student has a valid reason for missing the regularly scheduled exam. Verifiable illness with notification from the emergency dean or documentable family emergencies are valid reasons for missing an exam.

Exam Policy on Underperforming:
All students are eligible to earn some points back thatthey miss on an exam by going to office hours and working with the preceptor, TA, or faculty member to have their questions answered and then to be evaluated on that understanding. Students who receive less than a 60 % on an exam will be required to go to office hours twice in the following week and will be required to turn in a copy of the Exam Office Hour Form to the instructor to demonstrate they met in office hours as they attempted to earn points back. Students may go to any two office hours or may also schedule additional time with the instructor outside those office hours. In the first office hour, students who received less than 60 % are expected to ask questions that help them master the content from the exam, which does not mean that they just watch the problems being solved. During the second office hour meeting, or the first for those who scored higher than 60%, the student will be given a make-up question where they will either solve the problem, or explain the steps that would reach the solution. Students who successfully do this can earn up to 5 points back on that particular exam, unless their score on the exam goes above 100.

Final exam: (30 % of grade).
Comprehensive final on Monday December 14, 1 pm to 3:00 pm. A comprehensive final will be given during the scheduled period during finals.

Plagiarism: Although this course is not writing intensive, plagiarism is strongly discouraged. The plagiarism policies within the Student Code of Academic Integrity will be strictly followed: http://doc.web.arizona.edu/uapolicies.

Threatening Behavior: The general policies against threatening behavior by students will be followed: http://policy.web.arizona.edu/~policy/threaten.shtml

Grading Rubric:
Letter grades on exams or assignments will not be determined; a final letter grade will be given at the end of the semester instead. This course will be graded on a straight scale as follows:

Total percentage of points earned	Final Grade
90 - 100 %	A
78 – 89.999 %	B
66 – 77.999 %	C
54 – 65.999 %	D
< 54.999%	E

Course Lectures and Attendance Policies:
This class uses an active learning environment after doing pre-class work, and attendance is not optional for students to be able to master the material. Students who miss two or more consecutive classes may be dropped from the class if the administrative deadline has not passed and thee are students on the waitlist.

Pagers/telephones, or other communication technologies are strongly discouraged unless used for legitimate learning purposes, like finding information to solve a problem assigned in class. Students who disrupt class or learning activities will be asked to leave the classroom.

Participation for i-Course Students:
Like the in class version, participation with the online content is critical for student success for students in the i-Course. Students who do not work through recorded content within 48 hours of the lecture may be administratively dropped.

Accessibility and Accommodations: It is the University's goal that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact Disability Resources (520-621-3268) to establish reasonable accommodations

SALT Center and Disabililty Resource Center: Students who are able to use the services of the Strategic Alternatives Technology Center or may have other educational needs may see the professor at any time to discuss accommodations for their needs. However, this should be done at least 1 week prior to the first exam to allow for preparations that may be needed. Students who are registered with the Disability Resource Center must submit appropriate documentation to the instructor if they are requesting reasonable accommodations: http://drc.arizona.edu/teach/syllabus-statement.html.

Student Success in This Course
Students who succeed in this class, i.e., those who earn grades of A or B, typically are serious students who follow the Arizona Board of Regents policy of studying three hours for every in class hour. This means that you should expect to spend 9-10 hours of outside time on this class each week, consistently, throughout the semester. This means:
1) Students should attend class for all scheduled lecture periods and get notes from classmates when they are unable to attend.
2) Students should read the book sections that are assigned prior to attending the lecture for that material. Students will often be referred to the book information during the lecture and their success will depend upon some familiarization with the readings.
3) Students should come to class prepared to participate in active learning methods that encourage them to explore and question the material they are learning. This means that students should not expect any time during class for other activities like text messaging, telephone calls, other courses, or activities not part of the class. An active learning environment like the one used in the class maximizes exposure to problem solving techniques and mastery of the information.
4) Students should do their homework in a timely manner. Most homework assignments will be covered in class approximately three to five days in advance of when they are due. This leaves students ample time to reflect on the examples in class, come to office hours, and submit complete and correct homework solutions. Students should begin working on their solutions as soon as the topics are covered in the active learning lectures so they have time to reach the correct answer.

Standards for Homework Problems and Quizzes:
1. Briefly restate the problem using a sketch or diagram where appropriate. Label the sketch or diagram with all quantities involved.
2. Indicate the basis you select, and indicate any change of basis within the problem. State assumptions.
3. Include both the numerical value and units for all quantities involved, including intermediate results.
4. Answers should be circled or otherwise marked, and reported to an appropriate number of significant digits.
5. Values obtained from a handbook or other reference should be accompanied by a citation. For example:

CCl_4 boiling pt. 76.5 ^oC (CRC, pg C-373)

6. Show how you have checked your work if appropriate.
7. Be clear and concise when writing answers to questions.

Homework Submissions:
Homework may be submitted either to D2L as a scan that is legible, or may be turned in, in person, at the beginning of the class when they are due.

Standards for Style and Presentation of Problem Sets
1. All assignments are to be submitted on 8.5 x 11 inch paper with writing on one side only. Multiple pages must be stapled together. Unlined paper may be used if the work is done neatly. Handwriting must be legible.
2. Each page must have the student's name, the course number and the page number in the upper right hand corner.

Substandard work will result in a loss of credit.

Required Extracurricular Activities: none

Special Materials Required for the Class: See online course content.

Changes to the Syllabus: The information contained in the course syllabus, other than the grade and absence policies may be subject to change with reasonable advanced notice as deemed appropriate by the instructor.

ChEE 201 Fall 2015 Class Schedule (subject to change - check D2L for updates): 8-22-15

Week	Date	Day	Lec #	Reading Assigned	Homework Due	In Class Quiz	Topic
1	8/24	M	1	Preface, Chap 1, 2.1-2.4	Recent Picture and 2-3 personal facts		introduction to course conversion factors
	8/26	W	2	3.1-3.3		D2L Quiz 1 on Pre –Lect 2	process variables
	8/28	F	3	3.3-3.5		In Class Quiz 2 – pl 3	definitions and concepts
2	8/31	M					
	9/2	W	4	4.0-4.3c	Writing Assignment HW 1	In Class Quiz 3– pl 4	material balances
	9/4	F	5	4.3e-4.4		In Class Quiz 4– pl 5	
3	9/7	M	6	Labor Day - No Class		In Class Quiz 5– pl 6	
	9/9	W	7	4.5, Chapter Summaries 1-4	HW2	In Class Quiz 6– pl 7	
	9/11	F	8	Life Skills Practice 1		In Class Quiz 7 – pl 8	
4	9/14	M	9	**Test # 1**			
	9/16	W	10				
	9/18	F	11		Survey 2		
5	9/21	M	12	4.6a-b	HW 3	In Class Quiz 8 – pl 11	
	9/23	W	13	4.6c-4.7e		In Class Quiz 9 – pl 12	
	9/25	F	14	4.7f-4.10		In Class Quiz 10 – pl 13	
6	9/28	M	15		HW4	In Class Quiz 11 – pl 14 and exam review	Ideal and Non-ideal gas law
	9/30	W	16	5.1-5.2		In Class Quiz 12 – pl 15	
	10/2	F	17	Life Skills Practice 2		In Class Quiz 13	
7	10/5	M	18	**Test #2**			
	10/7	W	19				
	10/9	F	20			In Class Quiz 14 – pl 19	
8	10/12	M	21	6.0-6.1	HW 5	In Class Quiz 15 – pl 20	Mass Transfer and Phase Behavior
	10/14	W	22	6.2-6.3		In Class Quiz 16 – pl 21	
	10/16	F	23			In Class Quiz 17 – pl 22	
9	10/19	M	24		HW 6	In Class Quiz 18 – pl 23	
	10/21	W	25			In Class Quiz 19 – Exam 3 practice	

	10/23	F	26			In Class Quiz 20 – Exam 3 practice	
10	10/26	M	27	**Test #3**		In Class Quiz 21 – Exam 3 practice	
	10/28	W	28			In Class Quiz 22 – Exam 3 practice	Raoult's law and phase diagrams
	10/30	F	29			In Class Quiz 23 – Exam 3 practice	
11	11/2	M	30	Life Skills Practice 3	HW 7	None	
	11/4	W	31	Test Review		None	
	11/6	F	32				
12	11/9	M	33	7.1-7.3 (pages 313-210)	HW 8	In Class Quiz for Lecture 33	
	11/11	W	34	7.4 (pages 320-325)		In Class Quiz for Lecture 34	material balances integrated with energy balances
	11/11	F	35	7.5-7.6 (pages 325-333		In Class Quiz for Lecture 35	
13	11/16	M	36		HW 9	No Quiz - Blowers Gone	
	11/18	W	37			No Quiz - Blowers Gone	
	11/20	F	38	7.7-7.8 (pages 333 – 340)		In Class Quiz for Lecture 38	
14	11/23	M	39	**Test #4**		In Class Quiz for Lecture 39	
	11/25	W	40	8.0-8.2 (pages 357-369)8.3b– 8.4c (pages 365-384)		In Class Quiz for Lecture 40 Reward for being in class when you should	
	11/27	F		Thanksgiving Break			
15	11/30	M	41	8.4d-c (pages 384-395)	HW10	In Class Quiz for Lecture 41	
	12/2	W	42	Life Skills Practice 4			
	12/4	F	43				transient processes, again
16	12/7	M	44	Review for Final	HW 11	In Class Quiz for Lecture 44	
	12/9	W	45	Review for Final		In Class Quiz for Lecture 45	
					Concept Inventory Post Class		
	12/18	Th			Final Exam – 1 pm – 3:00 pm		

All homework is due on the days listed above unless otherwise designated on a specific problem handout.

Future software and possibilities for streaming/collaboration:
Apple airplay – non-apple devices are now linking to this and it's possible to use with those.

Student work can be streamed to the master screen

Chrome and firefox collaboration software
Talky.io – videoconferencing
Login.skype.com – webbrowser based and don’t need skype app.

$$\frac{(58.08x + 159.83 - 159.83x)g}{(73.42x + 51.24 - 51.24x)\,ml} = 1.35\frac{g}{ml}$$

$$\frac{(159.83 - 101.75x)g}{(22.18x + 51.24)\,ml} = 1.35\frac{g}{ml}$$

$$159.83 - 101.75x = 1.35(22.18x + 51.24)$$

$$159.83 - 101.75x = 29.943x + 69.174$$

$$90.656 = 131.723x$$

$$\frac{90.656}{131.723} = x = 0.688$$

$$100\ mol\ total\left(\frac{0.9\ \ mol\ ethanol}{mol\ total}\right)\left(\frac{MW\ ethanol\ g}{mol}\right) = ???$$

$$100\ mol\ total\left(\frac{0.9\ \ mol\ ethanol}{mol\ total}\right)\left(\frac{46.07\ ethanol\ g}{mol}\right) = 4146.3\ g\ ethanol$$

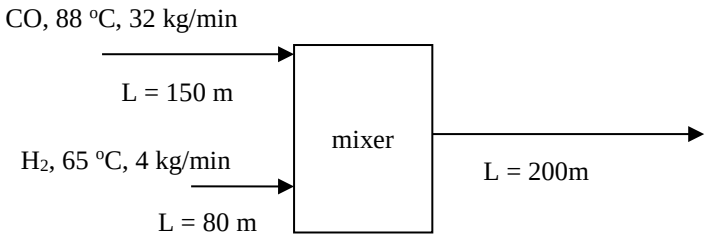
$$100\ mol\ total\left(\frac{0.1\ \ mol\ water}{mol\ total}\right)\left(\frac{18.01\ water\ g}{mol}\right) = 180.1\ g\ water$$

$$mass\ total = \ 4146.3\ g\ ethanol + \ 180.1\ g\ water$$

$$mass\ fraction\ of\ ethanol = \frac{mass\ g\ ethanol}{mass\ g\ total} = 0.958\ g\frac{ethanol}{g\ total}$$

Concept inventory Quiz Question Diagrams:

9



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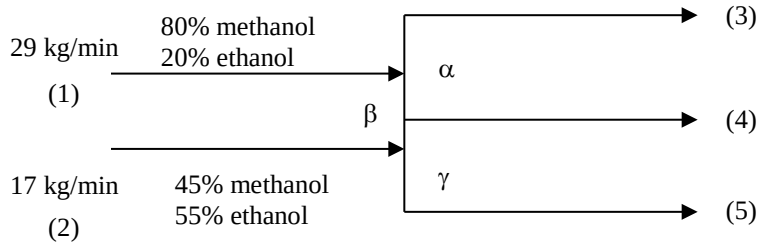

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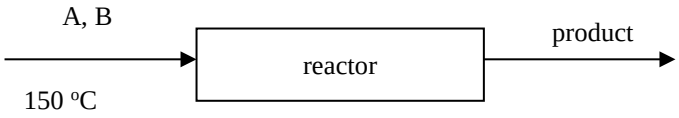

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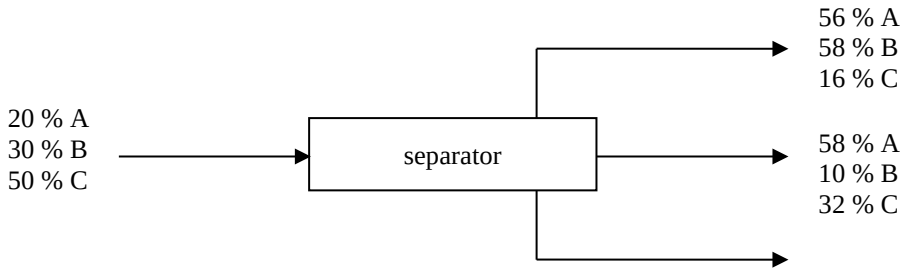


Lecture 5 slides:

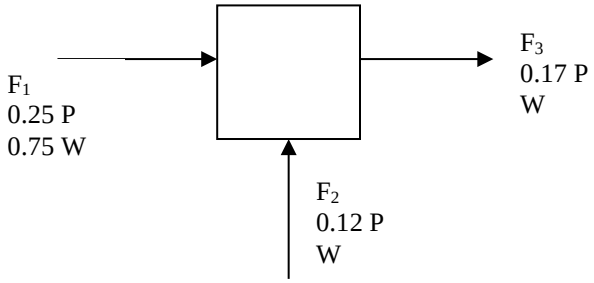
$$\frac{F_1}{F_2} = \frac{45}{55}$$

Lecture 6 slides:

$$\frac{45\ lb}{92.16\ lb} = \frac{F_1}{1\ lb}$$

A paint mixture containing 25% of a pigment and 75% water is being mixed with another paint that is 12% pigment and the rest water. What would be the ratio of the two solutions in order to make a 17% pigment?

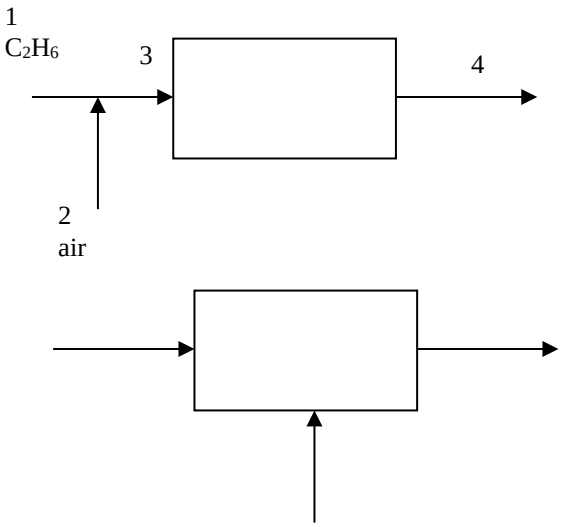
If we represented this as:

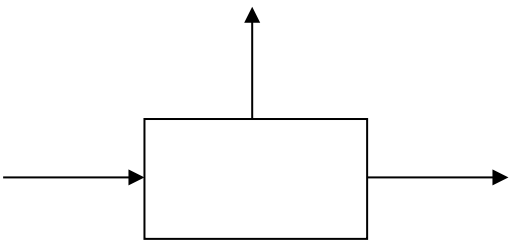


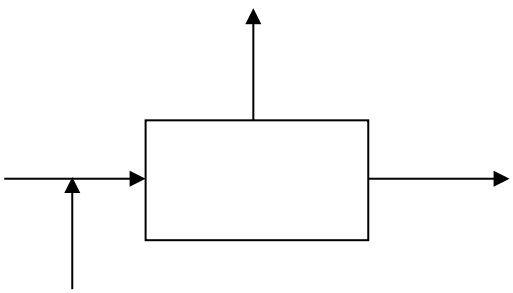
Lecture 10 slides:

$$\frac{F_{6,O}}{F_{6,H}} = \frac{F_{5,O}}{F_{5,H}}$$

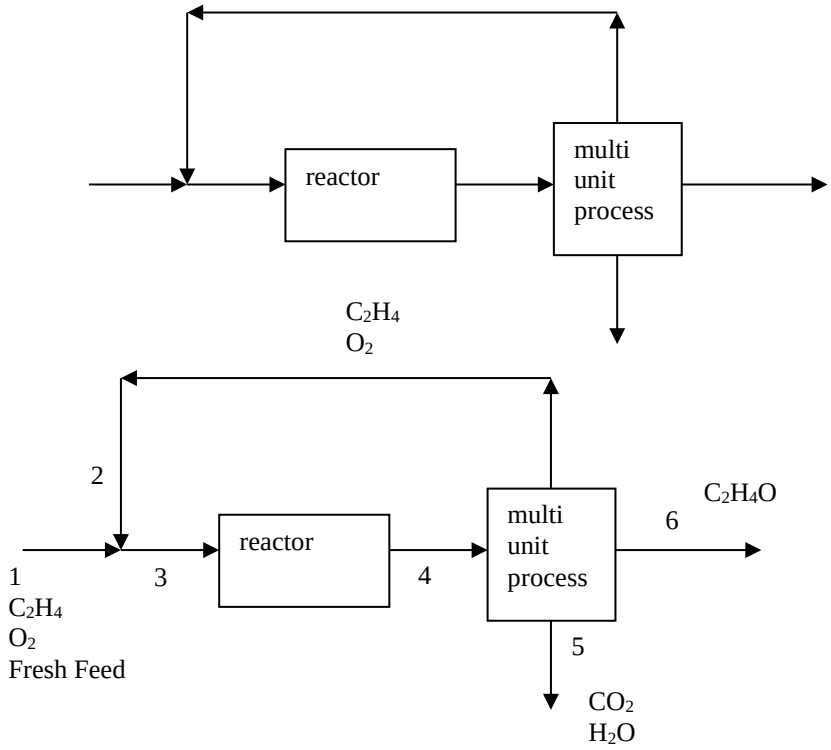
Pre-lecture 12 quiz







Lecture 12



Prelecture 20 – Multiphase Systems

$$log_{10}P^* = A - \frac{B}{T + C}$$

Lecture 20 equations

$$V_{EtOH} = 0.4\left(\frac{1\ cup}{2}\right)\left(\frac{pint}{2\ cup}\right)\left(\frac{qrt}{2\ pint}\right)\left(\frac{gal}{4\ qrt}\right)\left(\frac{1000\ L}{264.17\ gal}\right)\left(\frac{1000\ ml}{L}\right) = 47.3\ ml$$

$$V_{H2O} = \left\{0.6\left(\frac{1\ cup}{2}\right) + 1\ cup\right\}\left(\frac{pint}{2\ cup}\right)\left(\frac{qrt}{2\ pint}\right)\left(\frac{gal}{4\ qrt}\right)\left(\frac{1000\ L}{264.17\ gal}\right)\left(\frac{1000\ ml}{L}\right) = 307.57\ ml$$

$$n_{EtOH} = 47.3\ ml\left(\frac{0.789\ g}{ml}\right)\left(\frac{mol}{46.07\ g}\right) = 0.81\ mol$$

$$n_{H2O} = 307.5\ ml\left(\frac{1\ g}{ml}\right)\left(\frac{mol}{18.01\ g}\right) = 17.01\ mol$$

$$x_{EtOH} = \frac{0.81\ mol}{0.81\ mol + 17.01\ mol} = 0.045$$

$$log_{10}P^{sat} = 8.1122 - \frac{1592.864}{T + 226.184}$$

$$log_{10}P^{sat} = 3.2288$$

$$P^{sat} = 10^{3.2288} = 1693.83$$

$$39\ \frac{g\ EtOH}{m^3}\left(\frac{mol\ EtOH}{46.07\ g\ EtOH}\right)\left(\frac{m^3}{1000\ L}\right)\left(\frac{22.4\ L}{mol}\right) = 0.019$$

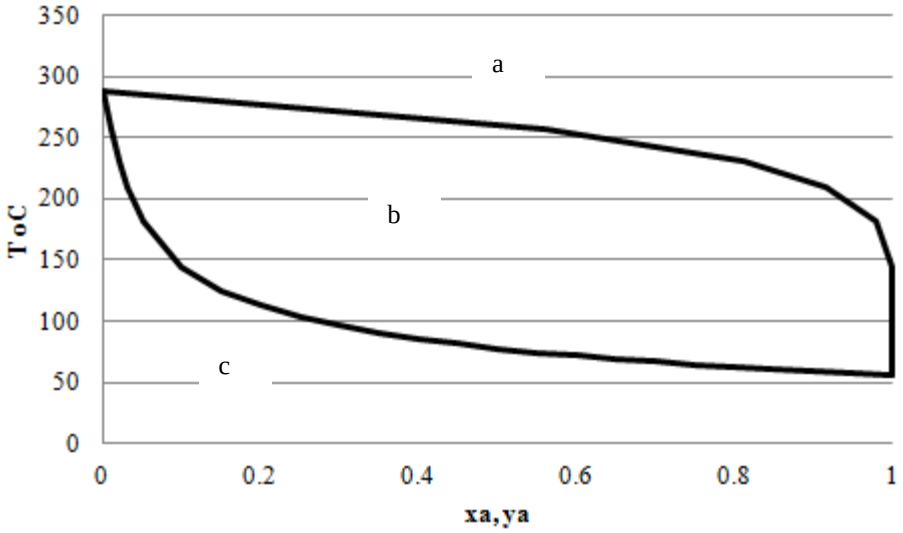
Lecture 21 – relative humidity

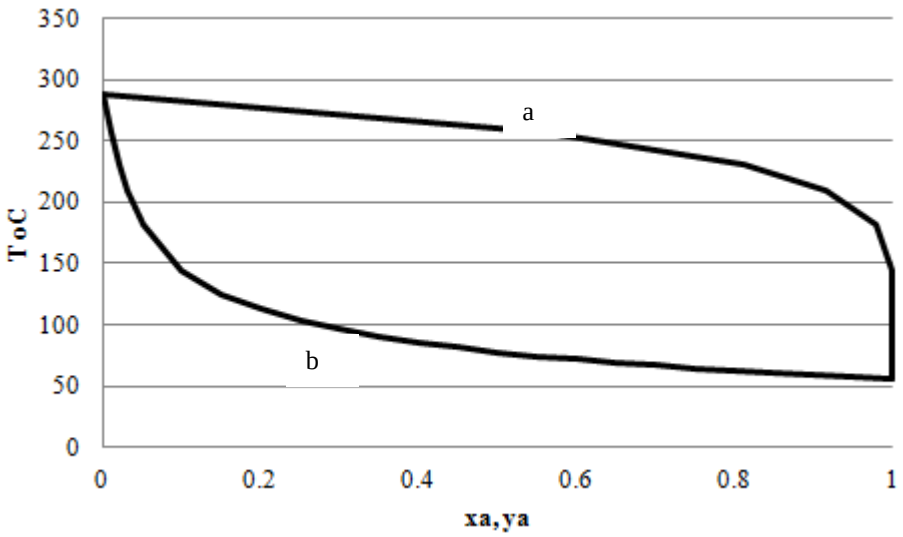
$$P = 30.05"\frac{1000\ mm\ Hg}{39.37"\ Hg} = 762.27\ mmHg$$

$$P = 30.02"\frac{1000\ mm\ Hg}{39.37"\ Hg} = 762.5 mmHg$$

$$0.045\left(10^{8.11220-\frac{1592.864}{T+226.184}}\right) + (1 - 0.045)\left(10^{7.96681-\frac{1668.21}{T+228.0}}\right)$$

Prelecture 23:





Lecture 30- unit conversions

$$0.001\ \frac{gal}{min}\frac{1000\ L}{gal}\frac{m^3}{1000L}\frac{1000kg}{m^3}\frac{kmol}{18kg}\frac{1000mol}{kmol} = 0.2122\ mol$$

Lecture 34 Open energy balance

$$\Delta H = n\int_{T_i}^{T_f} C_p dT = 2.237\ kJ/sec$$

$$13.01mol\int_{25\ ^oC}^{100\ ^oC} 0.074\ \frac{kJ}{mol\ ^oC}dT = 2.237\ kJ/sec$$

$$13.01\left(0.074\ \frac{kJ}{mol\ ^oC}(75\ ^oC)\right) = 2.237\ kJ/sec$$

$$(72.726\ kJ) = time\ 2.237\ kJ/sec$$

Prelecture 38

$$\frac{\Delta P}{\rho} + \frac{1}{2}\Delta(u^2) + g\Delta h + \hat{F} = \frac{-W_s}{\dot{m}}$$

Lecture 38:

$$\frac{\Delta P}{\rho} = \frac{(30.26 - 30.05) in\ H_2O}{1000\ \frac{kg}{m^3}} \frac{ft\ H_2O}{12\ in\ H_2O} \frac{101325\ \frac{N}{m^2}}{33.9\ ft\ H_2O} = 0.052 \frac{Nm}{kg}$$

$$0.052 \frac{N}{kg} + g\Delta h = \frac{-W_s}{\dot{m}}$$

$$g\Delta h = 9.8 \frac{N}{kg} (9159 - 2643) ft \frac{m}{3.2808\ ft} = 19463.789 \frac{Nm}{kg}$$

$$0.052 \frac{N}{kg} + 19463.789 \frac{Nm}{kg} = \frac{-W_s}{\dot{m}}$$

$$\dot{m} = 1000000 \frac{gal}{day} \frac{m^3}{264.17\ gal} \frac{1000kg}{m^3} \frac{day}{24\ hr} \frac{hr}{60\ min} \frac{min}{60sec} = 43.81 \frac{kg}{min}$$

$$-W_s = 19463.8 \frac{Nm}{kg} \frac{43.81kg}{sec} \frac{J}{Nm} \frac{Ws}{J} \frac{kW}{1000\ W} = 853\ kW * 24\ hr = 20472\ kWh$$

Prelecture 39:

$$\underset{A}{\Delta\widehat{H_1}} + \underset{B}{\Delta\widehat{H_2}} + \underset{C}{\Delta\widehat{H_3}} + \underset{D}{\Delta\widehat{H_4}} + \underset{E}{\Delta\widehat{H_5}} + \underset{F}{\Delta\widehat{H_6}} = \Delta\widehat{H}_{\ true\ path}$$

$$\int C_{p,solid} dt$$

$$\int C_{p,liquid} dt$$

$$\int C_{p,vapor} dt$$

$$\Delta\widehat{H}_{\ vap}$$

$$\Delta\widehat{H}_{\ melt}$$

Lecture 39:

$$\Delta U = 0 = m_{final}\widehat{U}_{final} - m_{water}\widehat{U}_{water} - m_{steam}\widehat{U}_{steam}$$

$$\Delta U = 0 = 11\ kg\widehat{U}_{final} - 1\ kg\left(104.8\ \frac{kJ}{kg}\right) - 10\ kg\left(2811\ \frac{kJ}{kg}\right)$$

$$\widehat{U}_{final} = 2564\ \frac{kJ}{kg}$$

$$\Delta U = n\int_{T_i}^{T_f} C_v dT$$

Lecture 40:

$$n = \frac{PV}{RT} = \frac{(1\ atm)\left(226\ \frac{m^3}{min}\right)}{0.08206\ \frac{Latm}{mol\ K}(309.5\ K)}\frac{1000\ L}{m^3} = 8909\frac{mol}{min}$$

$$\Delta H_1 = n_{air}\int_{36\ ^oC}^{10\ ^oC} C_{p,air}dT$$

$$\Delta H_2 = n_{2,w}\int_{36\ ^oC}^{10\ ^oC} C_{p,water\ vapor}dT = n_{2,w}\left(\widehat{H}_{2,w} - \widehat{H}_{1,w}\right)$$

$$\Delta H_3 = n_{2,w}\left(\int_{36\ ^oC}^{100\ ^oC} C_{p,water\ vapor}dT - \Delta H_{vap} + \int_{100\ ^oC}^{10\ ^oC} C_{p,water\ liquid}dT\right) = n_{2,w}\left(\widehat{H}_{2,w} - \widehat{H}_{1,w}\right)$$