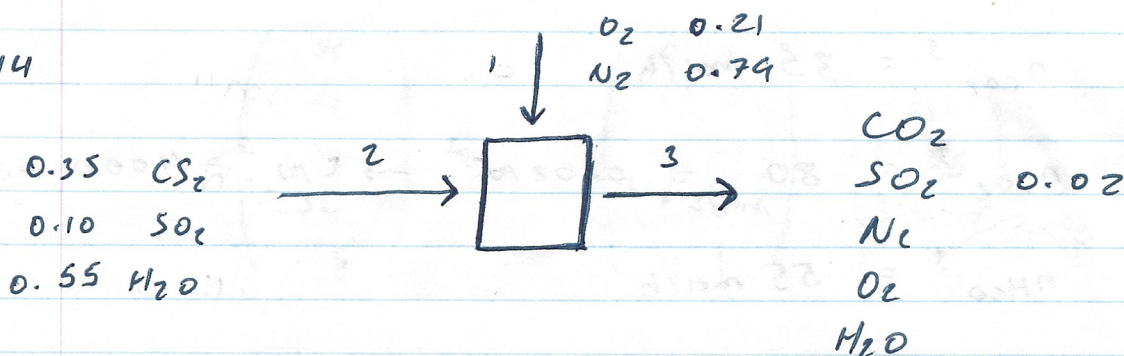


4.14



$$\begin{array}{r}
 \text{DoF} = 10 \text{ \#SV} \\
 - 5 \text{ \#EB} \\
 - 4 \text{ \#SV} \\
 - 0 \text{ \#SR} \\
 \hline
 1 \\
 - 1 \text{ (basis)} \\
 \hline
 0
 \end{array}$$

• let $N^2 = 100 \text{ mol/h} \rightarrow$

$$\begin{aligned}
 n_{\text{CS}_2}^2 &= 35 \text{ mol/h} \\
 n_{\text{SO}_2}^2 &= 10 \text{ mol/h} \\
 n_{\text{H}_2\text{O}}^2 &= 55 \text{ mol/h}
 \end{aligned}$$

• element balances

unknown
known

1. O: $2n_{\text{SO}_2}^2 + n_{\text{H}_2\text{O}}^2 + 2 \cdot 0.21N^1 = 2n_{\text{CO}_2}^3 + 2 \cdot 0.02N^3 + 2n_{\text{O}_2}^3 + n_{\text{H}_2\text{O}}^3$

✓ C: $n_{\text{CS}_2}^2 = n_{\text{CO}_2}^3$

✓ S: $2n_{\text{CS}_2}^2 + n_{\text{SO}_2}^2 = n_{\text{SO}_2}^3 = 0.02N^3$

✓ H: $2n_{\text{H}_2\text{O}}^2 = 2n_{\text{H}_2\text{O}}^3$

2. N: $2 \cdot 0.79N^1 = 2n_{\text{N}_2}^3 = 2(N^3 - n_{\text{CO}_2}^3 - 0.02N^3 - n_{\text{O}_2}^3 - n_{\text{H}_2\text{O}}^3)$

$$n_{CO_2}^3 = 35 \text{ mol/h}$$

$$n_{SO_2}^3 = 80 \frac{\text{mol}}{\text{h}} = 0.02 N^1 \rightarrow N^1 = 4000 \text{ mol/h}$$

$$n_{H_2O}^3 = 55 \text{ mol/h}$$

$$\rightarrow 2. \quad n_{O_2}^1 = (1+x) n_{O_2}^{th} = 0.21 N^1$$

$$\rightarrow n_{O_2}^{th} = 3 \cdot n_{CS_2}^2$$



3 equations, 7 unknowns

\rightarrow from MATLAB (elementBalance.m)

$$N^1 = 3935 \text{ mol/h}$$

$$n_{O_2}^3 = 721.35 \text{ mol/h}$$

$$1+x = 7.87$$

$$x = 6.87 \rightarrow \boxed{687\%}$$

species balance

$$V \cdot R = \begin{matrix} & \text{CS}_2 & \text{SO}_2 & \text{H}_2\text{O} & \text{O}_2 & \text{N}_2 & \text{CO}_2 \\ \begin{matrix} \text{C} \\ \text{H} \\ \text{O} \\ \text{S} \\ \text{N} \end{matrix} & \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 2 & 0 & 0 & 0 \\ 0 & 2 & 1 & 2 & 0 & 2 \\ 2 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2 & 0 \end{bmatrix} \end{matrix}$$

row-reduce

(RREF on Matlab, Week 5 a2. m)

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & -2 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 3 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

rank 5

$$R = M - E$$

$$= \text{rank} 6 - 5$$

$$= 1$$

reaction max.

$$\rightarrow \begin{bmatrix} \text{CS}_2 \\ \text{SO}_2 \\ \text{H}_2\text{O} \\ \text{O}_2 \\ \text{N}_2 \\ \text{CO}_2 \end{bmatrix} = - \begin{bmatrix} 1 \\ -2 \\ 0 \\ 3 \\ 0 \\ -1 \end{bmatrix} \quad [\text{CO}_2] = r_1$$

$$R_{\text{CS}_2} = r_1$$

$$R_{\text{SO}_2} = 2r_1$$

$$R_{\text{H}_2\text{O}} = 0$$

$$R_{\text{O}_2} = -3r_1$$

$$R_{\text{N}_2} = 0$$

$$R_{\text{CO}_2} = r_1$$



$$\begin{aligned}
 \text{Dof} &= 10 \text{ \#SU} \\
 &+ 1 \text{ \#RR} \\
 &- 6 \text{ \#MB} \\
 &- 4 \text{ \#SU} \\
 &- 0 \text{ \#SX} \\
 \hline
 &1 \\
 &- 1 \text{ (DAN)}
 \end{aligned}$$

$$\begin{aligned}
 \text{let } N^2 &= 100 \text{ mol/h} \rightarrow n_{\text{CS}_2}^2 = 35 \text{ mol/h} \\
 n_{\text{SO}_2}^2 &= 10 \text{ mol/h} \\
 n_{\text{H}_2\text{O}}^2 &= 55 \text{ mol/h}
 \end{aligned}$$

$$\times \quad (\text{CS}_2) \quad n_{\text{CS}_2}^2 - r_1 = 0$$

$$\times \quad (\text{SO}_2) \quad n_{\text{SO}_2}^2 - 0.02N^3 + 2r_1 = 0$$

$$\times \quad (\text{H}_2\text{O}) \quad n_{\text{H}_2\text{O}}^2 - n_{\text{H}_2\text{O}}^3 = 0$$

$$1. \quad (\text{O}_2) \quad 0.21N^1 - n_{\text{O}_2}^3 - 3r_1 = 0$$

$$2. \quad (\text{N}_2) \quad 0.79N^1 - (N^3 - n_{\text{O}_2}^3 - n_{\text{CO}_2}^3 - n_{\text{H}_2\text{O}}^3 - 0.02N^3)$$

$$\times \quad (\text{CO}_2) \quad -n_{\text{CO}_2}^3 + r_1 = 0$$

$$3. \quad \text{EO} \quad 0.21N^1 = (1+x) n_{\text{CS}_2}^2$$

$$\rightarrow r_1 = 35 \text{ mol/h} = n_{\text{CO}_2}^3$$

$$N^3 = 4000 \text{ mol/h}$$

$$n_{\text{H}_2\text{O}}^3 = 55 \text{ mol/h}$$

3 equations, 3 unknowns

→ MATLAB (speciesBalance.m)

$$N' = 3935 \text{ mol/h}$$

$$n_{O_2} = 741.35 \text{ mol/h}$$

$$1 + x = 7.87$$

$$x = 6.87 \rightarrow \boxed{687\%}$$