Exam 1 Results

Answer Key for Exam 1

Homework for Monday
- 4-69 – Please do the DOF on element balances
- 4.78 – Workbook available, plus hint on web (work by hand and then using solver in Excel or Mathcad)

Road Map
- DOF for Reacting Systems (Finish Ch. 4)
- Non-Ideal Gases (Ch. 5)
- Multiple Phases (Vapor-Liquid) (Ch. 6)
- Energy Balances (Ch. 7-9)
- Exam 2
- Exam 3 ➔ Case Study

Class 14
Multiple Reactions, Multiple Units
- Conversion & Excess Reactant (Review)
- Extent of Reaction (Review)
- Recommendations & Cautions (repeat)
- Definitions
  - Recycle
  - Purge
- Examples

Conversion & Excess Reactant
- Definition of conversion
  \[ X_A = \frac{n_{A,0} - n_A}{n_{A,0}} \]
- \( n_{A,0} \) ALWAYS defined based on inlet stream
- Definition of Excess Reactant
  \[ \%_{excess} = \frac{n_{A,0} - n_{A,stoich}}{n_{A,stoich}} \]
- \( n_{A,0} \) ALWAYS defined based on inlet stream
  - not based on conversion of limiting reactant
Extent of Reaction

- Moles reacted for a given reaction (normalized)
- Example: Carbon Tetrachloride Production
  \[ \text{CS}_2 + 3\text{Cl}_2 \rightarrow \text{S}_2\text{Cl}_2 + \text{CCl}_4 \quad \xi_1 \]
  \[ \text{CS}_2 + \text{S}_2\text{Cl}_2 \rightarrow 6\text{S} + \text{CCl}_4 \quad \xi_2 \]
  \[ 6\text{S} + 3\text{C} \rightarrow 3\text{CS}_2 \quad \xi_3 \]
- Write expressions for \( n_{\text{CCl}_4}, n_{\text{C}_2}, \) and \( n_{\text{CS}_2} \) in terms of \( \xi \)'s
  \[ n_{\text{CCl}_4} = n_{\text{CCl}_4} + \xi_1 + \xi_2 \]
  \[ n_{\text{C}_2} = n_{\text{C}_2} - 3\xi_1 \]
  \[ n_{\text{CS}_2} = n_{\text{CS}_2} - \xi_1 + \xi_2 + 3\xi_3 \]

Cautions

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

Definitions - Recycle

- Overall Conversion = \( \frac{(m_{i1} - m_{i4})}{m_{i1}} \)
- Single Pass Conversion = \( \frac{(m_{i2} - m_{i3})}{m_{i2}} \)

Definitions - Purge

- Recycle can result in buildup of unwanted species
- Purge streams are used to release a small portion of the recycle stream
- Unwanted species therefore have a path for release

Examples

A. Multiple Species, Elements
B. Multiple Units

Problem 4-71, 4-52 in 3rd Ed.
(Multiple Reactions, Elements)

\[
\text{CaF}_2(s) + \text{H}_2\text{SO}_4(l) \Rightarrow \text{CaSO}_4(\text{diss}) + 2\text{HF}(l) \\
6\text{HF}(l) + \text{SiO}_2(aq) \Rightarrow \text{H}_2\text{SiF}_6(s) + 2\text{H}_2\text{O}(l)
\]

15% excess Aq. Sulfuric Acid
95% of ore reacts

Find all unknowns, and check
DOF with Element Balances

Balances:
- Ca
- Si
- P
- S
- H

DOF Practice
(Problem 4-58, 4-77 in 4th Ed.)

Show Excel File