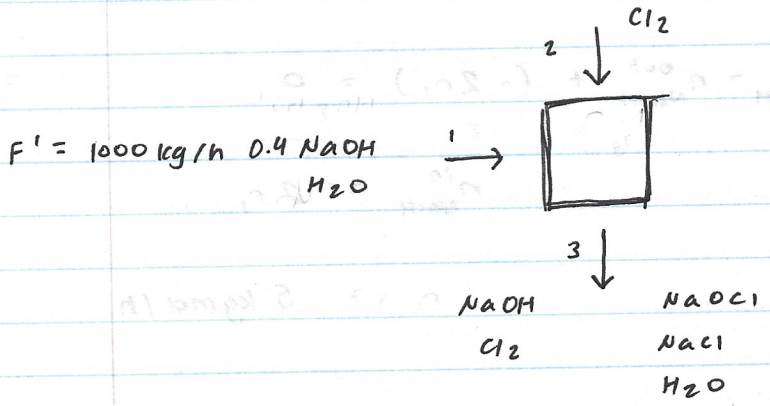
3.8 $2\ NaOH + Cl_2 \rightarrow NaOCl + NaCl + H_2O$

· bubbling Cl_2 through 40% (by mass) NaOH solution



a) DOF = 8 #SV
+1 #RR
−5 #MB
−3 #SSV
−1 #SR (conversion)
0

→ well specified!

b) · determine limiting reactant

→ $m'_{NaOH} = 0.4 \cdot 1000\ kg/h$
$= 400\ kg/h$
$MW_{NaOH} = 40\ kg/kg\,mol$
$n_{NaOH} = 10\ kg\,mol/h$

	Cl_2	NaOH	
n^{in}	10 kg mol/h	10 kg mol/h	→ equimolar
σ	1	2	
$\frac{n^{in}}{\sigma}$	10 kg mol/h	5 kg mol/h	∴ NaOH is the limiting reactant

c) · 100 % conversion of limiting reactant

ie. $n_{NaOH}^{3} = 0$

(NaOH)

$$n_{NaOH}^{in} - n_{NaOH}^{out} + (-2r_1) = 0$$

$$n_{NaOH}^{in} = 2r_1$$

$$r_1 = 5 \text{ kgmol/h}$$

(Cl_2)

$$n_{Cl_2}^{in} - n_{Cl_2}^{out} - r_1 = 0$$

$$n_{Cl_2}^{out} = 5 \text{ kgmol/h}$$

(H_2O)

$$m_{H_2O}' = 0.6 \cdot 1000 \text{ kg/h}$$
$$= 600 \text{ kg/h}$$
$$MW_{H_2O} = 18 \text{ kg/kgmol}$$
$$n_{H_2O}' = 33.33 \text{ kgmol/h}$$

$$n_{H_2O}^{in} - n_{H_2O}^{out} + r_1 = 0$$

$$n_{H_2O}^{out} = 38.33 \text{ kgmol/h}$$

(NaOCl)

$$n_{NaOCl}^{in} - n_{NaOCl}^{out} + r_1 = 0$$

$$n_{NaOCl}^{out} = 5 \text{ kgmol/h}$$

(NaCl)

$$n_{NaCl}^{in} - n_{NaCl}^{out} + r_1 = 0$$

$$n_{NaCl}^{out} = 5 \text{ kg mol/h}$$

(Total)

$$N^3 = \sum_{i=1}^{5} n_i^{out}$$

$$= 53.33 \text{ kg mol/h}$$

$$\omega_{Cl_2} = \frac{5 \text{ kg mol/h}}{53.33 \text{ kg mol/h}} \simeq 0.094$$

$$\omega_{H_2O} = \frac{38.33 \text{ kg mol/h}}{53.33 \text{ kg mol/h}} \simeq 0.719$$

$$\omega_{NaOCl} = \frac{5 \text{ kg mol/h}}{53.33 \text{ kg mol/h}} \simeq 0.094$$

$$\omega_{NaCl} = \frac{5 \text{ kg mol/h}}{53.33 \text{ kg mol/h}} \simeq 0.094$$

d) - 60 % conversion

(NaOH)

$$n_{NaOH}^{3} = 0.40\, n_{NaOH}^{'} = 4 \text{ kg mol/h}$$

$$n_{NaOH}^{in} - n_{NaOH}^{out} - 2r_1 = 0$$

$$n_{NaOH}^{in} - 0.4\, n_{NaOH}^{out} - 2r_1 = 0$$

$$r_1 = 3 \text{ kg mol/h}$$

(Cl_2)

$$n_{Cl_2}^{in} - n_{Cl_2}^{out} - r_1 = 0$$

$$n_{Cl_2}^{out} = 7 \text{ kg mol/h}$$

(H_2O)

$$n_{H_2O}^{in} - n_{H_2O}^{out} + r_1 = 0$$

$$n_{H_2O}^{out} = 36.33 \text{ kg mol/h}$$

($NaOCl$)

$$n_{NaOCl}^{in} - n_{NaOCl}^{out} + r_1 = 0$$

$$n_{NaOCl}^{out} = 3 \text{ kg mol/h}$$

($NaCl$)

$$n_{NaCl}^{in} - n_{NaCl}^{out} + r_1 = 0$$

$$n_{NaCl}^{out} = 3 \text{ kg mol/h}$$

(Total)

$$N^3 = \sum_{i=1}^{5} n_i^{out}$$

$$= 53.33 \text{ kg mol/h}$$

$$w_{NaOH} = \frac{4 \text{ kg mol/h}}{53.33 \text{ kg mol/h}} = 0.075$$

$$w_{Cl_2} = \frac{7 \text{ kg mol/h}}{53.33 \text{ kg mol/h}} = 0.131$$

$$w_{H_2O} = \frac{36.33 \text{ kg mol/h}}{53.33 \text{ kg mol/h}} = 0.681$$

$$w_{NaOCl} = \frac{3 \text{ kg mol/h}}{53.37 \text{ kg mol/h}} = 0.056$$

$$w_{NaCl} = \frac{3 \text{ kg mol/h}}{53.33 \text{ kg mol/h}} = 0.056$$