Important Reactor Performance Equations for Constant Volume Reactions Formulas PDF

Formulas
Examples
with Units

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

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

Evaluate Formula

Formula

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

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

$$79.1483\,\text{mol/m}^3 = \left(\frac{1}{0.608\,\text{m}^3\text{/(mol*s)} \cdot 0.051\,\text{s}}\right) \cdot \left(\frac{0.7105}{1 - 0.7105}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$79.2254\,\text{mol/m}^3 = \frac{1125\,\text{mol/m}^3\text{*s} \cdot 0.05\,\text{s}}{0.71}$$

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

Evaluate Formula

Formula

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

Example with Units

$$80.4659\,\text{mol/m}^3 = \frac{1121\,\text{mol/m}^3\text{*s} \cdot 0.051\,\text{s}}{0.7105}$$

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

Evaluate Formula

Formula

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

Example with Units

$$46.6667\,\text{s}^{-1} = \left(\frac{1}{0.05\,\text{s}}\right) \cdot \left(\frac{80\,\text{mol/m}^3 - 24\,\text{mol/m}^3}{24\,\text{mol/m}^3}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$24.8061\,\text{s}^{-1} = \left(\frac{1}{0.051\,\text{s}}\right) \cdot \ln\left(\frac{81.5\,\text{mol/m}^3}{23\,\text{mol/m}^3}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$48.9655\,\text{s}^{-1} = \left(\frac{1}{0.05\,\text{s}}\right) \cdot \left(\frac{0.71}{1 - 0.71}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$24.3059\,\text{s}^{-1} = \left(\frac{1}{0.051\,\text{s}}\right) \cdot \ln\left(\frac{1}{1 - 0.7105}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$1.9444\,\text{m}^3\text{/(mol*s)} = \frac{80\,\text{mol/m}^3 - 24\,\text{mol/m}^3}{(0.05\,\text{s}) \cdot (24\,\text{mol/m}^3)^2}$$

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

Evaluate Formula

Formula

$$k'' = \frac{C_{o\ Batch} - C_{Batch}}{\tau_{Batch} \cdot C_{o\ Batch} \cdot C_{Batch}}$$

Example with Units

$$0.6119\,\mathrm{m^3/(mol*s)} = \frac{81.5\,\mathrm{mol/m^3} - 23\,\mathrm{mol/m^3}}{0.051\,\mathrm{s} \cdot 81.5\,\mathrm{mol/m^3} \cdot 23\,\mathrm{mol/m^3}}$$

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

Evaluate Formula

Formula

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

Example with Units

$$2.1106\,\mathrm{m^3/(mol*s)} = \frac{0.71}{\left(1 - 0.71\right)^2 \cdot \left(0.05\,\mathrm{s}\right) \cdot \left(80\,\mathrm{mol/m^3}\right)}$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.5905\,\mathrm{m^3/(mol*s)} = \left(\frac{1}{0.051\,\mathrm{s} \cdot 81.5\,\mathrm{mol/m^3}}\right) \cdot \left(\frac{0.7105}{1 - 0.7105}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$1136\,\mathrm{mol/m^3*s} = \frac{0.71 \cdot 80\,\mathrm{mol/m^3}}{0.05\,\mathrm{s}}$$

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

Evaluate Formula

Formula

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

Example with Units

$$1135.4069\,\mathrm{mol/m^3*s} = \frac{0.7105 \cdot 81.5\,\mathrm{mol/m^3}}{0.051\,\mathrm{s}}$$

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

Evaluate Formula

Formula

$$C = C_o - \left(k_{mixed\ flow} \cdot \tau_{mixed}\right)$$

Example with Units

$$23.75\,\mathrm{mol/m^3} = 80\,\mathrm{mol/m^3} - \left(1125\,\mathrm{mol/m^3*s} \cdot 0.05\,\mathrm{s}\right)$$

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

Evaluate Formula

Formula

$$C_{Batch} = C_{o\ Batch} - \left(k_{Batch} \cdot \tau_{Batch} \right)$$

Example with Units

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

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

Evaluate Formula

Formula

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

Example with Units

$$0.7031 = \frac{1125\,\text{mol/m}^3\text{*s} \cdot 0.05\,\text{s}}{80\,\text{mol/m}^3}$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.7015 = \frac{1121\,\text{mol/m}^3\text{*s} \cdot 0.051\,\text{s}}{81.5\,\text{mol/m}^3}$$

19) Space Time for First Order Reaction for Mixed Flow Formula

Evaluate Formula

Formula

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

Example with Units

$$0.0976\,\text{s} = \left(\frac{1}{25.08\,\text{s}^{-1}} \right) \cdot \left(\frac{0.71}{1 - 0.71} \right)$$

20) Space Time for First Order Reaction for Plug Flow Formula

Evaluate Formula

Formula

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

Example with Units

$$0.0494\,\text{s} = \left(\frac{1}{25.09\,\text{s}^{-1}} \right) \cdot \ln\left(\frac{1}{1 - 0.7105} \right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.093\,\text{s} = \left(\frac{1}{25.08\,\text{s}^{-1}} \right) \cdot \left(\frac{80\,\text{mol/m}^3 - 24\,\text{mol/m}^3}{24\,\text{mol/m}^3} \right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.0504\,\text{s} = \left(\frac{1}{25.09\,\text{s}^{-1}}\right) \cdot \ln\left(\frac{81.5\,\text{mol/m}^3}{23\,\text{mol/m}^3}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.1733\,\text{s} = \frac{0.71}{\left(1 - 0.71\right)^2 \cdot \left(0.609\,\text{m}^3/(\text{mol*s})\right) \cdot \left(80\,\text{mol/m}^3\right)}$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.0495\,\text{s} = \left(\frac{1}{0.608\,\text{m}^3/(\text{mol*s}) \cdot 81.5\,\text{mol/m}^3}\right) \cdot \left(\frac{0.7105}{1 - 0.7105}\right)$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.1596\,\text{s} = \frac{80\,\text{mol/m}^3 - 24\,\text{mol/m}^3}{\left(0.609\,\text{m}^3/(\text{mol*s})\right) \cdot \left(24\,\text{mol/m}^3\right)^2}$$

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

Evaluate Formula

Formula

$$\tau_{Batch} = \frac{C_{o\ Batch} - C_{Batch}}{k'' \cdot C_{o\ Batch} \cdot C_{Batch}}$$

Example with Units

$$0.0513\,\text{s} = \frac{81.5\,\text{mol/m}^3 - 23\,\text{mol/m}^3}{0.608\,\text{m}^3/(\text{mol*s}) \cdot 81.5\,\text{mol/m}^3 \cdot 23\,\text{mol/m}^3}$$

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

Evaluate Formula

Formula

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

Example with Units

$$0.0505\,s = \frac{0.71 \cdot 80\,mol/m^3}{1125\,mol/m^3{*}s}$$

28) Space Time for Zero Order Reaction for Plug Flow Formula

Evaluate Formula

Formula

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

Example with Units

$$0.0517\,s = \frac{0.7105 \cdot 81.5\,mol/m^3}{1121\,mol/m^3{*}s}$$

Variables used in list of Reactor Performance Equations for Constant Volume Reactions Formulas above

- **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 in list of Reactor Performance Equations for Constant Volume Reactions Formulas above

- Functions: **ln**, ln(Number)
  The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Molar Concentration** in Mole per Cubic Meter (mol/m³)
  Molar Concentration Unit Conversion
- Measurement: **Reaction Rate** in Mole per Cubic Meter Second (mol/m³*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 (m³/(mol*s))
  Second Order Reaction Rate Constant Unit Conversion

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