Course code	Course Name	L-T-P-Credits	Year of Introduction
CH305	CHEMICAL REACTION ENGINEERING-I	3-0-0-3	2016

Prerequisite : CH204 Chemical engineering thermodynamics

Course Objectives

- To expose the students to the fundamental concepts of chemical kinetics and reactor design.

Syllabus

Reaction kinetics, rate laws, factors affecting rate law, analysis of rate equations by various methods. Ideal reactors, design aspects of single and multiple reactions, multiple reactor systems, pressure drop through reactors, simultaneous reactions and separations, kinetics of enzymatic reactions, bioreactors.

Expected Outcome

At the end of the course the students will be able to

1. Explain the principles of chemical kinetics and thermodynamics to find reaction rate.
2. Determine chemical kinetic parameters using various experimental methods.
3. Design and analyze problems related to isothermal operation of common types of chemical reactors
4. Extend reactor design principles to multiple reactions.
5. Determine rate laws for enzymatic reactions and hence design bioreactors.

Reference Books:

1. H, Scott Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India.
2. K.G Denbigh& J.C.R Turner, 'Chemical Reactor Theory- An Introduction', 3rd Ed., Cambridge University Press
3. Levenspiel Octave , "Chemical Reaction Engineering", John Wiley & Son's.
4. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, 'Introduction to Chemical Reaction Engineering and Kinetics', John Wiley & Sons
5. Smith J.M, "Chemical Engineering Kinetics," McGraw Hill.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	An overview of chemical reaction engineering. Brief outline of reactor design procedure and types of industrial reactors. Classification of chemical reactions with examples. Basic concepts of chemical kinetics. Rate equations, rate constant, temperature dependency-Arrhenius law, collision theory, transition state theory, comparisons and predictions.	5	15%
II	Concentration dependency-non-elementary homogeneous reactions: Active intermediates, pseudo steady state hypothesis (PSSH), searching for a mechanism, General considerations, hydrogen bromide reaction, polymerisation - steps in free radical polymerization. Other examples of non-elementary reactions	6	15%

FIRST INTERNAL EXAMINATION			
III	Analysis of rate equations –Interpretation of batch reactor data: integral and differential method of rate analysis. Integral method; irreversible first order, second order and third order type reactions, zero order reactions, reversible reactions, autocatalytic reactions. Variable volume batch reactor. Differential method of rate analysis, method of half lives, method of initial rates, least square analysis.	10	15%
IV	Evaluation of laboratory reactors, Integral (fixed bed) reactor, stirred batch reactor, stirred contained solid reactor (SCSR), Differential reactors: Continuous stirred tank reactor (CSTR), Laminar flow reactor, stirred through transport reactor, recirculating transport reactor. Ideal reactors, concept of ideality, design equations for batch, tubular and stirred tank reactors. Space time and space velocity, steady state mixed flow, plug flow and laminar flow reactors.	4	15%
SECOND INTERNAL EXAMINATION			
V	Multiple reactor systems, Plug flow reactor in series and parallel, equal sized mixed reactors in series, mixed flow reactors of different sizes in series, determination of the best system for a given conversion. Advantages and limitations of series combinations. Recycle reactors, optimum recycle ratio, plug flow and mixed flow reactors for an autocatalytic reaction. Design for multiple reactions: Reactions in parallel, contacting patterns for reactions in parallel, quantitative treatment of product distribution and reactor size for reactions in parallel and series.	10	20%
VI	Pressure drop in reactors, accounting the pressure drop in the rate law, flow through a packed bed, pressure drop in pipes, simultaneous reactions and separations, Reactive distillation, membrane reactors, inert membrane reactor. Enzymatic reaction fundamental: Michaelis - Menten kinetics, batch reactor calculations for enzymatic reactions. Bioreactors-cell growth kinetics- Monod equation- batch and chemostat models.	7	20%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 15 marks for all the subdivisions put together. (2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in each main question with a total of 20 marks for all the subdivisions put together. (2 x20= 40 Marks)