

## Chemical Reaction Engineering

### The rate of a reaction $r_A$

Since chemical reaction engineering concerns itself with the kinetics of the reaction, we must first define what is meant by the "rate of a reaction".

We define the rate of a reaction for component A as follows: "the amount of moles of A disappearing or being generated per unit time per unit volume is the rate of the reaction, denoted as  $r_A$ ".

### Equation for Rate

The rate of a reaction is determined by the rate law. For example, for the reaction,



The rate law could look like,

$$-r_A = k[A]$$

Here,  $[A]$  means the concentration of A in mol/L. We will use  $C_A$  to denote the concentration from now on. So,

$$-r_A = kC_A$$

In this case we say that the reaction is **first order in A**, as the exponent of  $C_A$  is 1. The rate law could also look like,

$$-r_A = kC_A^2$$

In this case, the reaction would be second order in A.

The rate law could also look something like this,

$$-r_A = \frac{k_1 C_A}{1 + k_2 C_A}$$

In which case the order would be hard to determine.

### Rate for components of a reaction

Given the reaction,



The rate laws for each component are related as,

$$\frac{1}{a} r_A = \frac{1}{b} r_B = \frac{1}{c} r_C = \frac{1}{d} r_D$$

### General Mole Balance for a System / Reactor

We now consider a system volume with a species j as shown below:

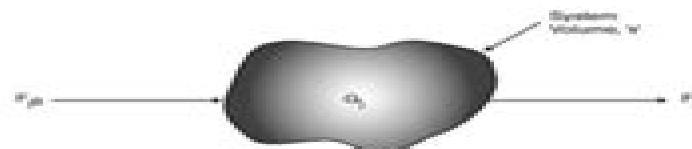


Figure E-5 : Mole balance on species j in a system volume, V

The mole balance on this system is,

$$[\text{moles of } j \text{ in per unit time}] - [\text{moles of } j \text{ out per unit time}] + [\text{moles of } j \text{ generated per unit time}] = [\text{moles of } j \text{ accumulated per unit time}]$$

$$F_{j0} - F_j + G_j = \frac{dN_j}{dt}$$

If all the properties of a system, such as catalysis concentration, temperature, concentration of species are uniform throughout the volume, then we can write the  $G_j$  term simply as the product of  $r_j$  and the system volume  $V$ .

$$F_{j0} - F_j + r_j V = \frac{dN_j}{dt}$$

# Chemical Reaction Engineering Notes

**CO Houle**



## **Chemical Reaction Engineering Notes:**

**Elements of Chemical Reaction Engineering** H. Scott Fogler, Bryan R. Goldsmith, Eranda Nikolla, Nirala Singh, 2025-03-19 The Essential Textbook for Mastering Chemical Reaction Engineering Now Fully Updated with Expanded Coverage of Electrochemical Reactors H Scott Fogler's Elements of Chemical Reaction Engineering now in its seventh edition continues to set the standard as the leading textbook in chemical reaction engineering This edition coauthored by Bryan R Goldsmith Eranda Nikolla and Nirala Singh still offers Fogler's engaging and active learning experience with updated content and expanded coverage of electrochemical reactors Reflecting current theories and practices and with a continuing emphasis on safety and sustainability this edition includes expanded sections on molecular simulation methods analysis of experimental reactor data and catalytic reactions Leveraging the power of Wolfram Python POLYMATH and MATLAB students can explore the intricacies of reactions and reactors through realistic simulation experiments This hands on approach allows students to clearly understand the practical applications of theoretical concepts This book prepares undergraduate students to apply chemical reaction kinetics and physics to the design of chemical reactors Advanced chapters cover graduate level topics including diffusion and reaction models residence time distribution and tools to model non ideal reactors The seventh edition includes An expanded section on molecular simulation methods and potential energy surfaces Updated examples of experimental reactor data and its analysis Detailed discussion of definitions in catalysis and examples of catalytic reactions Additional examples and an expanded section on surface reaction mechanisms and microkinetic modeling A new chapter on electrochemical reactors with example problems reflecting the growing importance of this field in renewable energy and industrial processes About the Companion Web Site [umich.edu/elements/7e/index.html](http://umich.edu/elements/7e/index.html) Comprehensive PowerPoint slides for lecture notes for chemical reaction engineering classes Links to additional software including POLYMATH™ MATLAB™ Python Wolfram Mathematica™ AspenTech™ and COMSOL™ Interactive learning resources linked to each chapter including Learning Objectives Summary Notes Web Modules Interactive Computer Games Solved Problems FAQs additional homework problems and links to LearnChemE and other resources Living Example Problems provide interactive simulations allowing students to explore the examples and ask what if questions Professional Reference Shelf which includes advanced content on reactors weighted least squares experimental planning pharmacokinetics detailed explanations of key derivations and more Redesigned Web site to increase accessibility Register your book for convenient access to downloads updates and or corrections as they become available See inside book for details

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*Essentials of Chemical Reaction Engineering* H. Scott Fogler, 2011 Accompanying DVD ROM contains many realistic interactive simulations

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**Fundamentals of Chemical Reaction Engineering** Charles Donald Holland, Rayford Gaines Anthony, 1979

Chemical Reaction Engineering Octave Levenspiel, 1998-09-01 Chemical reaction engineering is concerned with the exploitation of chemical reactions on a commercial scale Its goal is the successful design and operation of chemical reactors This text emphasizes qualitative arguments simple design methods graphical procedures and frequent comparison of capabilities of the major reactor types Simple ideas are treated first and are then extended to the more complex

Elements of Chemical Reaction Engineering H. Scott Fogler, 1992 This covers chemical reactions and kinetics for engineers and increased emphasis has been placed on numerical solutions to reaction engineering problems

*Introduction to Chemical Reaction Engineering and Kinetics* Ronald W. Missen, Charles A. Mims, Bradley A. Saville, 1999 Solving problems in chemical reaction engineering and kinetics is now easier than ever As students read through this text they will find a comprehensive introductory treatment of reactors for single phase and multiphase systems that exposes them to a broad range of reactors and key design features They will gain valuable insight on reaction kinetics in relation to chemical reactor design They will also utilize a special software package that helps them quickly solve systems of algebraic and differential equations and perform parameter estimation which gives them more time for analysis Key Features Thorough coverage is provided on the relevant principles of kinetics in order to develop better designs of chemical reactors E Z Solve software on CD ROM is included with the text By utilizing this software students can have more time to focus on the development of design models and on the interpretation of calculated results The software also facilitates exploration and discussion of realistic industrial design problems More than 500 worked examples and end of chapter problems are included to help students learn how to apply the theory to solve design problems A web site [www.wiley.com/college/missen](http://www.wiley.com/college/missen) provides additional resources including sample files demonstrations and a description of the E Z Solve software

**Chemical and Catalytic Reaction Engineering** James J. Carberry, 2001-01-01 Designed to give chemical engineers background for managing chemical reactions this text examines the behavior of chemical reactions and reactors conservation equations for

reactors heterogeneous reactions fluid fluid and fluid solid reaction systems heterogeneous catalysis and catalytic kinetics diffusion and heterogeneous catalysis and analyses and design of heterogeneous reactors 1976 edition Chemical Reaction Engineering Octave Levenspiel, 1962 **Chemical Reaction Engineering**, 1976 Chemical Reaction Engineering Nishith Verma, 2025-08-19 This book mainly deals with the design of flow reactors for homogeneous reactions ChE CRE is built upon lecture notes of Chemical Reaction Engineering CRE that the author has taught at the undergraduate UG level Few chapters are added toward the latter part of the book dealing with the basics of heterogeneous chemical reaction engineering ChE CRE is recommended for teaching the upper undergraduate program when the students have been exposed to stoichiometry thermodynamics fluid dynamics unit operation and a few numerical techniques ChE CRE comes with the audio lectures synchronized with the book chapters and is freely downloadable from the web link prescribed in the book

**Chemical Reaction Engineering** Walas, 1995-06-27 Reactors are the basic equipment in any chemical plant This book describes their process design in terms of numerically solved examples It covers numerical techniques analysis of rate data sizes and performances of ideal reactors residence time distributions and performance of non ideal models solid catalyzed reactions behavior of porous catalysts and reactions between multiple phases including biochemical processes The 1 000 plus problems are classified into 54 categories Each of the eight chapters provides definitions and an outline of theory Solutions are presented mostly as graphs or tables Some key theoretical developments are given in problem form The scope is suitable for the first undergraduate course of this topic and for beginning or graduate students as well as review for professional engineers examinations *Fundamentals of Chemical Reaction Engineering* Charles Donald Holland, Rayford Gaines Anthony, 1989 Very Good No Highlights or Markup all pages are intact **Classed Subject Catalog** Engineering Societies Library, 1966 **Chemical Reaction Engineering** Martin Schmal, José Carlos Pinto, 2021-11-09 The first English edition of this book was published in 2014 This book was originally intended for undergraduate and graduate students and had one major objective teach the basic concepts of kinetics and reactor design The main reason behind the book is the fact that students frequently have great difficulty to explain the basic phenomena that occur in practice Therefore basic concepts with examples and many exercises are presented in each topic instead of specific projects of the industry The main objective was to provoke students to observe kinetic phenomena and to think about them Indeed reactors cannot be designed and operated without knowledge of kinetics Additionally the empirical nature of kinetic studies is recognized in the present edition of the book For this reason analyses related to how experimental errors affect kinetic studies are performed and illustrated with actual data Particularly analytical and numerical solutions are derived to represent the uncertainties of reactant conversions in distinct scenarios and are used to analyze the quality of the obtained parameter estimates Consequently new topics that focus on the development of analytical and numerical procedures for more accurate description of experimental errors in reaction systems and of estimates of kinetic parameters have been included in this version of the book Finally kinetics

requires knowledge that must be complemented and tested in the laboratory Therefore practical examples of reactions performed in bench and semi pilot scales are discussed in the final chapter This edition of the book has been organized in two parts In the first part a thorough discussion regarding reaction kinetics is presented In the second part basic equations are derived and used to represent the performances of batch and continuous ideal reactors isothermal and non isothermal reaction systems and homogeneous and heterogeneous reactor vessels as illustrated with several examples and exercises This textbook will be of great value to undergraduate and graduate students in chemical engineering as well as to graduate students in and researchers of kinetics and catalysis

*Chemical Engineering Education* ,1996      *Programmed Learning of Chemical Reaction Engineering* H. Scott Fogler,1971

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