Fundamental Concepts: Reactions

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Reactions

- **Reactions** are processes that transform the arrangement of one group of molecules into a different arrangement of molecules

Reaction Terms

- **Reactants** are the original components
- **Products** are the final products

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Reactants $\rightarrow$ Products

Reaction Terms

- The **reaction rate** describes how quickly a reaction takes place
- A **reactor is a system** which facilitates a reaction

Reactions Types

- There are two types of reactions that may occur:
  - Irreversible Reactions
  - Reversible Reactions

Reaction Types

In **irreversible reactions**, the final products may not be converted back to the original reactants

For example, when we burn gasoline, we cannot convert the final products back into gasoline. The process is irreversible.

Reaction Types

In **reversible processes**, the chemical reaction that takes place CAN be reversed

For example, glucose can be broken into pieces (CO_2 and H_2O) and can also be reassembled back into glucose again

Hydraulic Retention Time

The **hydraulic retention time** is the average amount of time that flow spends in a reactor

Hydraulic Retention Time

The longer the HRT, the more time the reactants will have to react with each other and the purer the products will be

Remember, a longer HRT will often be more expensive than a shorter one

Hydraulic Retention Time

The HRT is dependent on both the flow rate (Q) and the volume (V)

$$\theta = \frac{V}{Q}$$

Where:

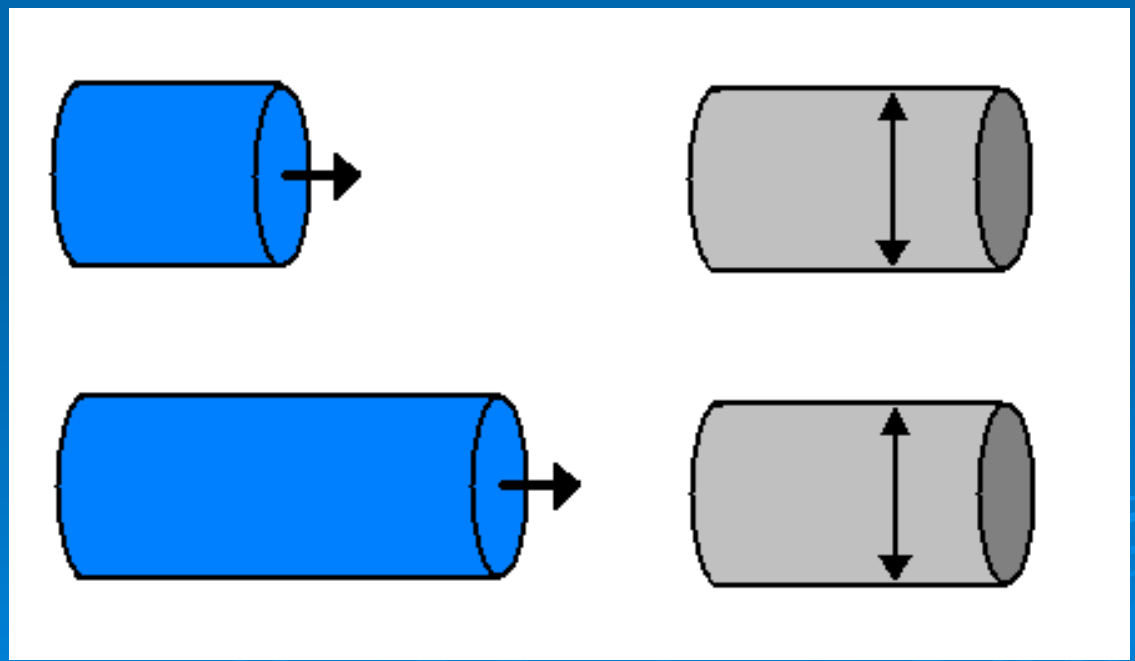
V = Volume of the reactor tank (volume)

Q = Fluid flow rate (volume /time)

θ = Hydraulic retention time (time)

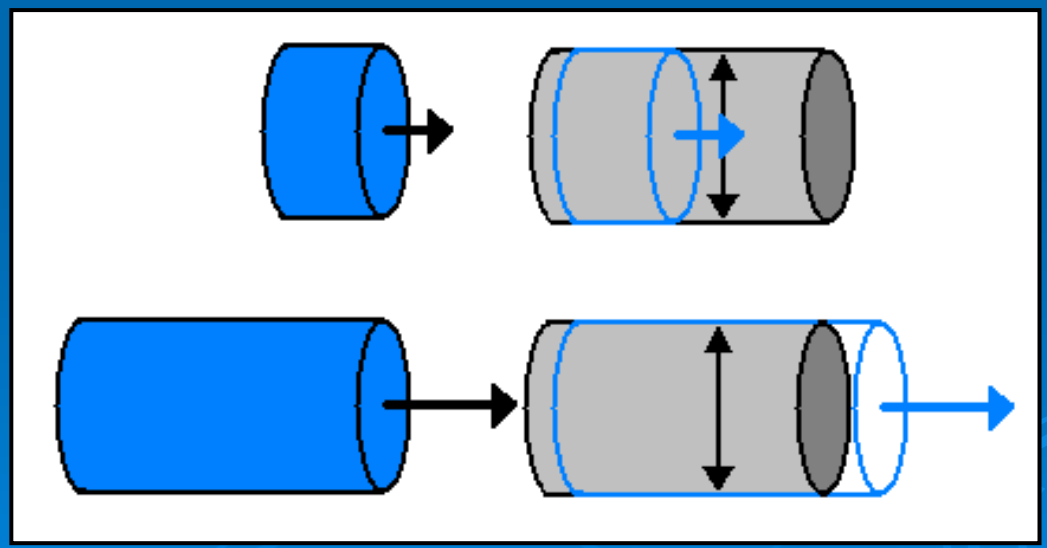
Hydraulic Retention Time

- For constant q, greater reactor volume will yield a longer hydraulic retention time



Hydraulic Retention Time

- For a constant reactor volume, greater q will yield a smaller hydraulic retention time



Types of Reactors

There are three general types of reactors:

- Batch Reactors
- Continuous Stirred Tank Reactors (CSTR) Reactors
- Plug Flow Reactors (PFR)

Batch Reactors

Batch reactors receive all inputs at once, allow time for the reaction to occur, and then all outputs are removed together

No material enters or leaves the reactor during the reaction

Batch Reactors

The end concentration will depend on the amount of time that has passed

The following equation may be used to determine concentration of the reactants:

$$C_A = C_{Ao}e^{-kt}$$

Continuous Stirred Tank Reactors (CSTR)

CSTR reactors have continuous flow of reactants into and products out of the reactor. Mixing occurs while material is in the reactor

The concentration of products depends on hydraulic retention time

$$C_A = \frac{C_{Ao}}{(\theta k + 1)}$$

Plug Flow Reactors (PFR)

In a PFR, there is a continuous flow of inputs and outputs, but the materials are not mixed

The following equation may be used to find effluent concentration:

$$C_A = C_{Ao}e^{-k\theta}$$