The University of Jordan
Chemical Engineering Department
Chemical Reaction Engineering 1
Fall 2023

Instructors: Reyad A. Shawabkeh

Course Description:

Kinetics of homogeneous reactions, rate equations and conservations equation applied to homogeneous reaction, design of isothermal reactors (batch, CSTR, and plug flow), single and multiple ideal reactors, non-catalytic packed bed reactors, choice of reactor for various reactions. Non-elementary homogeneous reactions, yield and selectivity for isothermal reactors with multiple reactions. Collection and analysis of reaction rate data. Non-isothermal reactions. Stability of CSTR's.

Prerequisites: Numerical Methods in Chemical Engineering (**0935301**)
Chemical Engineering Thermodynamics-II (**0905322**)

Course Objectives:

1. Provide a core foundation for the analysis and design of chemical reactors.
2. Provide instruction in the analysis of experimental data to obtain rate equations and kinetic and thermodynamic data.
3. Provide instruction in the formulation of reaction engineering analysis and design problems and their solution using mathematical analysis, computer tools, and engineering judgment.

Course Outcomes:

By the end of the course, you will be able to:

OBJECTIVE 1

1. Understand the performance characteristics and the advantages and disadvantages of major reactor types **(**O1)
2. Set up material and energy balances and identify known and unknowns (O1).
3. Make comparisons of ideal reactor types (batch, plug flow, mixed flow, etc.) and
4. Be able to determine the best choice for simple objectives when using a single reactor or a set of reactors (O1).

OBJECTIVE 2

Analyze experimental data to obtain rate equations and kinetic and thermodynamic data: Develop reaction mechanism and rate laws (reaction order and specific reaction rate that are consistent with experimental data) for use in reactor design based on reaction data from a reactor or set of reactors (O1).

OBJECTIVE 3

1. Describe the algorithm that allows the student to solve chemical reaction engineering problems through logic rather than memorization (O1).
2. Predict reactor performance in situations where a reacting gas has a significantly changing density, including the case of variable pressure within an ideal plug flow reactor.
3. Identify design alternatives and evaluate these alternatives (O1, O2).
4. Determine optimal ideal reactor design for multiple reactions for yield or selectivity (O1, O2).
5. Predict reactor performance for reactors when the temperature is not uniform within the (O1, O2).
6. Analyze multiple reactions carried out non-isothermally in flow, batch and semi batch reactors to determine selectivity and yield (O1, O2).
7. Transform calculation problems in chemical reaction engineering into mathematical models and, if necessary, choose a numerical method for solving those models and, if necessary, choose suitable ready-made software and carry out the calculations on a computer (O1, O2).

Topics covered:

Content	Text book	Week	Outcomes
1. Introduction: reaction rate, reactor molar balances, conversion	Chapter 1	1	1, 2, 3
2. Conversion and Reactor Sizing: Design Equations: Batch Reactor, CSTR, PFR, Applications for Continuous-Flow Reactors, Reactors in Series CSTRs in Series, PFRs in Series, Combinations of CSTRs and PFRs in Series	Chapter 2	2+3	1, 6, 8, 11
3. Rate Laws and Stoichiometry: Relative Rates of Reaction, The Reaction Order and the Rate Law, Power Law Models and Elementary Rate Laws, Nonelementary Rate Laws, Reversible Reaction, Reaction Rate Constant, Activation Energy, Stoichiometry	Chapter 3 + Chapter 4+	4+5	1, 2, 3
4. Isothermal Reactor Design: Batch Reactor, Design of CSTR Reactors, Single CSTR, CSTR's in Series, CSTR's in Parallel, Design of PFR Reactors, Flow Through a Packed Bed.	Chapter 5 + Chapter 6	6+7	1, 5-8 and 11
5. Analysis of Data: The Algorithm for Data Analysis, Batch Reactor Data, Finding the Rate Law Parameters	Chapter 7	8	4

6. Multiple Reactions: Types of Reactions, Selectivity, Reaction Yield, Parallel Reactions, Series Reactions, Net Rates of Reaction, Complex Reactions in PFR and CSTR.	Chapter 8	9+10	8
7. Steady State non-isothermal Reactor Design: First Law of Thermodynamics, Heat of Reaction, Dissecting the Enthalpies, Adiabatic Operation, Tubular Reactor with Heat Exchange, Equilibrium Conversion, CSTR with Heat Effects	Chapter 11 + Chapter 12	11+13	9, 10, 11
8. Multiple Steady States, Non-isothermal Multiple Chemical Reactions	Chapter 12	14+15	9, 10, 11
Final Exam		16	

Relationship to Program outcome:

NEW ABET 1 -7	1	2	3	4	5	6	7
	x	x					

Relationship to CHE Program Objectives:

PEO1	PEO 2	PEO 3	PEO 4
x	x	x	x

Textbook: Fogler, H. S., "Elements of Chemical Reaction Engineering", 5th ed., Prentice Hall (2005).

Key Reference:

1. Levenspiel, O., "Chemical Reaction Engineering", 3rd ed., John Wiley & Sons (1999).
2. James B. Rawlinga and John G. Ekerdt, Chemical Reactor analysis and Design Fundamentals, 7th Edition, Nob Hill Publishing, Madison, USA, 2002
3. Cutlip & Shacham, Problem Solving in Chemical and Biochemical Engineering with POLYMATH, Excel, and MATLAB, 2nd Edition 2008

Grading: Homework and Quizzes (20%)
Mid-Term exam: Tuesday, November 28, 2023 (30%)
Final exam (50%)

Communication: E-learning Portal is used in this course.