1. Conservation

(rate of change)

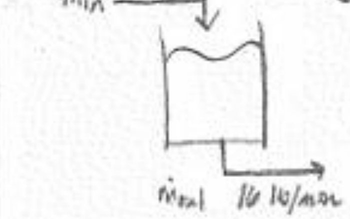
accumulation = in − out + generation − consumption

flow rates (in, out) reaction rates (generation, consumption)

amount

$$\frac{dn}{dt} = \dot{n}_{in} - \dot{n}_{out} + \dot{r}_{gen} - \dot{r}_{cons}$$

Ex1: Water draining from a bucket

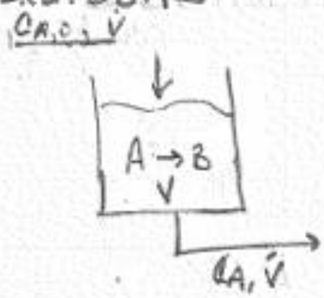


0 0 for mass

$$\frac{dm}{dt} = \dot{m}_{in} - \dot{m}_{out} + \cancel{r_{gen}} - \cancel{r_{cons}}$$

$$\boxed{\frac{dm}{dt} = \dot{m}_{in} - 16}$$

Ex2: CSTR



Reaction: $r_A = -kC_A V$

Assume mass density is constant.

Mass balance: $\frac{dm}{dt} = \dot{m}_{in} - \dot{m}_{out}$

$$\frac{d(\rho V)}{dt} = \rho\dot{V} - \rho\dot{V} = 0$$

$$\rho\frac{dV}{dt} = 0 \rightarrow \boxed{\frac{dV}{dt} = 0}$$

Mole balance: $\frac{dn_A}{dt} = \dot{n}_{A,in} - \dot{n}_{A,out} + \cancel{\dot{r}_{gen}} - \dot{r}_{cons}$

$$\frac{d(C_A V)}{dt} = C_{A,0}\dot{V} - C_A\dot{V} - kC_A V$$

$$C_A \underbrace{\frac{dV}{dt}}_{0} + V\frac{dC_A}{dt} = (C_{A,0} - C_A)\dot{V} - kC_A V$$

$$\boxed{\frac{dC_A}{dt} = (C_{A,0} - C_A)\frac{\dot{V}}{V} - kC_A}$$

2. Steady state

The rate of change (accumulation) is zero.

Ex 1: $0 = \frac{dm}{dt} = \dot{m}_{in} - 16 \rightarrow \quad \dot{m}_{in} = 16$ lb/min at steady state

Ex 2: $0 = \frac{dc_A}{dt} = (c_{A,0} - c_A)\frac{\dot{V}}{V} - kc_A$

$$\rightarrow \left(k + \frac{\dot{V}}{V}\right)c_A = c_{A,0}\frac{\dot{V}}{V}$$

$$\boxed{c_A = \frac{c_{A,0}}{kV/\dot{V} + 1}}$$