Types of Biochemical Reactors

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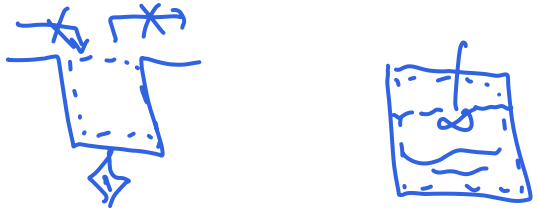
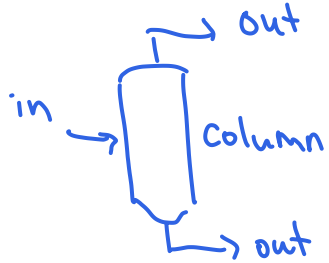
Chemical processes can be classified as batch, continuous, or semibatch

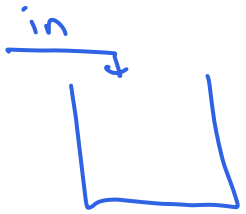
- **Batch process** - no mass crosses the system boundary

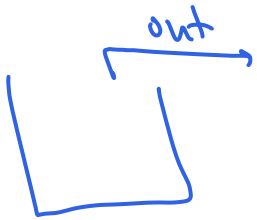


- **Continuous process** - inputs and outputs flow continuously through the system boundary



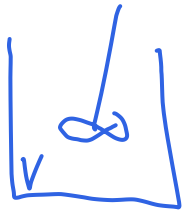
- **Semibatch process** - neither batch nor continuous



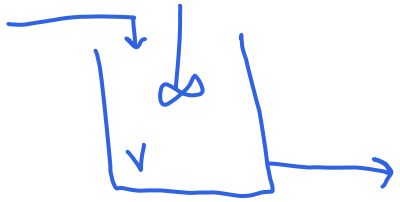


Biochemical reactors can also be classified as batch, continuous, or semibatch

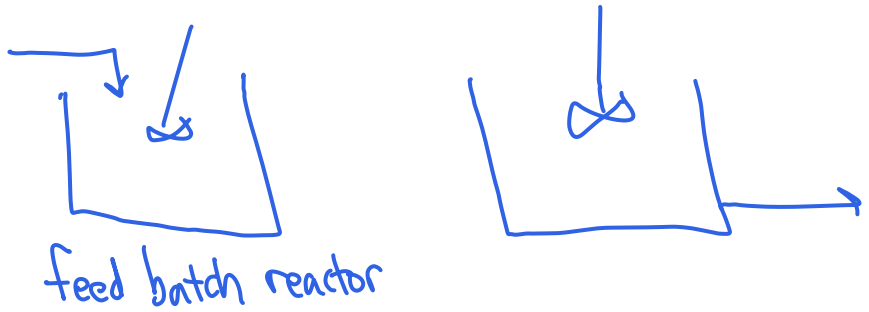
- **Batch reactor** - feed is put into the reactor before $t = 0$, no inlet or outlet during operation
  - Batch process



- **Continuous stirred tank reactor (CSTR, chemostat)** - inlet and outlet flow continuously in and out
  - Continuous process



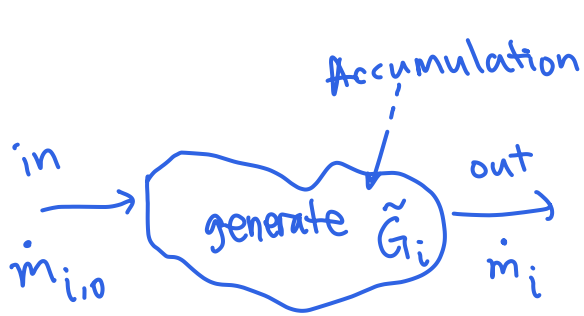
- **Semibatch reactor** - feed is added to the reactor OR the reactor content is drained
  - Semibatch process



Conservation of mass is the foundation of mass balance

- **Conservation of mass** - no mass is created nor destroyed in physical and chemical processes
- **Mass balance** of a chemical species

NOT nuclear rxn



$$\text{In} - \text{Out} + \text{Generation} = \text{Accumulation}$$

$$\dot{m}_{i,0} - \dot{m}_i + \tilde{G}_i = \frac{dm_i}{dt} \qquad / \, MW_i$$

mass basis → mole basis

$$\dot{n}_{i,0} - \dot{n}_i + G_i = \frac{dn_i}{dt}$$

- In $\dot{n}_{i,0}$ ✓
- Out $\dot{n}_i$ ✓
- Generation/Destruction $G_i = \int_V r_i \, dV$ Assume: spatially uniform = well-mixed $r_i V$
- Accumulation $\frac{dn_i}{dt}$

Batch reactor mass balance gives its design equation

$$\dot{n}_{i,0} - \dot{n}_i + G_i = \frac{dn_i}{dt}$$

- Assumptions
  - No inlet - $\dot{n}_{i,0} = 0$
  - No outlet - $\dot{n}_i = 0$

$$\frac{dn_i}{dt} = \int_V r_i \, dV$$

$$\boxed{\frac{dn_i}{dt} = r_i V}$$

- spatially uniform
- well-mixed

const V:

$$r_i = \frac{1}{V}\frac{dn_i}{dt}$$

$$C_i = \frac{n_i}{V}$$

$$\boxed{r_i = \frac{dC_i}{dt}}$$

Continuous stirred tank reactor (CSTR) mass balance gives its design equation

$$\dot{n}_{i,0} - \dot{n}_i + G_i = \frac{dn_i}{dt} \to 0$$

- Assumptions
  - Steady state - $\frac{dn_i}{dt} = 0$

no accumulation $\frac{d}{dt}() \to 0$

$$\dot{n}_{i,0} - \dot{n}_i + \int_V r_i \, dV = 0$$

$$\dot{n}_{i,0} - \dot{n}_i + r_i V = 0$$

$$r_i = \frac{\dot{n}_i - \dot{n}_{i,0}}{V}$$

Constant V

spatially uniform (well-mixed)

Semibatch reactor mass balance gives its design equation

$$\dot{n}_{i,0} - \dot{n}_i + G_i = \frac{dn_i}{dt}$$

- Assumptions
  - Feed batch, no outlet - $\dot{n}_i = 0$
  - Well-mixed, spatially uniform - $G_i = r_i V(t)$

$$\dot{n}_{i,0} + r_i V(t) = \frac{dn_i}{dt}$$

$$r_i = \frac{\frac{dn_i}{dt} - \dot{n}_{i,0}}{V(t)}$$