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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

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

[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

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

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

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

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

$$\text{fx } k_{\text{p}} = \frac{C_{\text{o Batch}} - C_{\text{Batch}}}{\tau_{\text{Batch}} \cdot C_{\text{o Batch}} \cdot C_{\text{Batch}}}$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

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

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

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

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

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



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

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

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

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

20) Space Time for First Order Reaction for Plug Flow

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

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

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

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

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

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9_img.jpg\)](#)

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



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 

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

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 

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

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 

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



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 !\[\]\(0f848bbd71cef6b345273b16f905912a_img.jpg\)](#)

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

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 !\[\]\(3211b5d1d968fc1665909b34f9f16010_img.jpg\)](#)

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

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 !\[\]\(9c2e8d1b5bd77cb5c9f83b7a9cff79fd_img.jpg\)](#)

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



28) Space Time for Zero Order Reaction for Plug Flow

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

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

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








Variables Used

- **C** Reactant Concentration at given Time (Mole per Cubic Meter)
- **C_{Batch}** Reactant Conc at any Time in Batch Reactor (Mole per Cubic Meter)
- **C_{o Batch}** Initial Reactant Concentration in Batch Reactor (Mole per Cubic Meter)
- **C_o** Initial Reactant Concentration in Mixed Flow (Mole per Cubic Meter)
- **k** Rate Constant for First Order Reaction (1 Per Second)
- **k_{..}** Rate Constant for Second Order in Batch Reactor (Cubic Meter per Mole Second)
- **k_{batch}** Rate Constant for First Order in Batch Reactor (1 Per Second)
- **k_{Batch}** Rate Constant for Zero Order in Batch (Mole per Cubic Meter Second)
- **k_{mixed flow}** Rate Constant for Zero Order in Mixed Flow (Mole per Cubic Meter Second)
- **k_{mixed}** Rate Constant for Second Order in Mixed Flow (Cubic Meter per Mole Second)
- **X_{A Batch}** Reactant Conversion in Batch
- **X_{mfr}** Reactant Conversion in Mixed Flow
- **τ_{Batch}** Space Time in Batch Reactor (Second)
- **τ_{mixed}** 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 (mol/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 (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 



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