Homework for Monday

- 4-51 – Please do the DOF on element balances
- 4.59 – Workbook, 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)
Exam 2
Energy Balances (Ch. 7-9)
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
  \[ \begin{align*}
  CS_2 + 3Cl_2 & \rightarrow S_2Cl_2 + CCl_4 \quad \xi_1 \\
  CS_2 + S_2Cl_2 & \rightarrow 6S + CCl_4 \quad \xi_2 \\
  6S + 3C & \rightarrow 3CS_2 \quad \xi_3
  \end{align*} \]
- Write expressions for \( n_{CCl_4} \), \( n_{C_2} \), and \( n_{CS_2} \) in terms of \( \xi \)'s
  \[ \begin{align*}
  n_{CCl_4} &= n_{CCl_4,0} + \xi_1 + \xi_2 \\
  n_{C_2} &= n_{C_2,0} - 3\xi_1 \\
  n_{CS_2} &= n_{CS_2,0} - \xi_1 - \xi_2 + 3\xi_3
  \end{align*} \]

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 build up 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 4-52, 4-71 in 4th 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

WANTED!

5 Volunteers!
DOF Practice
(Problem 4-58, 4-77 in 4th Ed.)
Do the DOF on each subunit

WANTED!
6 MORE VOLUNTEERS!