Final Exam Review

Business

- Online course evaluation (19/32 = 59%)
  - Counts as a homework assignment (by Thurs)
- Professional program application
  - Past due!
- Case study due today by 5 pm
  - Leadership evaluation by 5 pm as well
  - Please put your name in the title if a MS Word document
- ABET questionnaire (50% of class right now)
- You can mark the Dean's lectures on the final exam

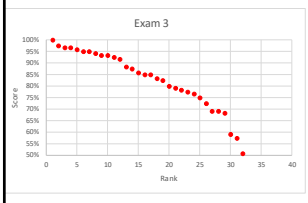
Schedule Today

- Review Exam #3
- Start Review for Final

Competencies

Level	Competency Expectation
3	Students will be able to solve steady-state, overall, material and energy balances for systems which include one or more of the following: recycle, multiple units, chemical reactions.
3	Students will understand the phase behavior of pure substances in relationship to the variables T, P, and density (including vapor pressure, critical point, freezing line, triple point, etc.).
3	Students will be able to use the mechanical energy balance equation to solve fluid flow problems both with and without friction.
3	Students will be introduced to the first law of thermodynamics for closed and open systems.
3	Students will understand and be able to use the extent of reaction in material balances
2	Students will be able to set up and solve simple transient material balances.
2	Students will be able to use a degree-of-freedom approach to assist in the solution of material and energy balances.
2	Students will be able to read mixture phase diagrams (solid solubility, liquid-liquid, VLE) and construct mass balances from them using the lever rule, tie lines, etc.
2	Students will be able to solve simple fluid statics problems (e.g., manometers, fluid head, etc.).
2	Students will be able to apply Raoult's law to solve VLE problems including bubble point, dew point, and flash calculations.
2	Students will be introduced to equations of state and corresponding states correlations.
2	Students will be introduced to the concepts of heat capacity, latent heat, heat of reaction, heat of combustion, and heat of formation.
2	Students will be introduced to process variables (e.g., P, T, flow rate, conc.) and their measurement.
2	Students will be introduced to calculations involving work in turbines, compressors, and pumps.

Review Exam #3



1. Pump, Turbine 86%
2. Psychro. Chart 80%
3. Stoich., Excess Air 78%
4. Adiab. Flame T 89%
5. Heat Exchanger 88%
6. Transient 83%

Average = 83%

Most missed on Exam 3

A mixture of 20 mols/min H_2 and 80 mols/min CO is burned with 5% excess dry air at constant pressure (1 atm). Calculate the molar flow rate of air.

Please calculate O_2 requirement for each species separately (not in one big equation)

$H_2 + \frac{1}{2}O_2 = H_2O$ Stoich O_2 = 20×0.5 = 10 mols/min

$CO + \frac{1}{2}O_2 = CO_2$ Stoich O_2 = 80×0.5 = 40 mols/min

Total O_2 needed = (50 mols/min) × 1.05 = 52.5 mols/min

Total Air needed = 52.5/0.21 = 250 mols/min

Final Exam

Monday, December 18

7:00 am to 10 am

393 CB

Get some sleep!

Business (cont.)

- I will be available today and Thursday
  - I will be busy after 10 am on Friday
  - I will try to answer emails quickly on Saturday
- TA help

Exam Format

- Closed Book
- Closed Notes
- Closed Homework
- Bring a Ruler, Calculator
- Up to three 8 ½ by 11 inch paper with handwritten or hand-typed notes on both sides
  - You can use the previous note pages you made for the three midterms

How to Review for Final

- Course Competencies
- Exam Review Sheets
  - Online if you have lost your copy
- Homework, Exams, Case Study
  - Studying exams from previous years, except for the practice final and practice exams given this semester, is an honor code violation!
- Make your own final exam
  - What are the important concepts in the class?
  - What types of problems are appropriate for an exam without a computer?
  - What are the things I understand least?

Steam vs. Water Turbines

- When is the mechanical energy balance valid?
  - "when heat flows and internal energy changes are secondary in importance to kinetic and potential energy changes and shaft work."
    - Wanted: velocity
  - i.e., when temperatures are relatively constant
  - Steam tables take into account non-ideal behavior of liquid and gas

Heat Exchangers

http://www.brit.com.au/thermal-units/thermal-gallery/heat-exchangers.html

Heat Exchanger Concept

- Transfer heat from one stream to another
- Q = positive when heat is added
- $Q_{stream\ 1} = -Q_{stream\ 2}$

$$Q_1 = \dot{m}_1\left(\hat{H}_{1,out} - \hat{H}_{1,in}\right) = \int_{T_{in}}^{T_{out}} C_{p,1}\,dT$$

$$Q_2 = \dot{m}_2\left(\hat{H}_{2,out} - \hat{H}_{2,in}\right) = \int_{T_{in}}^{T_{out}} C_{p,2}\,dT$$

- Also, material balance for each stream separately

Vapor Pressure

- Suppose you have a large covered liquid tank of gasoline at 25°C
- Does the amount of vapor above the liquid change if the tank is 50% full vs. 90% full?
- How about the mole fraction?
- Are you comfortable with Raoult's law?
- Pure component vs. multicomponent

Degrees of Freedom
(Material Balances)

- Non-Reacting
- Reacting
  - Molar ratios (not used much)
  - Extent of reaction method (ξ)
  - Element balance method

Energy Balances

- Know both methods
  - Path
    - uses heat of reaction (but not heat of formation)
  - In vs. Out
    - uses heats of formation
    - does not use heat of reaction explicitly
  - Dangerous ground
    - Equations 9.5.1a, 9.5.1b
    - Part 5, page 519
    - Tables B.8 and B.9

$$\Delta H = \xi \Delta H_r + \sum n_{out}\hat{H}_{out} - \sum n_{in}\hat{H}_{in}$$

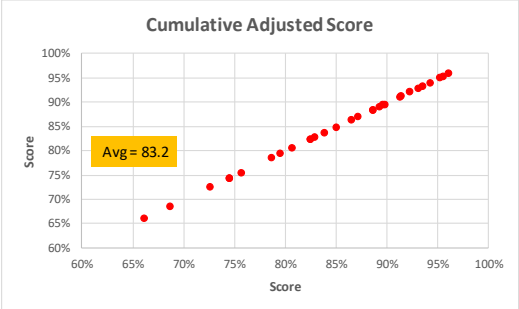
Bad

Top Problems Missed on Exams

- Stoichiometry
- DOF analysis
  - Non-reacting
  - Reacting
    - Extent of reaction
    - Element balance
- Transient Balance
- Manometers, Fluid Head
- Humidity Balance
  - Calculate mass flow rate of dry air
- Psychrometric Chart
- Mechanical Energy Balance
- Standard conditions (slpm, scf, etc.)

Most missed on W'17 Final
1. Element Balance (86%)
2. Heating Value (65%)
3. Heat Exchanger (75%)
4. Extent of Reaction (86%)
5. Multi-unit DOF 87%
6. Flash (94%)
7. Steam tables, Raoult's Law (49%)
8. Bernoulli (78%)

Current Grades



ChE 273
Review for Exam 1

Chapter 2
- Conversion of Units/Systems of Units
- Force Units (lb_m vs. lb_f, etc.)
- Least Squares - Fitting a Straight Line
- Logarithmic Coordinates

Chapter 3
- Mass vs. Mole Fractions
- Average Molecular Weight
- Fluid Pressure and Hydrostatic Head
- Manometers
- Atmospheric Pressure, Absolute Pressure, and Gauge Pressure

Chapter 4
- The General Balance Equation
- Material Balance Calculations
  - Flowcharts, Scaling and Basis of Calculation
  - Balancing a Process - degrees of freedom
  - Outline of a Procedure for Material Balance Calculations
- Balances on Multiple-Unit Processes/Recycle and Bypass

How to Study

Please study hard before the exam; there is not time to study during the exam!

- Look at the competencies
  - Do I know how to do that stuff?
  - What kind of problems could be on the exam for each competency?
- Read the text
  - work through the examples in the text (from scratch!)
- Review the homework problems, check answer key – (Did I understand everything?)
- Review Dr. Fletcher's lecture notes posted on the web and my class notes
- Study the practice exam (http://www.et.byu.edu/~tom/classes/273/Practice_E1.pdf)
  - The TA's have the answer key (caution: don't study only the practice exam!)
- Read the Rowley website/lecture notes on degrees of freedom analysis
  - walk through the examples in the lecture notes – (Do I understand?)

Exam 2 Review Sheet
Chemical Engineering 273

1. **Material Balances with Reaction**
   a. Species balances with generation/consumption
   b. Species balances with extent of reaction (ξ)
   c. Elemental balances
   d. DOF analysis on reacting systems
      i. Additional unknown for each reaction (extent of reaction)
      ii. Proper use of species balances will always give correct DOF
      iii. Elemental balances are preferred, but occasionally are not independent!!
      iv. Use element balances for "block" with reacting systems
      v. Always perform DOF analysis
   e. Definitions
      i. Limiting reactant
      ii. Yield
      iii. Single-Pass Conversion
      iv. Overall conversion
      v. Selectivity
   f. Combustion Reactions
      i. Should be able to write and balance these reactions for complete combustion, etc.
      ii. Theoretical and excess air
      iii. Dry basis for compositions
2. **Single-Phase Systems**
   a. Liquid densities of mixtures
   b. Ideal gas
      i. Most common equation of state
      ii. Range of applicability
      iii. Mixtures (partial pressure, volume fraction, mole fraction)
   c. Standard temperature and pressure
   d. Non-ideal equations of state
      i. Van der Waals
      ii. SRK
      iii. Corresponding States ($P_r = P/P_c$, $T_r = T/T_c$) and compressibility factor (z)
      iv. Kay's rule for mixtures ($P_c' = \sum y_i P_{c,i}$, $T_c' = \sum y_i T_{c,i}$)
3. **Multiphase Systems**
   a. Single-component phase behavior
   b. Tables for Saturated Steam (B.3, B.5, B.6)
   c. Vapor pressure estimation (P_i^*) – Antoine, DIPPR, Fig. 6.1-4
   d. Gibbs phase rule
   e. Gas-liquid systems with one condensable component
      i. Raoult's Law ($y_i P_{tot} = x_i P_i^*$, but $x_i = 1$)

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i. Limiting reactant
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d. Gibbs phase rule
e. Gas-liquid systems with one condensable component
i. Raoult's Law ($y_i P_{tot} = x_i P_i^*$, but $x_i = 1$)

ii. Humidity and drying (Relative humidity, absolute humidity)
f. Multicomponent Systems
i. Raoult's Law ($y_i P_{tot} = x_i P_i^*$)
1. Ideal systems
2. Real systems where x_A is close to 1
3. Dew point and bubble point
4. 2 phase separation (Flash calculations)
ii. Henry's Law ($y_i P_{tot} = x_i H_i$ used for small x_i)
iii. Solid-Liquid phase diagram and instruction from Web
iv. Liquid-Liquid ternary diagram
v. Tie lines and lever rule
vi. Material balances using phase equilibrium data/calculations

Exam 3 Review Sheet
Chapters 7-9, 11

Ch. 7 Energy Balances
1. Forms of Energy
   a. Internal, Potential, and Kinetic energy
   b. Heat and Work (Sign convention for both of these)
2. Closed system energy balance
   a. Significance of "Δ"
   b. Simplification of energy balance for closed systems
   c. Work term for closed systems (PV work)
3. Open system energy balance
   a. Significance of "Δ"
   b. Definition and use of enthalpy
   c. Shaft work
   d. Application to problems
4. Steam tables
   a. Saturated conditions (Tables B.3, B.5, B.6)
   b. Non-saturated conditions (Table B.7)
5. Mechanical Energy Balance
   a. Bernoulli's equation

Ch. 8 Energy Balances (Non-Reactive Systems)
1. Enthalpy is a state function (path independent)
2. $Q = \sum_{out} n_i \hat{H}_i - \sum_{in} n_i \hat{H}_i$
3. Inlet-Outlet Enthalpy Table
4. Heat Capacities (Table B.2)
5. Phase Change (Heat of melting, vaporization) (All columns in Table B.1)
6. Special cases (adiabatic, isobaric, isochoric, isentropic)
7. P-H diagrams (steam, refrigerants)
8. Psychrometric chart (Air-water at 1 atm)
   a. Definitions (wet bulb temperature, humid volume, absolute vs. relative humidity, dew point, etc.)
   b. Application to problems (use of dry air balance)
9. Skipped -- Heats of Mixing

Ch. 9 Energy Balances (Reactive Systems)
1. Heat of Reaction, Heat of Formation, Heat of Combustion
2. Energy Balances
   a. Use ΔH_r method (follow path from reactants to 25°C, then ΔH_r at 25°C, then products up to final temperature)
   b. Use $\hat{H}_i = \Delta H_{f,i}^{\circ} + \int_{25^\circ C}^{T} C_{p,i} dT$ and construct table of inlet and outlet enthalpies
3. Applications
   a. Combustion
   b. Adiabatic flame temperature

Ch. 11 Transient Material Balances
1. General balance equation
2. Applications to both overall mass/moles and/or species (we will not cover energy here)

Practice Final Exam

- Find a partner
- Read through the exam
  - Correlate each problem with a competency
  - Talk about a solution strategy
  - Identify topics to study

Single Stage Flash Calculation