CHAITANYA BHARATI INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING
Stake holder involvement in Curriculum Development
AY 2019-20

Action taken and implementation in Curriculum

INDEX

I/c HEAD
Dept. of Chemical Engineering
Chaitanya Bharathi Institute of Technology
Gandipet, Hyderabad-75.

1) Students

S.no.	Suggestions & opinion	Actions Taken
1	Data structures course is required	Introduced in curriculum
2	Problem solving courses required	Decision implemented
3	Software related elective courses like ML are required	Software courses are opted by the department as open electives

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Students (Proof)

Model Curriculum (with effect from 2019-20)

B.TECH (Chemical Engineering)

SEMESTER – IV

S.No	Course Code	Title of the Course	Schemeof Instruction			Scheme of Examination			Credits
			Hours per week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	18CSC05	Basics of Data Structures	2	-	-	3	20	50	2
2	18CHC07	Chemical Engineering Thermodynamics-II	3	1	-	3	30	70	4
3	18CHC08	Fluid mechanics	3	1	-	3	30	70	4
4	18CHC09	Material Science	3	-	-	3	30	70	3
5	18MEC09	Principles of management	3	-	-	2	30	70	3
6	18CEM01	Environment science	2	-	-	2	-	50	Non credit
PRACTICALS									
7	18EGC03	Soft skills lab	-	-	2	2	15	35	1
8	18CSC06	Basics of Data structures	-	-	2	2	15	35	1
Total			16	02	04	-	170	450	18

L: Lecture T: Tutorial D: Drawing P: Practical

CIE - Continuous Internal Evaluation SEE - Semester End Examination

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18CH C 03

NUMERICAL METHODS IN CHEMICAL ENGINEERING

Instruction	3L+1T Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	4

Course objectives: This course helps the students to understand the

1. Error analysis for various numerical methods
2. Appropriate numerical methods to solve non-linear algebraic and transcendental equations and linear system of equations
3. Appropriate numerical methods to approximate a function
4. Appropriate numerical methods to solve an ordinary differential equation
5. Various techniques to solve Partial differential equations

Course outcomes: At the end of the course, the students will be able to

1. Perform an error analysis for a given numerical method
2. Solve a linear system of equations and non-linear algebraic or transcendental equation using an appropriate numerical method
3. Calculate a definite integral and evaluate a derivative at a value using an appropriate numerical method
4. Solve an Ordinary differential equation using an appropriate numerical method
5. Solve partial differential equations using an appropriate numerical method

UNIT - I

Introduction, Approximation and concept of Error and Error Analysis: Taylor series expansion, Truncation error. Round-off error vs. Chopping-off error. Propagation of Error.

Linear Systems and Equations Matrix representation, Calculation of Eigen Values and Eigen vectors, Solution by Cramer's rule; Iterative Method— Jacobi iteration; Gauss-Seidel Method,

Chemical Engineering Examples: Material and energy balance problems involving at least 3 simultaneous equations

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(AUTONOMOUS)

Scheme of Instructions of VII Semester of B.Tech. – Chemical Engineering as per AICTE Model Curriculum 2021-22

DEPARTMENT OF CHEMICAL ENGINEERING

SEMESTER – VII

S No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	18CH C 21	Transport Phenomena	3	1	-	3	30	70	4
2	18CH C 22	Process Technology and Economics	3	-	-	3	30	70	3
3	18CH C 23	Process Instrumentation	2	-	-	2	20	50	2
4		Core Elective V	3	-	-	3	30	70	3
5		Open Elective II	3	-	-	3	30	70	3
	PRACTICALS								
6	18CH C 24	Process Instrumentation and Control lab	-	-	3	3	25	50	1.5
7	18CH C 25	Process Modeling and Simulation lab	-	-	3	3	25	50	1.5
8	18CH C 26	Project: Part I	-	-	4	-	50	-	2
Total			**14**	**1**	**10**	**-**	**240**	**430**	**20**

L: Lecture T:Tutorial D:Drawing P: Practical

CIE – Continuous Internal Evaluation SEE- Semester End Examination

Core Elective V	
18CH E 13	Mineral Processing Technology
18CH E 14	Corrosion Engineering
18CH E 15	Scale-up Methods

Open Elective II	
18ME O 11	Modern Manufacturing Processes
18EE O 02	Energy Management Systems
18ME O 03	Research Methodologies
18CE O 02	Disaster Mitigation and Management
18CS O 10	Machine Learning using Python

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2) Teachers

S.no	Suggestions & opinion	Action Taken
1	CRE I can have entire non ideal reactor concepts. This concept can be deleted from CRE II	Decision implemented
2	CRE II can have only heterogenous reaction concepts. Deactivation kinetics can be removed to accommodate the heterogenous reactor design concepts	Syllabus modification done accordingly
3	In MTO II extraction and leaching can be combined into one unit. Membrane concepts can be covered in one unit	This suggestion was implemented

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Teachers (Proofs)

18CH C10 **CHEMICAL REACTION ENGINEERING I**

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

urse Objectives: This course helps the students to

1. Analyze experimental kinetic data to determine reaction mechanisms.
2. Design different types of chemical reactors (Batch, Tube, and CSTR).
3. Assess the advantages and disadvantages of reactor types.
4. Understand the concepts of non ideal reactors.

urse Outcomes: At the end of the course students will be able to

1. Classify reactions, rate and forms of rate expressions.
2. Summarize fundamentals of kinetics and interpret the data including relationships between moles, Concentration, extent of reaction and conversion.
3. Explain Batch, CSTR, and PFR performance equations from general material balances for homogeneous and heterogeneous reactions.
4. Identify the right reactor among single, multiple, recycle reactors etc.
5. Apply the concepts of heat effects on reactions.
6. Analyze the non ideality of reactors.

UNIT-I

Introduction: Classification of Reactions, Definition - Variables affecting the rate of reaction. The rate equation and Stochiometric relations for a single phase reaction aA+bB → rR+sS. Single and multiple reactions, Elementary and non-Elementary reactions, Molecularity and order of Reaction, Specific reaction rate constant, Testing kinetic models – Steady state approximation, Equilibrium treatment, Fitting a rate law for the given reaction mechanism, predictability of reaction rate from theory. Temperature dependency from Arrhenius' law, Thermodynamics, Collision theory and Transition state theory, Comparison of theories with Arrhenius' law.

UNIT-II

Analysis and Correlation of experimental kinetic data: Constant volume batch reactor: Analysis of total pressure data, conversion. Integral method of analysis of data for single reaction, multiple reactions, Homogeneous catalyzed reactions, Auto catalytic reactions, Reversible reactions, and Reactions of shifting orders. Half life method, Partial analysis of the rate equation .Differential method of analysis of data.
Variable Volume Batch Reactor: Fractional change in volume of the system, Differential method of analysis, Integral method of analysis.

UNIT-III

Introduction to Reactor Design: Ideal reactors for a single reaction, generalized material balance, design equations-Ideal batch reactor, Space time – space velocity, Steady state mixed flow reactor, Steady state plug flow reactor, Holding time and space time for flow reactors, graphical interpretation. Design for single reactions, Size comparison of single reactors, Multiple reactor systems, Recycle reactor, Auto catalytic reactions – optimum recycle operation, Reactor combinations.

UNIT-IV

Design for Multiple Reactions: Series, Parallel and Independent reactions, Selectivity, Yield, Qualitative discussion about product distribution, Quantitative treatment of product distribution and of reactor size.
Temperature and Pressure effects for single reactions, Heat of reaction from thermodynamics, Heat of reaction and Temperature, Equilibrium constants and equilibrium conversions from Thermodynamics. General graphical design procedure, Optimum temperature progression. Heat effects, Adiabatic Operations, Non adiabatic operations. Exothermic reactions in mixed flow reactors – a qualitative treatment.

UNIT-V

Basics of Non-Ideal flow: The residence time distribution (R T D), State of aggregation of the flowing stream, earliness of mixing, Role of R T D, state of aggregation and earliness of mixing in determining reactor behavior. Exit age distribution of fluid, Experimental methods for finding E – pulse and step input experiments, Relationship between F and E curves. The convolution integral. Conversion in non- ideal flow reactors, Dispersion model-Axial dispersion and correlations for axial dispersion.

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18CH C16 **CHEMICAL REACTION ENGINEERING – II**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives This course helps the students to understand

1. Basic Concepts of Catalysis
2. Kinetics and Mechanistic aspects of Catalysts
3. Design and Rating of Catalytic Reactors
4. Design Aspects of Gas-Liquid Reactors

Course Outcomes At the end of the course, a student will be able to

1. Indentify and characterize solid catalysts
2. Explain the kinetics for solid catalyzed reactions
3. Interpret the kinetics of fluid and particle reactions
4. Identify regions of mass transfer control and reaction rate control in fluid-fluid reactions
5. Apply the concepts to Gas fluid and catalytic reactors

UNIT – I

Solid Catalysts - Adsorption, adsorption isotherms, surface area, void volume and solid density, pore volume distribution. Theories of heterogeneous catalysis, classification of catalysts, catalyst preparation, promoters and inhibitors

UNIT – II

Solid Catalyzed Reactions - Introduction; Development of rate expressions from L- H - H - W models for reaction $A + B \leftrightarrow R + S$ under adsorption, surface reaction and desorption controlling condition. Pore diffusion resistance combined with surface kinetics (Single cylindrical pore, first order reaction) Porous catalyst particles, mass and heat transfer within catalyst pellets. Experimental methods for finding rates.

UNIT – III

Kinetics of fluid-particle reactions: selection of a model, PCM, SCM, comparison of models with real situations. Shrinking core model for spherical particles of unchanging size: Diffusion through gas film controls, Diffusion through ash layer controls, chemical reaction controls. Rate of reaction for shrinking spherical particles.

UNIT – IV

Kinetics of fluid - fluid reactions: The rate equation for straight mass transfer of A (absorption). The general rate equation and the rate equation for reaction with mass transfer.

UNIT V

Fluid Fluid Reactors: Design of reactors for straight mass transfer and mass transfer plus not very slow reaction cases

Catalytic gas solid reactors: Design of single adiabatic fixed bed catalytic reactor

Text Books

1. Levenspiel O., "Chemical Reaction Engineering", 3rdEdition, John Wiley & Sons, Singapore, (1999).
2. Fogler H. S., "Elements of Chemical Reaction Engineering", 3rdEdition, Prentice Hall Inc., (1999)
3. Smith J. M., "Chemical Engineering Kinetics", 3rdEdition, McGraw Hill, (1981).

Suggested References Books

1. Chemical and Catalytic Reaction Engineering, Carberry, J. J., Dover Books on Chemistry, 2001.
2. Chemical Reactor Analysis and Design Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, John Wiley & Sons, Incorporated, 2010

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18CH C17 **MASS TRANSFERS- II**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives: This course will help the students to understand the

1. Principles of mass transfer operations to specific applications, separation and/or purification processes.
2. Theoretical/analytical aspects to design mass transfer equipments and to deal with complex problems of separations.
3. Suitable equipment required for various types of mass transfer operations.
4. Different types of Membrane process
5. Given industrial problem and apply concepts of mass transfer operations

Course outcomes: At the completion of this course, students able to

1. Understand the concept of different mass-transfer operations and their concerned equipment used in the chemical industries.
2. Interpret the importance and the role of liquid–liquid extraction and leaching in Separation Process
3. Articulate the process of adsorption and the equipment used in chemical industry
4. Calculate the enthalpies and interpret psychometric charts and design of cooling towers and drying equipment.
5. Distinguish among micro-filtration, ultra-filtration, nano-filtration, and reverse osmosis

UNIT – I: Introduction: Perspective on unified approach to operations.
Liquid – Liquid Extraction: Solubilities of ternary liquid systems. Triangular and solvent free coordinate systems. Choice of solvent. Extraction with insoluble and partially soluble systems – single stage, multistage cross-current and multistage counter-current extraction without reflux and Continuous contact extraction (packed beds). Equipment's for liquid – liquid extraction operation. Solid-Liquid Extraction:
Leaching: Preparation of solid, unsteady state operation, in-place leaching, heap leaching, percolation leaching, Shanks system, agitated vessels, percolation in closed vessels, Percolation Vs Agitation. Steady state continuous operation–equipment, methods of calculation of stage efficiency and practical equilibrium. Single stage leaching, multistage cross current leaching, multistage counter current leaching.

UNIT-II: Adsorption:
Principles of Adsorption and their applications – Types of adsorption – Adsorbents – Adsorption equilibrium – Adsorption Isotherms for vapor and dilute solutions. Single stage and multistage adsorption, Adsorption wave and breakthrough curve and fixed bed adsorption. Equipment for Adsorption operation, fixed bed adsorbers, break through . **Ion Exchange**: Principles of ion exchange, analogy between adsorption and ion exchange.

UNIT–III: Simultaneous Heat and Mass Transfer:
Humidification & Dehumidification: Vapour, gas mixtures – Humidity and relative saturation. Dew point adiabatic saturation and wet bulb temperatures – psychometric charts – Enthalpy of gas vapor mixtures. Humidification and Dehumidification techniques.
Design of Cooling Towers: Design calculations of cooling tower, Key points in the design of cooling tower step by step procedure of cooling tower.

UNIT-IV: Drying:
Equipments for Drying, moisture contents of solids – equilibrium, bound and unbound moisture. Design conditions – Rate of batch drying under constant drying conditions – Mechanism of batch drying – total time for batch drying.

UNIT-V: Membrane Process:
Types and choice of Membranes, Plate and Frame, tubular, spiral wound and hollow fiber Membrane Reactors and their relative merits, commercial, Pilot Plant and Laboratory Membrane permeators involving Dialysis, Reverse Osmosis, Nanofiltration, Ultra filtration and Micro filtration.

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3) Employers

S.No	Suggestions & opinions	Actions Taken
1	Courses on Employability and Communication skills can be introduced for Chemical Engineers	Decision is implemented
2	Employability skills can be improved, by introducing new courses in curriculum.	The suggestion is implemented and included in curriculum
3	Courses for employment generation is important. Case studies of chemical engineering can be introduced in ML and DS	Decision implemented to include ML and DS, but chemical engineering cases not yet implemented

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Employers Proofs

18EG C 03 **SOFT SKILLS LAB**

Instruction	2 Hours per week
Duration of SEE	2 Hours
SEE	35 Marks
CIE	15 Marks
Credits	1

Course Objectives: The course will introduce the students to:

1. Imbibe an impressive personality, etiquette, professional ethics & values, effective time management & goal setting.
2. Understand the elements of professional update & upgrade through industry exposure in a mini-live project. Understand confidence building strategies and thereby to make effective presentations through PPTs.
3. Learn what constitutes proper grooming and etiquette in a professional environment. Acquire the necessary skills to make a smooth transition from campus to corporate.

Course Outcomes: After successful completion of the course the students will be able to

1. Be assertive and set short term and long term goals. Also learn to manage time effectively and deal with stress.
2. Win in professional communication situations and participate in group discussions with confidence. Write abstracts.
3. Write effective resumes. Plan, prepare and face interviews confidently.
4. Adapt to corporate culture by being sensitive - personally and sensible - professionally. Draft an SOP.
5. Apply the soft skills learnt in the mini-live project, by collecting and analyzing data and making oral and written presentations on the same.

Exercise 1
Main Topics: Thinking Skills, Personality Development – Effective Time Management, setting realistic goals, self confidence and assertiveness, stress management, moral values.
Flipped Sessions: Personal Sensitivity & Professional Sensibility (Reading & Discussion)
Writing Input: Writing to Express - Drafting & Delivering a Speech (Free Writing Exercise)

Exercise 2
Main Topics: Advanced Group Discussion with Case studies : Dynamics of group discussion, intervention, summarizing, modulation of voice, body language, relevance, fluency and coherence.

Flipped Sessions: Importance of Professional Updating & Upgrading (Reading & Discussions)
Writing Input: Writing with Precision - Writing Abstracts

Exercise 3
Main Topics: Interview Skills – concept and process, pre-interview planning, opening strategies, answering strategies, mock interviews. Resume' writing – structure and presentation, planning, defining the career objective, projecting ones strengths and skills.
Flipped Sessions: Mock Interviews (Video Sessions & Practice)
Writing Input: Writing to Reflect - Resume Writing

Exercise 4
Main Topic: Corporate Culture – Grooming and etiquette, communication media, academic ethics and integrity
Flipped Sessions: Corporate Culture, Etiquette & Grooming (Video Sessions & Practice through Role-play)
Writing Input: Writing to Define - Writing an effective SOP.

Exercise 5
Main Topic: Mini Project – General/Technical. Research, developing a questionnaire, data collection, analysis, written report and project seminar. Elements & Structure of effective presentation. Presentation tools – Body language, Eye-contact, Props & PPT.
Flipped Sessions: Effective Presentations (Video & Writing Sessions, Practice through Emulation)
Writing Input: Writing to Record - Writing minutes of meeting.

Suggested Readings:

1. Madhavi Apte , "A Course in English communication", Prentice-Hall of India, 2007
2. Dr. Shalini Verma, "Body Language- Your Success Mantra", S Chand, 2006
3. Ramesh, Gopalswamy, and Mahadevan Ramesh, "The ACE of Soft Skills", New Delhi: Pearson, 2010
4. Van Emden, Joan, and Lucinda Becker, "Presentation Skills for Students", New York: Palgrave Macmillan, 2004

* Flipped Class-room: Students explore the concept first and then trainer explains it, students work on their own.

Web Resources:

1. https://www.goskills.com/Soft-Skills
2. https://www.trainerbubble.com
3. https://www.skillsconverged.com

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Scheme of Instructions of VII Semester of B.Tech. – Chemical En

as per AICTE Model Curriculum 2021-22

DEPARTMENT OF CHEMICAL ENGINEERING

SEMESTER – VII

S No	Course Code	Title of the Course	Scheme of Instruction			Scheme o	
			Hours per week			Duration of SEE in Hours	
			L	T	P/D		CIE
	THEORY						
1	18CH C 21	Transport Phenomena	3	1	-	3	3
2	18CH C 22	Process Technology and Economics	3	-	-	3	3
3	18CH C 23	Process Instrumentation	2	-	-	2	2
4		Core Elective V	3	-	-	3	3
5		Open Elective II	3	-	-	3	3
	PRACTICALS						
6	18CH C 24	Process Instrumentation and Control lab	-	-	3	3	2
7	18CH C 25	Process Modeling and Simulation lab	-	-	3	3	2
8	18CH C 26	Project: Part I	-	-	4	-	5
Total			14	1	10	-	2

L: Lecture T:Tutorial D:Drawing P: Practical

CIE – Continuous Internal Evaluation SEE- Semester End Examin

Core Elective V	
18CH E 13	Mineral Processing Technology
18CH E 14	Corrosion Engineering
18CH E 15	Scale-up Methods

Open Elective II	
18ME O 11	Modern Manufacturing Processes
18EE O 02	Energy Management Systems
18ME O 03	Research Methodologies
18CE O 02	Disaster Mitigation and Management
18CS O 10	Machine Learning using Python

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Alumni

S.No	Suggestions & opinion	Actions Taken
1	Electives on Water Conservation, Renewable energy are needed	These subjects are introduced as electives
2	Electives on Analytical methods, scaleup methods needed.	The decision is implemented
3	Need design concepts of Packed bed reactor, adiabatic reactor reactors.	This decision is implemented in Chemical Reaction Engg II subject in the unit V

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Alumni Proofs

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Model Curriculum (with effect from 2019-20)

B.TECH (Chemical Engineering)

SEMESTER – V

S.No	Course Code	Title of the Course	Scheme of Instruction Hours per week			Scheme of Examination Duration of SEE in Hours	Maximum Marks		Credits
			L	T	P/D		CIE	SEE	
	THEORY								
1	18CH C10	Chemical Reaction Engineering I	3	-	-	3	30	70	3
2	18CH C11	Mass Transfer I	3	-	-	3	30	70	3
3	18CH C12	Heat Transfer	3	1	-	3	30	70	4
4	18CH C13	Particle and Fluid Particle Processing	3	-	-	3	30	70	3
5		Core Elective I	3	-	-	3	30	70	3
6		Core Elective II	3	-	-	3	30	70	3
	PRACTICALS								
7	18CH C14	Chemical Engineering Lab IA- MUO	-	-	3	3	15	35	1
8	18CHC15	Chemical Engineering Lab IB- FM and HT	-	-	3	3	15	35	1
Total			18	01	06	-	210	490	21

L:Lecture T:Tutorial D:Drawing P: Practical

CIE – Continuous Internal Evaluation SEE- Semester End Examination

Core Elective I		Core Elective II	
18CH E 01	Water Conservation and Management	18CH E 04	Polymer Science and Technology
18CH E 02	Renewal Energy	18CH E 05	Green Technology
18CH E 03	Experimental and Analytical Techniques	18CH E 06	Catalysis

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18CH E 03 **EXPERIMENTAL AND ANALYTICAL TECHNIQUES**
(Core Elective I)

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	70Marks
CIE	30Marks
Credits	3

Course Objectives: This course will help the students to
1. Acquire knowledge about the widely used analytical Instruments
2. Essential chemical and physical principles of analytical techniques
3. Understand & select Instrument for a particular analysis with some idea of its merits, demerits and limitations
4. Practical aspects of classical chemical analysis
5. Work as a service and maintenance engineering for these Instruments

Course outcomes: At the end of the course students will be able to
1. Build basic knowledge of analytical techniques
2. Distinguish the applicability of Microscopy techniques
3. Identify the suitable spectroscopy methods
4. Select the electro-analytical techniques
5. Infer the role of different separation techniques

UNIT-I
Microscopy Techniques: scanning electron microscopy (SEM); secondary Auger microscopy (SAM); scanning probe microscopy (SPM); scanning tunneling microscopy (STM); transmission electron microscopy (TEM); upright microscope, inverted microscope, image analysis.

UNIT-II
Spectroscopy methods: FTIR, AAS, UV-VIS, UV-fluorescent, Wavelength and energy dispersive X-ray fluorescence spectroscopy (WDS and EDS); X-ray absorption spectroscopy (XANES and EXAFS); secondary ion mass spectrometry (SIMS); temperature programmed desorption (TPD); thermal desorption spectroscopy TDS), ICP-OES, XRD.

UNIT-III
Atomic absorption spectroscopy (AAS); inductively coupled plasma-atomic emission spectroscopy (ICP-AES).

UNIT-IV
Electro analytical Techniques: Voltametry; coulometry; amperometry; potentiometry; polarography; electrolytic conductivity; impedance spectroscopy, rotating disc electrode, rotating ring disc electrode.

UNIT-V
Separation Methods: Normal and reversed phase liquid chromatography (NP-& RP-LC); Gas Chromatography (GC); GC-MS; High Performance Liquid Chromatography (HPLC); Size-Exclusion Chromatography (SEC); Ion Chromatography (IC)

Text Books:
1. Wiesendanger, Scanning Probe Microscopy and Spectroscopy, Cambridge University Press, 1994
2. Frank A Settle, Handbook of instrumental techniques for analytical chemistry, Prince Hall, New Jersey, 1997

Suggested Reading:
1. D A Skoog, D M West, F. J. Holler and S. R. Couch, Fundamentals of analytical chemistry. Brooks/Cole Cengage learning, New Delhi, 2004
2. P Atkins and J de Paula, Atkins' Physical Chemistry, Oxford University Press, New Delhi, 8th Edition, 2008
3. K W Kolasinski, Surface Science: Foundations of Catalysis and Nano science, John Wiley and Sons, 2002

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18CH C16 **CHEMICAL REACTION ENGINEERING – II**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE	30 Marks
Credits	3

Course Objectives This course helps the students to understand

1. Basic Concepts of Catalysis
2. Kinetics and Mechanistic aspects of Catalysts
3. Design and Rating of Catalytic Reactors
4. Design Aspects of Gas-Liquid Reactors

Course Outcomes At the end of the course, a student will be able to

1. Indentify and characterize solid catalysts
2. Explain the kinetics for solid catalyzed reactions
3. Interpret the kinetics of fluid and particle reactions
4. Identify regions of mass transfer control and reaction rate control in fluid-fluid reactions
5. Apply the concepts to Gas fluid and catalytic reactors

UNIT – I

Solid Catalysts - Adsorption, adsorption isotherms, surface area, void volume and solid density, pore volume distribution. Theories of heterogeneous catalysis, classification of catalysts, catalyst preparation, promoters and inhibitors

UNIT – II

Solid Catalyzed Reactions - Introduction; Development of rate expressions from L- H - H - W models for reaction $A + B \leftrightarrow R + S$ under adsorption, surface reaction and desorption controlling condition. Pore diffusion resistance combined with surface kinetics (Single cylindrical pore, first order reaction) Porous catalyst particles, mass and heat transfer within catalyst pellets. Experimental methods for finding rates.

UNIT – III

Kinetics of fluid-particle reactions: selection of a model, PCM, SCM, comparison of models with real situations. Shrinking core model for spherical particles of unchanging size: Diffusion through gas film controls, Diffusion through ash layer controls, chemical reaction controls. Rate of reaction for shrinking spherical particles.

UNIT – IV

Kinetics of fluid - fluid reactions: The rate equation for straight mass transfer of A (absorption). The general rate equation and the rate equation for reaction with mass transfer.

UNIT V

Fluid Fluid Reactors: Design of reactors for straight mass transfer and mass transfer plus not very slow reaction cases

Catalytic gas solid reactors: Design of single adiabatic fixed bed catalytic reactor

Text Books

1. Levenspiel O., "Chemical Reaction Engineering", 3rdEdition, John Wiley & Sons, Singapore, (1999).
2. Fogler H. S., "Elements of Chemical Reaction Engineering", 3rdEdition, Prentice Hall Inc., (1999)
3. Smith J. M., "Chemical Engineering Kinetics", 3rdEdition, McGraw Hill, (1981).

Suggested References Books

1. Chemical and Catalytic Reaction Engineering, Carberry, J. J., Dover Books on Chemistry, 2001.
2. Chemical Reactor Analysis and Design Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, John Wiley & Sons, Incorporated, 2010

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