Design Equations

Homogeneous	Heterogeneous
Ideal batch reactor $N_{A0}\frac{dX}{dt} = -r_A V$ or $t = N_{A0}\int_0^X \frac{dX}{(-r_A)V}$	Batch catalytic reactor $N_{A0}\frac{dX}{dt} = -r_A' W$ $t = N_{A0}\int_0^X \frac{dX}{(-r_A')W}$
Tubular reactor $F_{A0}\frac{dX}{dV} = -r_A$ $V = F_{A0}\int_{X_{in}}^{X_{out}} \frac{dX}{-r_A}$	Fixed bed reactor $F_{A0}\frac{dX}{dW} = -r_A'$ $W = F_{A0}\int_{X_{in}}^{X_{out}} \frac{dX}{-r_A'}$
CSTR $V = \frac{F_{A0}(X_{out} - X_{in})}{-r_A}$	Fluidized bed reactor $W = \frac{F_{A0}(X_{out} - X_{in})}{-r_A'}$

Reaction rate

Homogeneous	Heterogeneous
$-r_A = \frac{1}{V}\frac{dN_A}{dt}$	$-r_A' = \frac{1}{W}\frac{dN_A}{dt}$

Concentration and conversion

Batch	Flow system
$C_A = \frac{N_A}{V}$ $X_A = \frac{N_{A0} - N_A}{N_{A0}}$	$C_A = \frac{F_A}{v}$ $X_A = \frac{F_{A0} - F_A}{F_{A0}}$

Stoichiometry

aA + bB → cC + dD

$$\frac{-r_A}{a} = \frac{-r_B}{b} = \frac{r_C}{c} = \frac{r_D}{d}$$

Heterogeneous reaction

Catalyst properties

$$Porosity, \varepsilon_p = \frac{\text{void (pore) volume of particle}}{\text{total volume of particle}} = V_g \rho_p$$

ρ_p = density of particle

V_g = void volume per unit mass of particles

The average pore radius of catalyst is

$$\bar{r} = \frac{2V_g}{S_g}$$

S_g = surface area per unit mass of particles