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# Reactor Performance Equations for Constant Volume Reactions Formulas

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# List of 28 Reactor Performance Equations for Constant Volume Reactions Formulas

## Reactor Performance Equations for Constant Volume Reactions

### 1) Initial Reactant Concentration for Second Order Reaction using Space Time for Mixed Flow

$$\text{fx } C_o = \frac{X_{\text{mfr}}}{(1 - X_{\text{mfr}})^2 \cdot (\tau_{\text{mixed}}) \cdot (k_{\text{mixed}})}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b\_img.jpg\)](#)

$$\text{ex } 277.2522 \text{ mol/m}^3 = \frac{0.71}{(1 - 0.71)^2 \cdot (0.05 \text{ s}) \cdot (0.609 \text{ m}^3 / (\text{mol} \cdot \text{s}))}$$

### 2) Initial Reactant Concentration for Second Order Reaction using Space Time for Plug Flow

$$\text{fx } C_{o \text{ Batch}} = \left( \frac{1}{k'' \cdot \tau_{\text{Batch}}} \right) \cdot \left( \frac{X_{A \text{ Batch}}}{1 - X_{A \text{ Batch}}} \right)$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d\_img.jpg\)](#)

$$\text{ex } 79.14833 \text{ mol/m}^3 = \left( \frac{1}{0.608 \text{ m}^3 / (\text{mol} \cdot \text{s}) \cdot 0.051 \text{ s}} \right) \cdot \left( \frac{0.7105}{1 - 0.7105} \right)$$



### 3) Initial Reactant Concentration for Zero Order Reaction using Space Time for Mixed Flow

$$\text{fx } C_o = \frac{k_{\text{mixed flow}} \cdot \tau_{\text{mixed}}}{X_{\text{mfr}}}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)

$$\text{ex } 79.22535 \text{ mol/m}^3 = \frac{1125 \text{ mol/m}^3 \cdot \text{s} \cdot 0.05 \text{ s}}{0.71}$$

### 4) Initial Reactant Concentration for Zero Order Reaction using Space Time for Plug Flow

$$\text{fx } C_{o \text{ Batch}} = \frac{k_{\text{Batch}} \cdot \tau_{\text{Batch}}}{X_{A \text{ Batch}}}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)

$$\text{ex } 80.46587 \text{ mol/m}^3 = \frac{1121 \text{ mol/m}^3 \cdot \text{s} \cdot 0.051 \text{ s}}{0.7105}$$

### 5) Rate Constant for First Order Reaction using Reactant Concentration for Mixed Flow

$$\text{fx } k_1 = \left( \frac{1}{\tau_{\text{mixed}}} \right) \cdot \left( \frac{C_o - C}{C} \right)$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$\text{ex } 46.66667 \text{ s}^{-1} = \left( \frac{1}{0.05 \text{ s}} \right) \cdot \left( \frac{80 \text{ mol/m}^3 - 24 \text{ mol/m}^3}{24 \text{ mol/m}^3} \right)$$



## 6) Rate Constant for First Order Reaction using Reactant Concentration for Plug Flow

$$\text{fx } k_{\text{batch}} = \left( \frac{1}{\tau_{\text{Batch}}} \right) \cdot \ln \left( \frac{C_{\text{o Batch}}}{C_{\text{Batch}}} \right)$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95\_img.jpg\)](#)

$$\text{ex } 24.80605\text{s}^{-1} = \left( \frac{1}{0.051\text{s}} \right) \cdot \ln \left( \frac{81.5\text{mol/m}^3}{23\text{mol/m}^3} \right)$$

## 7) Rate Constant for First Order Reaction using Space Time for Mixed Flow

$$\text{fx } k = \left( \frac{1}{\tau_{\text{mixed}}} \right) \cdot \left( \frac{X_{\text{mfr}}}{1 - X_{\text{mfr}}} \right)$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2\_img.jpg\)](#)

$$\text{ex } 48.96552\text{s}^{-1} = \left( \frac{1}{0.05\text{s}} \right) \cdot \left( \frac{0.71}{1 - 0.71} \right)$$

## 8) Rate Constant for First Order Reaction using Space Time for Plug Flow

$$\text{fx } k_{\text{batch}} = \left( \frac{1}{\tau_{\text{Batch}}} \right) \cdot \ln \left( \frac{1}{1 - X_{\text{A Batch}}} \right)$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7\_img.jpg\)](#)

$$\text{ex } 24.30588\text{s}^{-1} = \left( \frac{1}{0.051\text{s}} \right) \cdot \ln \left( \frac{1}{1 - 0.7105} \right)$$



## 9) Rate Constant for Second Order Reaction using Reactant Concentration for Mixed Flow

$$fx \quad k_{\text{mixed}} = \frac{C_o - C}{(\tau_{\text{mixed}}) \cdot (C)^2}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\)](#)

$$ex \quad 1.944444\text{m}^3/(\text{mol}\cdot\text{s}) = \frac{80\text{mol}/\text{m}^3 - 24\text{mol}/\text{m}^3}{(0.05\text{s}) \cdot (24\text{mol}/\text{m}^3)^2}$$

## 10) Rate Constant for Second Order Reaction using Reactant Concentration for Plug Flow

$$fx \quad k_p = \frac{C_{o \text{ Batch}} - C_{\text{Batch}}}{\tau_{\text{Batch}} \cdot C_{o \text{ Batch}} \cdot C_{\text{Batch}}}$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021\_img.jpg\)](#)

$$ex \quad 0.611928\text{m}^3/(\text{mol}\cdot\text{s}) = \frac{81.5\text{mol}/\text{m}^3 - 23\text{mol}/\text{m}^3}{0.051\text{s} \cdot 81.5\text{mol}/\text{m}^3 \cdot 23\text{mol}/\text{m}^3}$$

## 11) Rate Constant for Second Order Reaction using Space Time for Mixed Flow

$$fx \quad k_{\text{mixed}} = \frac{X_{\text{mfr}}}{(1 - X_{\text{mfr}})^2 \cdot (\tau_{\text{mixed}}) \cdot (C_o)}$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd\_img.jpg\)](#)

$$ex \quad 2.110583\text{m}^3/(\text{mol}\cdot\text{s}) = \frac{0.71}{(1 - 0.71)^2 \cdot (0.05\text{s}) \cdot (80\text{mol}/\text{m}^3)}$$



## 12) Rate Constant for Second Order Reaction using Space Time for Plug Flow

$$\text{fx } k' = \left( \frac{1}{\tau_{\text{Batch}} \cdot C_{o \text{ Batch}}} \right) \cdot \left( \frac{X_{A \text{ Batch}}}{1 - X_{A \text{ Batch}}} \right)$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0\_img.jpg\)](#)

$$\text{ex } 0.590456 \text{m}^3 / (\text{mol} \cdot \text{s}) = \left( \frac{1}{0.051 \text{s} \cdot 81.5 \text{mol} / \text{m}^3} \right) \cdot \left( \frac{0.7105}{1 - 0.7105} \right)$$

## 13) Rate Constant for Zero Order Reaction using Space Time for Mixed Flow

$$\text{fx } k_{\text{mixed flow}} = \frac{X_{\text{mfr}} \cdot C_o}{\tau_{\text{mixed}}}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5\_img.jpg\)](#)

$$\text{ex } 1136 \text{mol} / \text{m}^3 \cdot \text{s} = \frac{0.71 \cdot 80 \text{mol} / \text{m}^3}{0.05 \text{s}}$$

## 14) Rate Constant for Zero Order Reaction using Space Time for Plug Flow

$$\text{fx } k_{\text{Batch}} = \frac{X_{A \text{ Batch}} \cdot C_o \text{ Batch}}{\tau_{\text{Batch}}}$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60\_img.jpg\)](#)

$$\text{ex } 1135.407 \text{mol} / \text{m}^3 \cdot \text{s} = \frac{0.7105 \cdot 81.5 \text{mol} / \text{m}^3}{0.051 \text{s}}$$



### 15) Reactant Concentration for Zero Order Reaction using Space Time for Mixed Flow

$$\text{fx } C = C_o - (k_{\text{mixed flow}} \cdot \tau_{\text{mixed}})$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5\_img.jpg\)](#)

$$\text{ex } 23.75\text{mol/m}^3 = 80\text{mol/m}^3 - (1125\text{mol/m}^3\cdot\text{s} \cdot 0.05\text{s})$$

### 16) Reactant Concentration for Zero Order Reaction using Space Time for Plug Flow

$$\text{fx } C_{\text{Batch}} = C_{o \text{ Batch}} - (k_{\text{Batch}} \cdot \tau_{\text{Batch}})$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5\_img.jpg\)](#)

$$\text{ex } 24.329\text{mol/m}^3 = 81.5\text{mol/m}^3 - (1121\text{mol/m}^3\cdot\text{s} \cdot 0.051\text{s})$$

### 17) Reactant Conversion for Zero Order Reaction using Space Time for Mixed Flow

$$\text{fx } X_{\text{mfr}} = \frac{k_{\text{mixed flow}} \cdot \tau_{\text{mixed}}}{C_o}$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2\_img.jpg\)](#)

$$\text{ex } 0.703125 = \frac{1125\text{mol/m}^3\cdot\text{s} \cdot 0.05\text{s}}{80\text{mol/m}^3}$$

### 18) Reactant Conversion for Zero Order Reaction using Space Time for Plug Flow

$$\text{fx } X_{A \text{ Batch}} = \frac{k_{\text{Batch}} \cdot \tau_{\text{Batch}}}{C_{o \text{ Batch}}}$$

[Open Calculator !\[\]\(06a315363e7801bba8c7489a6694af19\_img.jpg\)](#)

$$\text{ex } 0.701485 = \frac{1121\text{mol/m}^3\cdot\text{s} \cdot 0.051\text{s}}{81.5\text{mol/m}^3}$$



19) Space Time for First Order Reaction for Mixed Flow 

$$fx \quad \tau_{\text{mixed}} = \left( \frac{1}{k} \right) \cdot \left( \frac{X_{\text{mfr}}}{1 - X_{\text{mfr}}} \right)$$

Open Calculator 

$$ex \quad 0.097619s = \left( \frac{1}{25.08s^{-1}} \right) \cdot \left( \frac{0.71}{1 - 0.71} \right)$$

20) Space Time for First Order Reaction for Plug Flow 

$$fx \quad \tau_{\text{Batch}} = \left( \frac{1}{k_{\text{batch}}} \right) \cdot \ln \left( \frac{1}{1 - X_{A \text{ Batch}}} \right)$$

Open Calculator 

$$ex \quad 0.049406s = \left( \frac{1}{25.09s^{-1}} \right) \cdot \ln \left( \frac{1}{1 - 0.7105} \right)$$

21) Space Time for First Order Reaction using Reactant Concentration for Mixed Flow 

$$fx \quad \tau_{\text{mixed}} = \left( \frac{1}{k} \right) \cdot \left( \frac{C_o - C}{C} \right)$$

Open Calculator 

$$ex \quad 0.093036s = \left( \frac{1}{25.08s^{-1}} \right) \cdot \left( \frac{80\text{mol}/\text{m}^3 - 24\text{mol}/\text{m}^3}{24\text{mol}/\text{m}^3} \right)$$



## 22) Space Time for First Order Reaction using Reactant Concentration for Plug Flow

$$\text{fx } \tau_{\text{Batch}} = \left( \frac{1}{k_{\text{batch}}} \right) \cdot \ln \left( \frac{C_{\text{o Batch}}}{C_{\text{Batch}}} \right)$$

[Open Calculator !\[\]\(71ceb62b681518c82e95d615e7265d66\_img.jpg\)](#)

$$\text{ex } 0.050423\text{s} = \left( \frac{1}{25.09\text{s}^{-1}} \right) \cdot \ln \left( \frac{81.5\text{mol/m}^3}{23\text{mol/m}^3} \right)$$

## 23) Space Time for Second Order Reaction for Mixed Flow

$$\text{fx } \tau_{\text{mixed}} = \frac{X_{\text{mfr}}}{(1 - X_{\text{mfr}})^2 \cdot (k_{\text{mixed}}) \cdot (C_{\text{o}})}$$

[Open Calculator !\[\]\(fc3a57079704ef1b99671c8cafae23be\_img.jpg\)](#)

$$\text{ex } 0.173283\text{s} = \frac{0.71}{(1 - 0.71)^2 \cdot (0.609\text{m}^3/(\text{mol}\cdot\text{s})) \cdot (80\text{mol/m}^3)}$$

## 24) Space Time for Second Order Reaction for Plug Flow

$$\text{fx } \tau_{\text{Batch}} = \left( \frac{1}{k'' \cdot C_{\text{o Batch}}} \right) \cdot \left( \frac{X_{\text{A Batch}}}{1 - X_{\text{A Batch}}} \right)$$

[Open Calculator !\[\]\(d5831b2ac75eb48b4c49d27e61d24c03\_img.jpg\)](#)

$$\text{ex } 0.049528\text{s} = \left( \frac{1}{0.608\text{m}^3/(\text{mol}\cdot\text{s}) \cdot 81.5\text{mol/m}^3} \right) \cdot \left( \frac{0.7105}{1 - 0.7105} \right)$$



## 25) Space Time for Second Order Reaction using Reactant Concentration for Mixed Flow

$$\text{fx } \tau_{\text{mixed}} = \frac{C_o - C}{(k_{\text{mixed}}) \cdot (C)^2}$$

[Open Calculator !\[\]\(8b57f0e15e7dda24cf9977561475f640\_img.jpg\)](#)

$$\text{ex } 0.159642\text{s} = \frac{80\text{mol}/\text{m}^3 - 24\text{mol}/\text{m}^3}{(0.609\text{m}^3/(\text{mol}\cdot\text{s})) \cdot (24\text{mol}/\text{m}^3)^2}$$

## 26) Space Time for Second Order Reaction using Reactant Concentration for Plug Flow

$$\text{fx } \tau_{\text{Batch}} = \frac{C_o \text{ Batch} - C_{\text{Batch}}}{k'' \cdot C_o \text{ Batch} \cdot C_{\text{Batch}}}$$

[Open Calculator !\[\]\(ceb7cef9f9d693d102dfe501130037c6\_img.jpg\)](#)

$$\text{ex } 0.051329\text{s} = \frac{81.5\text{mol}/\text{m}^3 - 23\text{mol}/\text{m}^3}{0.608\text{m}^3/(\text{mol}\cdot\text{s}) \cdot 81.5\text{mol}/\text{m}^3 \cdot 23\text{mol}/\text{m}^3}$$

## 27) Space Time for Zero Order Reaction for Mixed Flow

$$\text{fx } \tau_{\text{mixed}} = \frac{X_{\text{mfr}} \cdot C_o}{k_{\text{mixed flow}}}$$

[Open Calculator !\[\]\(5a09a9dfd2f1e923eccb8c24714edf51\_img.jpg\)](#)

$$\text{ex } 0.050489\text{s} = \frac{0.71 \cdot 80\text{mol}/\text{m}^3}{1125\text{mol}/\text{m}^3\cdot\text{s}}$$



28) Space Time for Zero Order Reaction for Plug Flow [Open Calculator](#) 

$$\text{fx } \tau_{\text{Batch}} = \frac{X_{\text{A Batch}} \cdot C_{\text{o Batch}}}{k_{\text{Batch}}}$$

$$\text{ex } 0.051655\text{s} = \frac{0.7105 \cdot 81.5\text{mol/m}^3}{1121\text{mol/m}^3\cdot\text{s}}$$



## Variables Used

- **C** Reactant Concentration at given Time (*Mole per Cubic Meter*)
- **C<sub>Batch</sub>** Reactant Conc at any Time in Batch Reactor (*Mole per Cubic Meter*)
- **C<sub>o Batch</sub>** Initial Reactant Concentration in Batch Reactor (*Mole per Cubic Meter*)
- **C<sub>o</sub>** Initial Reactant Concentration in Mixed Flow (*Mole per Cubic Meter*)
- **k** Rate Constant for First Order Reaction (*1 Per Second*)
- **k<sub>o</sub>** Rate Constant for Second Order in Batch Reactor (*Cubic Meter per Mole Second*)
- **k<sub>batch</sub>** Rate Constant for First Order in Batch Reactor (*1 Per Second*)
- **k<sub>Batch</sub>** Rate Constant for Zero Order in Batch (*Mole per Cubic Meter Second*)
- **k<sub>mixed flow</sub>** Rate Constant for Zero Order in Mixed Flow (*Mole per Cubic Meter Second*)
- **k<sub>mixed</sub>** Rate Constant for Second Order in Mixed Flow (*Cubic Meter per Mole Second*)
- **X<sub>A Batch</sub>** Reactant Conversion in Batch
- **X<sub>mfr</sub>** Reactant Conversion in Mixed Flow
- **τ<sub>Batch</sub>** Space Time in Batch Reactor (*Second*)
- **τ<sub>mixed</sub>** Space Time in Mixed Flow (*Second*)



## Constants, Functions, Measurements used

- **Function:** **ln**,  $\ln(\text{Number})$   
*Natural logarithm function (base e)*
- **Measurement:** **Time** in Second (s)  
*Time Unit Conversion* 
- **Measurement:** **Molar Concentration** in Mole per Cubic Meter ( $\text{mol}/\text{m}^3$ )  
*Molar Concentration Unit Conversion* 
- **Measurement:** **Reaction Rate** in Mole per Cubic Meter Second ( $\text{mol}/\text{m}^3\cdot\text{s}$ )  
*Reaction Rate Unit Conversion* 
- **Measurement:** **First Order Reaction Rate Constant** in 1 Per Second ( $\text{s}^{-1}$ )  
*First Order Reaction Rate Constant Unit Conversion* 
- **Measurement:** **Second Order Reaction Rate Constant** in Cubic Meter per Mole Second ( $\text{m}^3/(\text{mol}\cdot\text{s})$ )  
*Second Order Reaction Rate Constant Unit Conversion* 



## Check other formula lists

- [Basics of Chemical Reaction Engineering Formulas](#) 
- [Basics of Parallel & Single Reactions Formulas](#) 
- [Basics of Reactor Design and Temperature Dependency from Arrhenius Law Formulas](#) 
- [Forms of Reaction Rate Formulas](#) 
- [Important Formulas in Basics of Chemical Reaction Engineering & Forms of Reaction Rate](#) 
- [Important Formulas in Constant and Variable Volume Batch Reactor](#) 
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