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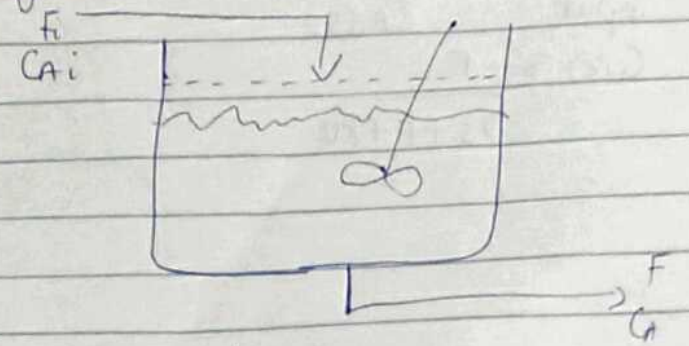
Chemical Engineering
14/ENG01/020
CHE 532
Assignment 1



a) Mass balance

$$\frac{dv}{dt} = F_i - F$$

Mole balance

$$\frac{dn}{dt} = \dot{n}_i - \dot{n} \pm rV$$

and $n = CV$

$$\frac{dCV}{dt} = C_{Ai}F_i - C_AF \pm rV$$

$$\frac{VdC_A}{dt} + \frac{C_A dv}{dt} = C_{Ai}F_i - C_AF - rV$$

$$\frac{VdC_A}{dt} = C_{Ai}F_i - C_AF - KC_AV - C_A\frac{dv}{dt}$$

$$\frac{VdC_A}{dt} = C_{Ai}F_i - C_AF - KC_AV - C_A(F_i - F)$$

$$\frac{VdC_A}{dt} = C_{Ai}F_i - \cancel{C_AF} - KC_AV - C_AF_i + \cancel{C_AF}$$

$$\frac{VdC_A}{dt} = F_i(C_{Ai} - C_A) - KC_AV \quad ; \; F_i = F \text{ [dynamic model]}$$

$$\frac{VdC_{As}}{dt} = F(C_{Ais} - C_{As}) - KC_{As}V \quad \text{— Steady state model}$$

$$\frac{Vd(C_A - C_{As})}{dt} = F(C_{Ai} - C_{Ais}) - F(C_A - C_{As}) - KV(C_A - C_{As})$$

$$\frac{Vd\bar{C}_A}{dt} = F\bar{C}_{Ai} - F\bar{C}_A - KV\bar{C}_A$$

Taking the laplace

$$V[s\bar{C}_A(s) - C_A(0)] = F\bar{C}_{Ai}(s) - F\bar{C}_A(s) - KV\bar{C}_A(s)$$

$$VS\bar{C}_A(s) + F\bar{C}_A(s) + KV\bar{C}_A(s) = F\bar{C}_{Ai}(s)$$

$$\bar{C}_A(s)[VS + F + KV] = F\bar{C}_{Ai}(s)$$

$$G(s) = \frac{\text{output}}{\text{input}} = \frac{\bar{C}_A(s)}{\bar{C}_{Ai}(s)}$$

$$G(s) = \frac{F}{VS + F + KV}$$