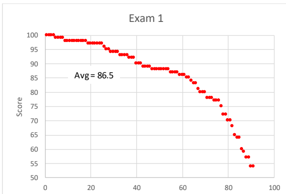
Exam 1 – Winter 2016



- Average 86.5%
  - 89% on Problem 1 (units)
  - 80% on Problem 2 (transient)
  - 88% on Problem 3 (DOF)
  - 91% on Problem 4 (manometer)
- Key is posted on learning suite
- 24 hr cooling-off period before talking to me about the exam
- I grade on a floating curve

Please Note How the Exam Questions Followed the Competencies!

- Students will be able to use basic engineering units in both SI and AES systems in solving problems, and be able to convert between unit systems by hand
- Students will be able to solve steady-state, overall material balances for systems which include one or more of the following: recycle, multiple units
- Students will be able to set up and solve simple transient material balances
- Students will be able to use a degree-of-freedom approach to assist in the solution of material balances
- Students will be able to solve simple fluid statics problems (e.g., manometers, fluid head, etc.)

Note: These concepts are fair game in future exams and on the final!

Hope for Those with Low Scores

- Person with highest score on the final receives an A
- There are lots of points still to be achieved on homework and the case study
- 2 more exams and the final

Computers

- I encourage you to use Excel or Mathcad for as many homework problems as possible for the rest of class

- The Case Study is coming…..

Homework Hints

- Please see the homework hints for problem 4.50!
  - This is a workbook problem
  - DO the algebra by hand – it is pretty easy

TA Note

- TA may move to the CAEDM computer lab on the 4th floor of the Clyde Bldg during TA hours
  - We want you to start using the computer for homework problems

Dean's Lecture Credit

- Dean's lecture credit
  - Dean's lectures (March 2 & 23, JS Aud, 11 am)
  - Leadership lectures
  - ChE graduate seminars that have outside speakers (Thursdays at 4 pm in 254 CB)
  - Other seminars if approved by Dr. F.

Notify the TAs somehow
- A note on your homework
- Email
- TA hours
- Separate sheet

Balances with Reactions

Class 13

Class Quiz:

(a) What is the equation for the %excess of a reactant?

(b) What is equation for the fractional conversion?

(c) What is the equation for the extent of reaction?

ADVICE

- Work through the examples in sections 4.7, 4.8
  - Ex 4.7-1 thru 3 (today)
  - Ex 4.8-1 thru 4 (for next time)

- Don't just browse through!

(Otherwise you will not learn this material)

3 Different Methods of Balances for Reacting Systems

1. Molecular Species Balances
2. Atomic Element Balances
3. Extent of Reaction

1. Molecular Species Balances
(reacting systems – used least)

- Use generation and consumption terms
- Use ratios of species based on stoichiometry
  - Moles species j generated/moles species i consumed
- Add # of independent chemical rxns to DOF analysis

Page 128 (144 in 4th Ed.)

+ # of unknowns
+ # of independent chemical reactions
- # of independent molecular species balances
- # of other equations
= DOF

2. Atomic Element Balances
(reacting systems – useful)

- No generation and consumption terms
  In = Out
- Count moles of atoms
  - Split up species into atoms
- Add # of independent atomic element balances to DOF analysis

+ # of unknowns
- # of independent atomic element balances
- # of independent non-reacting molecular species balances
- <u>- # of other equations</u>
= DOF

Page 129
143 in 4th Ed.

3. Balances Using Extent of Reaction
(useful)

- Use definition of ξ
  $n_i = n_{i,o} + \nu_i\,\xi$, or using flow rates
- One ξ_j for each reaction
  - Use problem info to get ξ_i's, then calculate unknown variables
- Add extent of reaction variables to DOF analysis

+ # of unknowns
+ # of independent ξ_i's
- # of independent reacting molecular species balances
- # of independent non-reacting species
- <u>- # of other equations</u>
= DOF

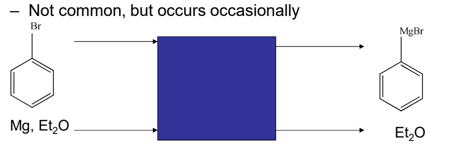
Page 130
145 in 4th Ed

Recommendations

- Book recommends <u>element balances</u>
  - I say only for complex reactions or solids)
  - Extent of reaction approach is easiest if simple reactions

Caution:

- Element balances are not always independent!!!
  - If ratio of two elements is constant everywhere, the element balances are not independent!
  - Not common, but occurs occasionally

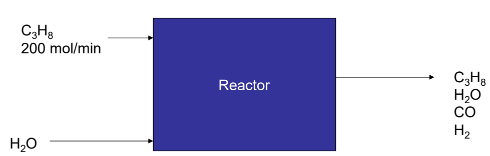


C/H ratio is same in two streams (twice)

Cautions

- If no reactions occur in the subunit, use the DOF for non-reacting systems
- If reactions occur in the overall system, you must use the DOF for reacting systems for the overall system

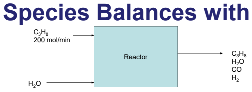
Example Problem



I will work this problem in each of three ways:
1. Molecular Balances
2. Element Balances
3. Extent of Reaction

Start with DOF! See Worksheet…

Molecular Species Balances with DOF Analysis



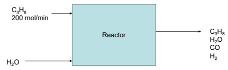
$C_3H_8 + 3\,H_2O \rightarrow 3\,CO + 7\,H_2$

DOF Analysis

Unknowns: $n_{H2O,in}$, n_{C3H8}, n_{H2O}, n_{CO}, n_{H2}	= +5
# of Rxns	= +1
# of Species Balances	= -4
<u># of Other Equations</u>	= 0
Degrees of Freedom	= 2!!!

(need to specify two things in order to solve problem)

Element Balances with DOF Analysis



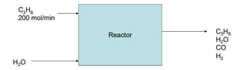
$C_3H_8 + 3\ H_2O \rightarrow 3\ CO + 7\ H_2$

DOF Analysis

Unknowns: $n_{H2O,in}$, n_{C3H8}, n_{H2O}, n_{CO}, n_{H2}	= +5
# of Reacting Elements	= -3
# of Non-reacting Species Balances	= -0
# of Other Equations	= -0
Degrees of Freedom	= 2!!!

(need to specify two things in order to solve problem)

Extent of Reaction with DOF Analysis



$C_3H_8 + 3\ H_2O \rightarrow 3\ CO + 7\ H_2$

DOF Analysis

Unknowns: $n_{H2O,in}$, n_{C3H8}, n_{H2O}, n_{CO}, n_{H2}	= +5
# of ξ's (# or reactions)	= +1
# of Independent Species Balances	= -4
# of Other Equations	= -0
Degrees of Freedom	= 2!!!

(need to specify two things in order to solve problem)

Example Problem

with zero DOF

Additional Relationships:

1. 65% conversion of C_3H_8
2. 25% excess H_2O