COURSE STRUCTURE AND SYLLABUS

III/IV B.TECH. CHEMICAL ENGINEERING (AUTONOMOUS)

III/IV B. Tech. 1st Semester

Code	Subject	Category	Instruction Lectures per week				Maximum Marks			Credits
			Lecture	Tutorial	Lab	Total	Sessional	External	Total	
CHE 311	Open Elective – I	OE	3	1	-	4	40	60	100	3
CHE 312	Chemical Engineering Thermodynamics – II	PC	4	1	-	5	40	60	100	4
CHE 313	Heat Transfer	PC	4	1	-	5	40	60	100	4
CHE 314	Mass Transfer – I	PC	4	1	-	5	40	60	100	4
CHE 315	Chemical Reaction Engineering – I	PC	4	1	-	5	40	60	100	4
CHE 316	Elective – I	PE	4	1	-	5	40	60	100	4
CHE 317	Heat Transfer Laboratory	PC	-	-	3	3	50	50	100	2
CHE 318	Soft Skills Laboratory	HS	-	-	3	3	100	-	100	2
CHE 319	Quantitative and Verbal Aptitude – I	HS	4	-	-	4	100	-	100	2
	Total		**27**	**6**	**6**	**39**	**490**	**410**	**900**	**29**

III/IV B. Tech. 2nd Semester

Code	Subject	Category	Instruction Lectures per week				Maximum Marks			Credits
			Theory	Tutorial	Lab	Total	Sessional	External	Total	
CHE 321	Mass Transfer – II	PC	4	1	-	5	40	60	100	4
CHE 322	Chemical Reaction Engineering – II	PC	4	1	-	5	40	60	100	4
CHE 323	Material Science and Engineering	PC	4	1	-	5	40	60	100	4
CHE 324	Chemical Technology	PC	4	1	-	5	40	60	100	4
CHE 325	Elective - II	PE	4	1	-	5	40	60	100	4
CHE 326	Mass Transfer Laboratory	PC	-	-	3	3	50	50	100	2
CHE 327	Chemical Reaction Engineering Laboratory	PC	-	-	3	3	50	50	100	2
CHE 328	Chem. Technology Laboratory	PC	-	-	3	3	50	50	100	2
CHE 329	Quantitative and Verbal Aptitude – II	HS	4	-	-	4	100	-	100	2
	Total		**24**	**5**	**9**	**38**	**450**	**450**	**900**	**28**

ELECTIVE SUBJECTS:

Elective – I

CHE 315 (A) Polymer Technology
CHE 315 (B) Fertilizer Technology
CHE 315 (C) Paper Technology
CHE 315 (D) Pharmaceutical Technology
CHE 315 (E) Soap and Detergent Technology

Elective - II

CHE 325 (A) Petrochemicals
CHE 325 (B) Computer Applications in Chemical Engineering
CHE 325 (C) Membrane Technology
CHE 325 (D) Catalysis
CHE 325 (E) Industrial Pollution and Control

Open Elective - I

CHE 316 (A) Industrial Safety and Hazard management
CHE 316 (B) Engineering Biology
CHE 316 (C) Fuel Cell Technology

Open Elective - II

CHE 411 (A) Food Processing Technology
CHE 411 (B) Corrosion Engineering
CHE 411 (C) Computational Tools for Engineers
CHE 411 (D) Bioinformatics

CHEMICAL ENGINEERING THERMODYNAMICS-II

CHE 312 **Credits:4**

Instruction : 4 Lectures & 1 Tutorial/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Physical Chemistry, Chemical Engineering Thermodynamics–I and Chemical Process Calculations.

Course Objectives:

1. To provide basic knowledge on refrigeration, liquefaction and Phase equilibrium.
2. To familiarize with non-ideal solutions and fugacity concepts and calculations.
3. To acquaint knowledge on chemical reaction equilibria.

Course Outcomes:

By the end of the course, the student will be able to

1. Understand the application of refrigeration and liquefaction.
2. Identify the relations between phases in equilibrium.
3. Know the concept of fugacity and its application to non-ideal solutions.
4. Apply the concepts to estimate activity co-efficients.
5. Know the procedure to estimate the equilibrium constant for a chemical reaction.

CO – PO – PSO Matrix:

		PO												**PSO**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	2	1	1	1						1	1			1	
	2	1	2	1	1	1					1	1		2	1	
	3	1	2	1	1	1					1	1		2	1	
	4	1	2	1	1	1					1	1		1		
	5	1	2	1	1	1					1	1		2	1	

SYLLABUS

UNIT I **12 L + 3 T**

Refrigeration and Liquefaction:

Carnot Refrigerator, vapour compression cycle, choice of refrigerant, absorption refrigerant, heat pump , liquefaction process.

UNIT II **12L + 3T**

Phase Equilibrium:

Nature of equilibrium, phase rule, Duhem's theorem, vapour-liquid equilibrium (VLE) qualitative behaviour, simple models for VLE, VLE by modified Raoult's law, VLE from k-value correlations, liquid-liquid equilibrium, vapour-liquid-liquid equilibrium, solid-liquid equilibrium, solid-vapour equilibrium.

UNIT III **12L + 3T**

Thermodynamics of Solution – Theory:

Fundamental property relation, chemical potential and phase equilibria, partial properties, ideal gas mixtures, fugacity and fugacity coefficient – pure species, species in solution, generalized correlations for the fugacity coefficients, ideal solution, excess properties.

UNIT IV **9L + 3T**

Thermodynamics of Solution – Applications:

Liquid-phase properties from VLE data, models for the excess Gibbs Energy, property changes of mixing, heat effects of mixing processes.

UNIT V **15L+3T**

Chemical Reaction Equilibria:

Reaction coordinate, application of equilibrium criteria to chemical reactions, standard Gibbs energy change and the equilibrium constant, effect of temperature on the equilibrium constant, evaluation of equilibrium constants, relation of equilibrium constants to composition, equilibrium conversions for single reactions, phase rule and Duhem's theorem for reacting systems, multi reaction equilibria.

Text Book

1. J.M.Smith, H.C.Van Ness, M.M. Abbott and B. I. Bhatt, *Introduction to Chemical EngineeringThermodynamics*,7th ed., 2009, McGrawHill Education.

Reference Books

1. Y.V.C.Rao, *Chemical Engineering Thermodynamics*, 1997, University Press (India) Ltd.,Hyderabad.
2. Michael M. Abbott and Hendrick C.VanNess, *Schaum'sOutlines of Theory and Problemsof Thermodynamics*, 3rd ed., 2013, McGrawHill education.
3. K.V. Narayanan, *A Text book of Chemical Engineering Thermodynamics*, 2013, PHI learning.

HEAT TRANSFER

CHE 313 **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Engineering Mathematics, Chemical Process Calculations.

Course Objectives:

1. To familiarize with three modes of heat transfer and to know about steady state and unsteady state heat conduction.
2. To know about heat transfer involving phase change and without phase change.
3. To familiarize the operation of different heat transfer equipments.
4. To understand the fundamental principles of radiation.
5. To impart knowledge on the principles of evaporation and evaporator design.

Course Outcomes:

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

1. Understand the conduction mode of heat transfer in steady state and unsteady state operations.
2. Understand heat transfer involving phase change and without phase change in laminar and turbulent flow conditions.
3. Use fundamentals of heat transfer to understand the design of heat exchangers
4. Analyse radiation heat transfer between different surfaces.
5. Apply material and energy balances to determine performance of Evaporator.

CO – PO – PSO Matrix:

		PO												**PSO**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	2	1	1	1	1					1	1		1		
	2	1	2	2	2	1		1			1	1		1	1	1
	3	1	3	2	2	1		1			1	1		1	1	1
	4	1	1	2	2	1		1			1	1		1	1	1
	5	1	3	2	2	1		1			1	1		1	1	1

SYLLABUS

UNIT-I **12 L+3 T**

Conduction:

Modes of heat flow: Conduction, convection and radiation.

C**onduction:** Basic laws of conduction, thermal conductivity; steady-state conduction – compound resistances in series, heat flow through a cylinder; critical insulation thickness. unsteady-state conduction – one dimensional heat flow with constant surface temperature, heat flow with variable surface temperature, semi-infinite solid.

UNIT II **12 L+3 T**

Convection :

Principles of heat flow in fluids – typical heat exchange equipment, countercurrent and parallel flows, energy balances, heat flux and heat transfer coefficients, LMTD.

Heat transfer to fluids without Phase change : Boundary layers, laminar flow heat transfer, heat transfer in turbulent flow, estimation of wall temperature, cross-sections other than circular, analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids outside tubes, natural convection.

Heat transfer to fluids with Phase change: heat transfer from condensing vapors, heat transfer to boiling liquids.

Unit III **12 L+3 T**

Radiation:

Fundamental facts concerning radiation, emission of radiation, absorption of radiation by opaque solids, radiation between surfaces, radiation to semitransparent materials, combined heat transfer by conduction-convection-radiation.

UNIT IV **12 L+3 T**

Heat-exchange equipment:

General design of heat exchange equipment, shell and tube heat exchangers, plate-type exchangers, extended surface equipment, scraped-surface exchangers, condensers and vaporizers, heat transfer in agitated vessels, heat transfer in packed beds.

UNIT V **12 L+3 T**

Evaporation:

Evaporation, types of evaporators, capacity and economy of evaporators, boiling point elevation and Duhring's rule, material and energy balances in single effect evaporator, multiple effect evaporators, methods of feeding and economy of multiple effect evaporators.

Text Book:

1. W. L. McCabe, J. C. Smith and P. Harriot, *Unit Operations of Chemical Engineering*, 7th Edition McGraw Hill International Edition, Singapore (2005).

Reference book:

1. D. Q. Kern, *Process Heat Transfer*, Tata McGraw Hill, New Delhi.
2. Holman. J.P., *Heat Transfer*, 9th Edition Tata McGraw Hill Book Co., New Delhi, 2008.
3. NecatiOzisik, *Heat Transfer: A Basic Approach*, Vol. 1, McGraw Hill, 1985.
4. Robert W. Serth, *Process Heat Transfer: Principles and Applications*, Academic Press, 2007.
5. J.P. Holman, *Heat Transfer*, 8th Edition, McGraw Hill, NewYork, 1997.

MASS TRANSFER-I

CHE 314 **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites: Introduction to Chemical Engineering, Chemical Process Calculations.

Course Objectives:

1. To understand the concepts of diffusion , stages, through mathematical equations
2. To understand the concepts of absorption and distillation
3. To expose the student to different types of equipment for Gas-Liquid Operations

Course Outcomes:

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

1. Estimate the flux of molecules transferred and diffusivity of gases, liquids and solids
2. Estimate the mass transfer coefficients and know its importance
3. Identify different solvents for absorption, write material balance on absorption tower for a given gas , liquid mixtures and estimate the number of stages in various absorption equipment
4. Generate VLE data for different types of distillation and calculate the number of stages by various methods
5. Identify the equipment for different gas-liquid operations.

CO – PO – PSO Matrix:

		PO												**PSO**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	2	1	2	1	1		1			1	2		2	2	1
	2	2	1	1	1	1		1			1	2		1	1	1
	3	2	3	1	2	1		1			1	2		2	2	2
	4	2	3	1	2	1		1			1	2		2	2	2
	5	2	3	1	2	1		1			1	2		2	2	2

SYLLABUS

UNIT I **12 L + 3T**

Introduction:

Classification of the mass transfer operations, molecular diffusion in fluids, binary solutions, Fick's law, equation of continuity, steady state molecular diffusion in fluids at rest and in laminar flow, Stefan's diffusion, estimation of diffusivity of gases and liquids, application of molecular diffusion, diffusion in solids.

UNIT II **12 L + 3T**

Mass Transfer Coefficients and Inter Phase Mass Transfer:
Concept of equilibrium, diffusion between phases, Theories of mass transfer, Mass, heat-, and momentum transfer analogies, Mass transfer coefficients in laminar flow, Mass transfer coefficients in turbulent flow, Correlations for mass transfer coefficients in simple situations, Material balances in steady state co-current and counter current stage processes

UNIT III **12 L + 3T**

Absorption and Stripping:
Solubilitys of gases in liquids, two component systems, multi-component systems, ideal and non-ideal solutions, choice of solvent for absorption, single component absorption material balances, counter current multistage operations, dilute gas mixtures, non-isothermal operation, tray efficiency, HETP, HTU, NTU concepts for single operation absorption with chemical reaction.

UNIT IV **12 L + 3T**

Distillation:
Principles of VLE for binary systems, phase diagrams, relative volatility, ideal solutions, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, continuous distillation, McCabe-Thiele method, Ponchon-Savarit method, tray efficiencies, introduction to multi-component distillation, azeotropic and extractive distillations.

UNIT V **12 L + 3T**

Equipment for Gas - Liquid Operations:
Sparged vessels (Bubble columns), mechanically agitated vessels for single phase liquids and gas-liquid mixtures, Tray towers, sieve tray design for absorption (Qualitative treatment), venturi scrubbers, wetted wall towers, packed towers, Comparison between Tray towers and packed towers., design of packed humidifiers, dehumidifiers and cooling towers, spray chambers.

TEXT BOOK:

1. Treybal R.E., *Mass transfer operations*, 3rd Edition, McGraw Hill, 1980.

REFERENCES:

1. Cussler E. L., *Diffusion: Mass Transfer in fluid system*, Cambridge University Press, 2009.
2. Binay.K. Dutta, *Principles of Mass Transfer and Seperation Processes*, PHI Learning Pvt. Ltd, 2007.

CHEMICAL REACTION ENGINEERING – I

CHE 315 **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Engineering Mathematics, Physical Chemistry, Chemical Process Calculations.

Course Objectives:

1. To learn principles of reaction engineering
2. To understand various mechanisms of chemical reactions
3. To gain knowledge on different reactors and their design

Course Outcomes:

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

1. Distinguish between elementary and non-elementary reactions, understand the effect of various variables on chemical reactions
2. Analyze batch reactor data by various methods
3. Design various ideal reactors
4. Design various combinations of reactor systems
5. Quantify product distribution for multiple reactions

Mapping of course outcomes with program outcomes :

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	2	3	2	2	2		1			1	2		1	2	1
	2	2	3	2	2	2		1			1	2		1	2	1
	3	2	3	2	2	2		1			1	2		1	2	1
	4	2	3	2	2	2		1			1	2		1	2	1
	5	2	3	2	2	2		1			1	2		1	2	1

SYLLABUS

UNIT I **12 L + 3T**

Introduction:

Introduction and overview of chemical reaction engineering – Variables affecting a chemical reaction – Kinetics of homogeneous reactions – Concentration dependent term of rate equation – Elementary and nonelementary reactions – Temperature dependent term – Arrhenius law, activation energy, collision theory, transition state theory Searching for a mechanism.

UNIT II **12 L + 3T**

Interpretation of Batch Reactor Data:

Methods of analysis, integral, differential and half life methods – Analysis of different types of reactions, irreversible and reversible – Variable volume reactor.

UNIT III **12 L + 3T**

Ideal Reactors:

Ideal reactors for a single reaction – Performance equations for batch, mixed flow and plug flow reactors – Space time, space velocity and mean residence time.

UNIT IV **12 L + 3T**

Design of Multiple Reactors:

Design for single reactions – Size comparison of reactors – Multiple reactor systems – Recycle reactor

UNIT V **12 L + 3T**

Design of Reactors with Multiple Reactions:

Design for parallel and series reactions – Qualitative and quantitative discussion about product distribution.

Text Book:

1. Levenspiel, O., *Chemical Reaction Engineering*, 3rd Edition, John Wiley and Sons.

Reference Books:

1. J. M. Smith., *Chemical Engineering Kinetics*, 3rd edition., Mc-Graw Hill, Inc.
2. H. Scott Fogler., *Elements of Chemical Reaction Engineering*, 5th edition., PHI Learning Private Ltd.

ELECTIVE-I

POLYMER TECHNOLOGY

CHE 316(A) **Credits:4**

Instruction : 4 Lectures & 1 Tutorial/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Organic Chemistry

Course Objectives:

1. To provide basic knowledge on polymers and their classification.
2. To familiarize with chemistry and methods of polymerization.
3. To acquaint knowledge on processing equipment for polymerization.
4. To familiarize with the manufacturing of different polymer compounds.

Course Outcomes:

By the end of the course, the student will be able to

1. Understand the applications of polymers and the role of Chemical Engineer.
2. Identify relations between properties and structure of polymers and their kinetics.
3. Know various methods of preparation and role of ingredients added to the polymers.
4. Understand the principles and working of processing equipment.
5. Understand the manufacturing of different polymer compounds.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	1		1	1		1			1	1		3		1
	2	2			1	1		1			1	1		1	2	1
	3	1	1	3	1	1		1			1	1		2	2	1
	4	1	2	1	1	1		1			1	1		1	3	1
	5	1	2	2	2	1		1			1	1		3	2	1

SYLLABUS

UNIT I **12 L + 3T**

Introductory Concepts and Fundamentals:

Definitions and concepts of plastics and polymers, comer, co-monomer, mesomer, co-polymer, functionality, visco-elasticity, Classification of polymers, methods of determining molecular weights of polymers: Methods based on colligative properties, Sedimentation velocity method, Sedimentation equilibrium method, Gel-chromatography method, Light scattering analysis method, End-group analysis method; Natural polymers: brief study of rubber, shellac, rosin, cellulose, proteins, Lignin.

UNIT II **12 L + 3T**

Chemistry of Polymerization:

Elementary concepts of addition polymerization, condensation polymerization and co-polymerization, glass transition temperature of polymers, methods of determining glass transition temperature, degradation of polymers due to mechanical, hydrolytic, thermal and backbone effects, Relation of the mechanical, thermal, electrical, physical and chemical properties with the structure of the polymer.

UNIT III **12 L + 3T**

Methods of Polymerization:

Mass, solution, emulsion and suspension, role of the initiators, catalysts, inhibitors, solvents, fillers, reinforcing agents, stabilizers, plasticizers, lubricants, blowing agents, coupling agents, flame retardants, photo-degradants and bio-degradable on polymerization

UNIT IV **12 L + 3T**

Processing Equipment:

Mixing, compounding, extrusion, calendaring, laminating, molding, compression, transfer, injection and blow molding.

UNIT V **12 L + 3T**

Manufacturing Processes of Addition Products:

Polyethylene (LDPE and HDPE), polypropylene, PVC and its copolymers, Polystyrene and its copolymers and PTFE (polytetraflouroethylene)

Manufacturing Processes of Condensation Products:

Polyesters: PMMA, PET, PF, UF and MF resins, epoxy resins.

Text Books:

1. R. Sinha, *Outlines of Polymer Technology: Manufacture of Polymers*, 2004, Prentice Hall India Pvt. Ltd. (UNIT – I, II, III and V).
2. R. Sinha, *Outlines of Polymer Technology: Processing Polymers*, 2004, Prentice Hall India Pvt. Ltd. (UNIT – IV).

Reference Books:

1. Billymeyer, F.W.Jr., *Textbook of Polymer Science*, 3rd edition, 2006, John Wiley & Sons
2. Anil Kumar. Gupta, R.K. *Fundamentals of PolymerEngineering*, 2ndEd, 2003, MarcelDekker.

ELECTIVE -I

Fertilizer Technology

CHE316(B) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Engineering Chemistry

Course Objectives:

- To understand the classification of fertilizers and the corresponding manufacturing processes for different fertilizers.

Course Outcomes:

At the end of the course, the student will be able to:

1. Classify the raw materials for fertilizer production and their importance.
2. Know manufacturing processes of nitrogenous fertilizers.
3. Understand the production of N, P, K fertilizers.
4. Gain the knowledge of design of reactors for the manufacturing processes.
5. Know the various methods of storage and handling of fertilizers.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	2		1	1	1					1	1			1	2
	2	2		2	1	1		1			1	2		3	1	1
	3	2		2	1	1		1			1	2		3	1	1
	4	2	3	1	1	1		1			1	1		1	2	2
	5	2			2	1		1			1	1		1	1	1

SYLLABUS

UNIT I **12 L + 3T**

Overview: Development of fertilizer industry, fertiliser production and consumption in India, nutrient contents of fertilizers, secondary nutrients, feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers.

UNIT II **12 L + 3T**

Nitrogenous Fertilizers: Ammonia from natural gas, associated gas, coke oven gas, naphtha, fuel oils and petroleum heavy stock, nitric acid, ammonium sulphate, ammonium nitrate, calcium ammonium nitrate, urea, ammonium chloride.

UNIT III **12 L + 3T**

Phosphatic Fertilizers: Phosphoric acid, single super phosphate, triple superphosphate.

Potassic Fertilizers: Potassium chloride, potassium sulphate.

Complex Fertilizers: Ammonium phosphate sulphate, MAP/ DAP, nitrophosphates, urea-ammonium phosphates.

Miscellaneous Fertilizers: Biofertilizers, liquid fertilizers, controlled release of fertilizers.

UNIT IV **12 L + 3T**

Design Aspects: Ammonia synthesis converters, urea autoclave, pipe reactors, prilling tower, retrofitting, upgrading and modernization of existing plants.

UNIT V **12 L + 3T**

Fertilizer Storage and Handling: Corrosion problems in fertilizer industries, fertilizer plants effluent treatment and disposal, case study of selected fertilizer plants with environmental aspects.

Text Books:

1. *Handbook of Fertilizer Technology*, Fertilizer Association of India, New delhi

Reference books:

1. *Production of Fertilizers (Booklets 1 to 8)*", European Fertilizer Manufacturers Association.
2. *Mineral Fertilizer Production and the Environment (Part 1 & 2)*, International Fertilizer Industry Association.
3. *Pollution Prevention and Abatement Handbook*, The world Bank Group

ELECTIVE -I

PAPER TECHNOLOGY

CHE 316(C) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Engineering Chemistry

Course Objectives:

1. To have an insight on paper industry and its raw materials
2. To acquire knowledge on pulping processes
3. To gain acquaintance with manufacturing and testing techniques of paper.

Course Outcomes:

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

1. Understand the importance of paper industry, types of paper and its uses
2. Know the types of raw materials and their preparation methods
3. Describe the various pulping processes
4. Describe the manufacturing processes of paper
5. Estimate and monitor the properties of paper

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3			1			1			1					1
	2	3		2	1	1		1			1	1		2	1	1
	3	2	1	1	1	1		1			1	2		3	2	1
	4	2	2	2	2	1		1			1	2		3	2	1
	5	2	1	3	2	1		1			1	1		2	1	1

SYLLABUS

UNIT I **12 L + 3T**

History, Types and Uses of Paper:

Importance of paper industry, historical background of paper making, development of paper industry in India, different types and uses of paper and paper products, composition, methods of making different types of paper and boards.

UNIT II **12 L + 3T**

Raw Materials and Their Preparation Methods:

Classification of fibres, characteristics and composition of some important vegetable fibers (hard woods, softwoods, bagasse, straws, rags and paper stock), wood preparation – pulp wood measurement, barking, chipping, screening and conveying of chips.

UNIT III **12 L + 3T**

Pulping Processes and Bleaching:

Mechanical pulping, alkaline pulping (Soda and Kraft), sulfite pulping, semi-chemical pulping, recovery of cooking chemicals from spent cooking liquors, bleaching agents, bleaching methods – single stage and multi stage bleaching

UNIT IV **12 L + 3T**

Manufacture of Paper:

Beating and refining, sizing and loading (filling), paper machines (Fourdrinier and Cylinder), making of paper – forming section, press section, dryer section, calendaring section.

UNIT V **12 L + 3T**

Testing of Paper:

Testing and evaluation of pulp, various properties of pulp and paper and their testing.

Text books:

1. K. P. Rao, *Pulp and paper technology*, 1st edition, 2003, CBS publishers

Reference Books:

1. Monica Ek, Göran Gellerstedt, Gunnar Henriksson, Pulp and paper Chemistry and technology, volume 2, 2009, Walter de Gruyter GmbH & Co.

ELECTIVE -I

PHARMACEUTICAL TECHNOLOGY

CHE 316(D) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Engineering Chemistry, Organic Chemistry

Course Objectives:

1. To know about various forms of drug development
2. To get acquaintance with semi solid and pharmaceutical aerosols
3. To have knowledge on pilot plant techniques

Course Outcomes:

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

1. Formulate and develop tablets and capsules
2. Distinguish the process and equipment for monophasic and biphasic liquids
3. Describe the various production processes of Parenterals and Ophthalmic preparations
4. Differentiate the manufacturing processes and equipments for semi solids and pharmaceutical aerosols.
5. Analyze the pilot plant and scale up techniques

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3		2		1		1			1			1	1	1
	2	2	3	2	1	1		1			1	1		2	1	1
	3	2	3	2	1	1		1			1	1		2	1	1
	4	2	3	2	1	1		1			1	1		2	1	1
	5	2	2	3	2	1		1			1			3	2	1

SYLLABUS

UNIT I **12 L + 3T**

Formulation Development of Solid Dosage Forms:

Historical development of pharmaceutical industry, Advances in materials, process, equipment and production of tablets and hard and soft gelatin capsules.

UNIT II **12 L + 3T**

Formulation Development of Liquid Dosage Forms:

Advances in materials, process, equipment and formulation of monophasic liquid dosage forms and biphasic liquid dosage forms including multiple and micro emulsions.

UNIT III **12 L + 3T**

Formulation Development of Sterile Dosage Forms:

Parenterals: Advances in materials and production techniques, filling machines, sterilizers, and layout for production of parenterals.

Ophthalmic preparations: Advances in materials and production techniques, filling machines and sterilizers for production of eye drops & eye Lotions.

UNIT IV **12 L + 3T**

Formulation Development of Semisolid Dosage Forms and Pharmaceutical Aerosols

Semi-solids: study of the principles, formulation, manufacturing process and equipment for semisolid dosage forms.

Pharmaceutical Aerosols: study of the pharmaceutical propellents, principles, formulation, manufacturing process and filling equipments for Aerosols.

UNIT V **12 L + 3T**

Scale-Up Techniques Used In Pharmaceutical Manufacturing:

Pilot plant: Technology transfer from R&D to pilot plant to pilot scale considerations of steps involved with manufacture (design, facility, equipment selection) of tablets, capsules, suspensions, emulsions & semisolids.

Scale up: Importance, Scale up process-size reduction, mixing, blending, granulation, compression, coating involved in tablets, capsules & liquid-liquid mixing.

Text books

1. Roop K. Khar, S. P. Vyas, Farhan J. Ahmad and Gaurav K. Jain, *Lachman / Lieberman's The Theory and Practice of Industrial Pharmacy*, 4th edition, 2013, CBS.

References

1. Tripathi K.D., *Pharmacological Classification of Drugs With Doses And Preparations*, 5th edition, 2014, Jaypee Brothers Medical publishers.

ELECTIVE -I

SOAP AND DETERGENT TECHNOLOGY

CHE 316(E) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Engineering Chemistry, Organic Chemistry

Course Objectives:

1. To know about soaps and detergents and their properties and applications
2. To have knowledge on manufacturing processes of soaps and detergents.
3. To get acquaintance with the environmental issues of soaps and detergent industry

Course Outcomes:

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

1. Distinguish between soaps and detergents and know their applications
2. Understand the properties and additives to be used in soaps
3. Know the properties and additives to be used in detergents
4. Describe the manufacturing processes and equipments for soaps and detergents
5. Analyze the issues related to environment and improve biodegradable qualities

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3		2	1	1		1			1	2		2	1	1
	2	2	3	2	1	1		1			1	2		2	2	1
	3	2	1	2	1	1		1			1	2		2	2	1
	4	2		1	1	1		3			1	1		1	1	1
	5	2	3	2	1	1		1			1	2		3	2	1

SYLLABUS

UNIT I **12 L + 3T**

Introduction to Soaps and Detergents:

Present status of soap and detergent industries, Soap: Introduction, raw materials, classification and uses of soap, Detergents: Introduction, raw materials, classification and uses of detergent, Glycerin: Recovery of glycerin from fatty acid.

UNIT II **12 L + 3T**

Soap :

Kinetics and phase reactions in soap boiling, physico- chemical properties of soap solutions, plants and processes employed in soap manufacture, recovery of by-products, various households and industrial soaps, soap additives, metallic soaps, miscellaneous application of soap-based products, testing and evaluation of soaps.

UNIT III **12 L + 3T**

Detergents:

Chemistry and technology of synthetic detergents (anionic, cationic, non-ionic, and amphoteric), detergent additives, formulations and processing of detergent powders, tablets, liquid and pastes for household and industrial applications, biosurfactants and enzyme detergents, dry cleaning systems.

UNIT IV **12 L + 3T**

Manufacturing Processes:

Soap manufacturing: Cold process, continuous process, fatty acid neutralization, Detergent manufacturing: spray drying process, agglomeration, dry mixing

UNIT V **12 L + 3T**

Environmental Issues:

Bio-degradation of surfactants, eutrophication and ecological aspects, eco-friendly washing systems, natural saponin based surfactants, modern trends in detergent formulations, testing and evaluation of synthetic surfactants.

Text books

1. Woollatt E, *Manufacture of Soaps, Other Detergents and Glycerine*, 1984, Ellis Horwood Ltd publisher.

Reference Books:

1. Cavitch, Susan Miller, *The Natural Soap Book, 1994*, Storey Publishing

HEAT TRANSFER LABORATORY

CHE 317 **Credits: 2**

Instruction: 3 Practical hours /week Sessional Marks: 50

End Exam: 3 Hours End Exam Marks: 50

Prerequisites: Heat Transfer

Course Objectives:

1. To understand the basic heat transfer principles.
2. To impart knowledge in handling various heat transfer equipments.

Course Outcomes:

At the completion of the course, the student will be able to

1. Understand basic heat transfer principles.
2. Understand the operation of various heat transfer equipments for a set of process conditions.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	3	3	2	1		1			1			3	2	1
	2	3	3	3	2	1		1			1			3	2	1

List of Experiments:

1. Determination of total thermal resistance and thermal conductivity of composite wall.
2. Determination of the thermal conductivity of a metal rod.
3. Determination of the natural convective heat transfer coefficient for a vertical rod.
4. Determination of critical heat flux point for pool boiling of water.
5. Determination of forced convective heat transfer coefficient for air flowing through a pipe.
6. Determination of over-all heat transfer coefficient in double pipe heat exchanger.
7. Study of the temperature distribution along the length of a pin fin under natural and forced convection conditions
8. Estimation of unsteady state film heat transfer coefficient between the medium in which the body is cooled.
9. Determination of Stefan-Boltzmann constant.
10. Determination of emissivity of a given plate at various temperatures.
11. Determination of radiation constant of a given surface.
12. Study of electrical analog of heat conduction

Prescribed Books

1. W. L. McCabe, J. C. Smith and P. Harriot, *Unit Operations of Chemical Engineering*, 7th edition, 2005, McGraw-Hill.
2. Donald Q. Kern, *Process heat transfer*, 2008, Tata McGraw-Hill.

SOFT SKILLS LAB

CHE 318 **Credits : 02**

Instruction: 3 Practical hours /week Sessional Marks: 100

Prerequisites:

Basic English language skills-LSRW, English theory, English Language Lab.

Course Objectives:

1. To inculcate effective communication skills with appropriate body language.
2. To produce potent leaders, productive team players and effective individuals with proper professional ethics.
3. To enable students to make successful oral presentations using relevant content.
4. To train students for group discussions and job interviews which improves their employability skills.
5. To facilitate students the importance of setting realistic goals and achieving them using time management techniques.

Course Outcomes:

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

1 Comprehend the core engineering subjects using effective verbal and nonverbal communication skills.

2 Present accurate and relevant information efficiently, using suitable material aids.

3 Work effectively as an individual as well in teams and emerge as responsible leaders with appropriate professional ethics.

4 Participate in group discussions and interviews using analytical and problem solving abilities, which enhance their employability skills.

5 Set time bound goals and realize them through strategic plans for successful career.

CO – PO – PSO Matrix:

		PO												PSO		
		1	2	3	4	5	6	7	8	9	1O	11	12	1	2	3
CO	1	1								3				1		
	2									3						
	3			2				2	2	3						1
	4									3						
	5										3	2				1

SYLLABUS

UNIT I **9 Lectures**

Art of Communication:

1. Definition of Communication
2. Types of Communication
3. Non-verbal Communication
4. Listening skills
5. Feed back

D.A. - Practice of proper hand shake, practice of different postures and gestures and activity on giving feedback

UNIT II **6 Lectures**

Presentation Skills:

1. Purpose
2. Effective presentation strategies
3. Analysis of audience
4. Preparing an outline of the presentation,
5. Audio –visual aids
6. Body language**.**

D.A. -Group presentation by each team

UNIT III **9 Lectures**

Group Discussions:

Introduction- as a part of selection process-guidelines for GD

1. Types of GD
2. Nature of topics of G.D
3. Roles to be played by participants in a GD
4. Evaluation process

D.A–Group discussions

UNIT IV **6 Lectures**

Team Building and Leadership:

1. Importance of team work
2. Different stages of team formation
3. Good team vs. effective team
4. Team player and Team leader
5. Types of leadership
6. Decision making and negotiating skills

D.A-Decision making for a given situation

UNIT V **3 Lectures**

Time- Management:

1. Importance of time-management
2. Time-Management models
3. Prioritization
4. The art of saying 'No'
5. Identifying Time Wasters

D.A -Time- Bound activities devised by the facilitator

UNIT VI

Goal-Setting: **3 Lectures**

1. Different type of Goals (Immediate and Short term)
2. 'SMART' Goals
3. Strategies to achieve goals

D.A - Prepare a chart of immediate, short term and long term goals

UNIT VI:

Job- Interviews **9 Lectures**

1. Preparing Resumes and C.V's
2. Preparing for the interview
3. FAQ's (Integrity, Stress management, Close- Ask questions)

D.A –Mock interviews

REFERENCE BOOKS:

1. Sanjay Kumar and Pushpalata, *Communication Skills* ,Oxford University Press , 2011.
2. Allan Pease, *Body Language***,** Sheldon Press,1997.
3. John A. Kline and BhavnaBhalla, *Speaking Effectively; Achieving Excellence in Presentations*, Pearson publication, 2013.
4. Marc Mancini, *Time Management*, Tata McGraw Hill publishing Comp.Ltd.,2003.
5. Peter Veruki, *The 250 Job Interview Questions***,** Adams Media Corporation Avon, Massachusetts,1999.

MASS TRANSFER-II

CHE 321 **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Mass Transfer-I

Course Objectives:

1. To understand liquid-liquid operations
2. To understand the solid-liquid, solid-gas operations
3. To understand the membrane separation processes

Course Outcomes:

By the end of the course, the student will be able to

1. Plot Ternary liquid equilibrium, select suitable solvent, design different types of extractors
2. Solve single stage and multiple stage leaching and know about the applications of different types of leaching equipment
3. Plot adsorption isotherms, know the applications of various adsorbents and different types of adsorption equipment
4. Calculate total time for drying and understand different types of drying equipment
5. Understand the crystal growth , different types of crystallization equipment and membrane separation processes

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	3	3	2	2		1			1	2		3	2	1
	2	3	3	3	2	2		1			1	2		3	2	1
	3	3	3	3	2	2		1			1	2		3	2	1
	4	3	3	3	2	2		1			1	2		3	2	1
	5	3	3	3	2	2		1			1	2		3	2	1

SYLLABUS

UNIT I **12 L + 3T**

Liquid-Liquid Extraction: Fields of applications of ternary liquid systems, triangular and solvent free coordinate systems, choice of solvent selectivity, extraction with insoluble and partially soluble systems, single stage and multistage cross current and counter current extraction without reflux, multistage counter current extraction with reflux, continuous contact extraction (packed beds), equipment for liquid-liquid extraction operation.

UNIT II **12 L+ 3 T**

Leaching: Fields of applications, preparation of solid for leaching, types of leaching, leaching equilibrium, single stage and multi stage leaching calculations, constant under flow conditions, Unsteady state operation equipment – percolation tanks, shank system, filter press leaching, agitated vessels, steady state operation equipment- agitated vessels, thickeners, CCD, classifiers, leaching of vegetable seeds.

UNIT III **12 L+ 3 T**

Adsorption: Theories of adsorption, recovery of solvent vapors, industrial adsorbents, adsorption equilibria and isotherms. single and multi- stage operations, unsteady state adsorption, and equipment for stage-wise and continuous contact.

UNIT IV **12 L + 3T**

Drying: Moisture contents of solids, equilibrium moisture content, bound and unbound moisture, drying conditions – rate of batch drying under constant drying conditions, mechanism of batch drying, drying time, thorough circulation drying, batch and continuous drying equipment, design of continuous counter current dryer.

UNIT V **12 L+ 3 T**

Crystallization and Membrane Separation Processes:

Crystallization: Equipment and analytical methods, factors governing nucleation and crystal growth rates, controlled rate of crystals, incorporation of principles into the design of the equipment

Membrane separation processes: Principles of membrane separations, separation of gases and liquids, dialysis, membranes for liquid extraction, pervaporation, reverse osmosis.

Case Studies for all mass transfer operations with interdisciplinary approach (for internal assessment only)

TEXT BOOK:

1. Treybal R.E., *Mass transfer operations*, 3rd Edition, McGraw Hill, 1980.

REFERENCES:

1. Cussler E. L., *Diffusion: Mass Transfer in fluid system*, Cambridge University Press, 2009.
2. Binay.K. Dutta, *Principles of Mass Transfer and Seperation Processes*, PHI Learning Pvt. Ltd, 2007.

CHEMICAL REACTION ENGINEERING - II

CHE 322 **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Chemical Reaction Engineering-I

Course Objectives:

1. To have an overview of temperature and pressure effects on chemical reactions
2. To analyse different non-ideal reactors
3. To interpret and design solid catalysed and fluid-fluid reactors

Course Outcomes:

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

1. Understand the temperature and pressure effects of chemical reactions
2. Distinguish between ideal and non-ideal reactors
3. Characterize the catalyst by knowing their properties
4. Design solid-catalyst reactors
5. Formulate the mechanisms for solid-fluid and fluid-fluid reactions

CO – PO – PSO Matrix:

		PO												**PSO**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	3	3	2	1		1			1	2		2	2	1
	2	2	2	2	1	1		1			1	2		1	2	1
	3	2	2	2	1	1		1			1	2		1	2	1
	4	2	3	2	1	1		1			1	2		1	3	1
	5	2	3	2	1	1		1			1	2		1	3	1

SYLLABUS

UNIT I **12 L+ 3 T**

Temperature and Pressure Effects:

Heats of reaction and temperature – Equilibrium constants from thermodynamics – Equilibrium conversion – General graphical design procedure – Optimum temperature progression – Adiabatic operations.

UNIT II **12 L+ 3 T**

Non Ideal Flow:

Basics of non-ideal flow: C,E and F curves – Conversion in non ideal flow reactors – Dispersion model – Tanks-in-series model.

UNIT III **12 L+ 3 T**

Heterogeneous Catalysis:

Physical adsorption – Chemisorption – Catalyst properties – Estimation of surface area, pore volume and porosity – Catalyst preparation – Catalyst poisons – Catalytic deactivation.

UNIT IV **12 L+ 3 T**

Solid Catalysed Reactions:

Rate equations – Pore diffusion combined with surface kinetics – Thiele modulus – Effectiveness factor – Performance equations for reactions containing porous catalyst particles – Experimental methods for finding rates – Determining controlling resistances.

UNIT V **12 L+ 3 T**

Non-Catalytic Systems:

Design of fluid-fluid reactors – Factors to consider in selecting a contractor – Various contractors and contacting patterns for G/L reactions. Design of fluid particle reactions – Progressive Conversion Model (PCM), Shrinking Core Model (SCM) – Comparison – Controlling mechanisms – Determination of rate controlling step.

Text Book:

1. Levenspiel O. *Chemical Reaction Engineering*, 3rd Edition, John Wiley & Sons.

Reference books:

1. J. M. Smith., *Chemical Engineering Kinetics*, 3rd edition., Mc-Graw Hill, Inc.
2. H. Scott Fogler., *Elements of Chemical Reaction Engineering*, 5th edition., PHI Learning Private Ltd.

MATERIAL SCIENCE AND ENGINEERING

CHE 323 **Credits:4**

Instruction : 4 Lectures & 1 Tutorial/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Engineering Physics, Engineering Chemistry, Mechanical Engineering and Strength of Materials

Course Objectives:

1. To provide an understanding on various crystal structures and their determination
2. To impart knowledge on various imperfections in crystals and their importance.
3. To furnish ability on mechanical properties of materials and failure mechanisms
4. To cater enlightenment on composite materials in present day scenario
5. To acquire knowledge on phase diagrams for alloy systems

Course Outcomes:

By the end of the course, the student will be able to

1. Identify and depict the crystal structure and their properties based on the structure.
2. Quantify the imperfections in a crystal.
3. Analyse the mechanical properties of engineering materials, draw the stress – strain diagrams and determine the failure mechanisms.
4. Classify composite materials and their importance in engineering design.
5. Make out heat treatment process to obtain required mechanical properties for a given alloy.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	1	1	1	1		1			1	1		1	1	1
	2	3	1	1	1	1		1			1	1		1	1	2
	3	3	1	2	2	2		1			1	1		1	1	2
	4	3	1	2	2	2		1			1	1		1	1	2
	5	3	1	2	1	1		1			1	1		1	1	2

SYLLABUS

UNIT I **12 L + 3T**

Atomic Structure and Inter Atomic Bonding:

Electrons in atoms:Rutherford model, Bohr atomic model, wave mechanical model; bonding forces and energies, primary interatomic bonds: ionic bonding, covalent bonding, metallic bonding; secondary bonding: Van der Waals bonding, Hydrogen bonding.

Structure of Crystalline Solids:

Unit cells, metallic crystal structures, density computations, crystal systems, crystallographic points, directions and planes, X-ray diffraction and Bragg’s law.

UNIT II **12 L + 3T**

Point Imperfections:

Vacancy, Interstitial, Frenkel and Schotkey defects, Line imperfections: Burgers circuit and Burgers vector, dislocation reaction, edge, screw and mixed dislocations; surface defects: grains grain boundary and stacking faults; Volume defects: introduction to precipitates, dispersants, inclusions and voids.

UNIT III **12 L+ 3 T**

Mechanical Properties of Materials:

Concepts of stress and strain, elastic compliances, stress-strain diagrams for ductile and brittle materials, elastic behaviour, plastic deformation, hardness: Rockwell hardness test, Brinell hardness test , Knoop and Vickers hardness test; critical resolved shear stress (CRSS), cold working and hot working, anelasticity, viscoelasticity, viscoelastic models.

UNIT IV **12 L + 3T**

Fracture Mechanism:

Ductile fracture, brittle fracture, creep mechanism and fatigue mechanism.

Composite Materials:

Classification and applications: particulate reinforced composites, fiber reinforced composites and structural composites.

UNIT V **12 L + 3T**

Phase Diagrams and Transformations:

Phase rule, unary, binary phase diagrams, thermal equilibrium diagrams, eutectic and eutectic phase diagrams, peritectic and peritectic phase diagrams, Cd-Bi, Pb-Sn, Cu-Ni, Ag-Cu, Fe-C or Fe-Fe_3C-phase transformations, time temperature, transformation curves for eutectoid steels, plain carbon steels, effect of addition of alloying elements on the properties of steels, types of steels used in chemical industries.

Text Book

1. William D. Callister Jr., *Material Science and Engineering*,7th ed., 2007, John Wiley & Sons.

Reference Books

1. V. Raghavan, *Materials Science & Engineering*, 5th edition, 2015, Prentice Hall of India Ltd, New Delhi

2. ManasChanda, *Science of Engineering Materials*, Vols.1-3, McMillan Companyof India, Delhi.

CHEMICAL TECHNOLOGY

CHE 324 **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Engineering chemistry, Organic chemistry.

Course Objectives:

1. To know about the inorganic chemical manufacturing processes of sulphur, nitrogen phosphorus, chloro alkali and cement industries.
2. To understand organic chemical manufacturing processes of coal, petroleum, vegetable oils, soaps, paints, pulp, cane sugar and polymerization industries.

Course Outcomes:

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

1. Understand the manufacturing of products of sulphur and nitrogen industries.
2. Describe the manufacturing of products of phosphoric acid, chloro-alkali and cement industries.
3. Understand the manufacture of coal, coal chemicals and petroleum products.
4. Know the extraction of vegetable oils and manufacture of paints and varnishes.
5. Describe the manufacture of pulp and cane sugar and polymerization products

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	2		1	1	1		1			1	2		3	1	1
	2	2		1	1	1		1			1	2		3	1	1
	3	2		1	1	1		1			1	2		3	1	1
	4	2		1	1	1		1			1	2		3	1	1
	5	2		1	1	1		1			1	2		3	1	1

SYLLABUS

UNIT I **12 L+ 3 T**

Sulphur and Sulphuric Acid: Sources of sulphur-sulphuric acid, different processes of manufacturing-contact process, DCDA process for sulphuric acid manufacture.

Nitrogen industries: Manufacture of ammonia, nitric acid and urea.

UNIT II **12 L+ 3 T**

Phosphorous and Phosphoric Acid: Methods for production of phosphoric acid.

Chloro-Alkali Industries: - Manufacture of soda ash, caustic soda and chlorine.

Cement: Types of cement, manufacture of ordinary portland cement [OPC], slag cement.

UNIT III **12 L+ 3 T**

Coal And Coal Chemicals: Types of coal, different uses, distillation of coal, treatment of products, low and high temperature carbonization of coal, coal tar distillation.

Petroleum: Origin, classification, composition of crude oil, production of crude oil, distillation of crude petroleum, refining-methods, uses of products.

UNIT IV **12 L+ 3 T**

Vegetable Oils: Extraction, purification, hydrogenation of oils. Manufacture of fatty acids and soaps, detergents- classification and manufacture.

Paints and Varnishes: Constituents of paints, manufacturing procedures, varnishes.

UNIT V **12 L+ 3 T**

Pulp and Paper: Kraft process and sulphite process, production of paper,

Cane Sugar: Refining, manufacture of sucrose, production of ethanol by fermentation. Manufacture of penicillin.

Polymerisation: Different methods, manufacture of polyethylene, phenol formaldehyde, SBR, 6-nylon, 6,6-nylon,.

Text book:

1. Gopala Rao, M. and Marshall Sitting, *Dryden's out lines of chemical Technology*, 3rd edition, East West Press Pvt.Ltd.

Reference books:

1. Austin,G.T, Shreve's, *Chemical Process Industries*, 5th edition, Mcgraw Hill Publishers
2. Kirk R .E. and Othmer D. F., *Encyclopedia of Chemical Technology, 4th edition*, Inter Science.

ELECTIVE-II
PETROCHEMICALS

CHE 325(A) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites: Organic Chemistry

Course Objectives:

1. To make a thorough understanding of the availability of petroleum feed stocks for petrochemicals.
2. To understand the methods to produce various petrochemicals from C_2, C_3, C_4 and higher carbon atoms.
3. To methodolically furnish the conversion of petroleum feedstocks to chemicals and intermediates.

Course Outcomes:

By the end of the course, the student will be able to

1. Know about petrochemical industry feedstocks, various chemicals produced from methane.
2. Understand the production of different chemicals from C_2 carbon atoms
3. Understand the production of different chemicals from C_3, C_4 and higher carbon atoms and production of various polymers.
4. Know the production of petroleum aromatics
5. Describe the production of different intermediate chemicals, synthetic fibres, rubber and synthetic detergents.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	2		1	1	1		1			1	1		1	1	1
	2	2		1	1	1		1			1	2		3	1	1
	3	2		1	1	1		1			1	2		3	1	1
	4	2		1	1	1		1			1	2		3	1	1
	5	2		1	1	1		1			1	2		3	1	1

SYLLABUS

UNIT I **12 L+ 3 T**

Petrochemical Industry-Feed Stocks: Petrochemical industry in India, feed stocks for petrochemicals. Chemicals from methane: Introduction, production of methanol, formaldehyde, ethylene glycol, PTFE, methylamines.

UNIT II **12 L+ 3 T**

Chemicals From C2 Carbon Atoms: ethylene production, vinyl chloride monomer, vinyl acetate monomer, ethylene oxide, ethylene glycol, acetylene, acetaldehyde from Acetylene.

UNIT III **12 L + 3T**

Chemicals From C3,C4 and Higher Carbon Atoms: Iso propylalcohol, acrylonitrile, acrylic acid, phenol, bisphenol-A, iso and n-butanol, methyltertbutylether, methacrylic acid, malic anhydride.

Polymers of Olefins: Polymer structure, methods of polymerization, high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene, polyvinylchloride, polystyrene.

UNIT IV **12 L + 3T**

Petroleum Aromatics: Aniline, styrene, benzoic acid, caprolactum, terephthalic acid, phthalic anhydride.

UNIT V **12 L+ 3 T**

Synthetic Fibres and Rubber: Production techniques of synthetic fibres, production of polyester, nylon-6,6, nylon- 6, acrylic fibers. Synthetic rubber: Styrene butadiene rubber (SBR), butyl rubber, synthesis of polyurethane.

Plastics: Phenol formaldehyde resins, urea formaldehyde resins, polycarbonates.

Synthetic detergents: Classification of detergents, general manufacture of sulphonates, keryl benzene sulphonate (Surf).

TEXT BOOK:

1. B.K.BhaskaraRao, *A Text book on Petrochemicals*, 3rd Edition, Khanna Publishers, New Delhi.

REFERENCE BOOKS:

1. A.Chanvel and G. Lefebvre, *Petrochemical processes*, Vol.2, 2nd Edition, Gulf publishing company.
2. George T. Austin, *Shreve's chemical process industries*, 5th edition, McGraw Hill Publishers.
3. Gopala Rao, M. and Marshall Sitting, *Dryden's out lines of chemical Technology*, 3rd edition, East West Press Pvt.Ltd.

ELECTIVE-II

COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING

CHE 325(B) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites: Engineering Mathematics, Chemical Process Calculations

Course Objectives:

1. To provide knowledge of matrix and numerical mathematics for direct numerical analysis.
2. To provide knowledge of numerical integration and differential equations for iterative numerical analysis.
3. To introduce the concept of computer simulation for engineering process.
4. To provide the basic procedure to simulate elementary chemical engineering equipment.
5. To impart the knowledge of performing optimization and sensitivity analysis of elementary chemical engineering equipment.

Course Outcomes:

By the end of this course students will be able to

1. Perform basic matrix operations and apply direct numerical methods.
2. Perform basic iterative numerical analysis.
3. Understand the need for computer simulation in chemical engineering and its applications.
4. Simulate elementary chemical engineering equipment using ASPEN Plus.
5. Analyze equipment for sensitivity and optimization using ASPEN Plus.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	2	2		2	1	3	1			1	1		1	3	1
	2	2	2		2	1	3	1			1	1		1	3	1
	3	2	2		2	1	3	1			1	1		1	3	1
	4	2	2		2	1	3	1			1	1		1	3	1
	5	2	2		2	1	3	1			1	1		1	3	1

SYLLABUS

UNIT I **12 L+ 3 T**

Matrix Algebra And Numerical Methods:

Introduction to basic matrix and special matrix – triangular, symmetrical and diagonal, elementary operations for matrix, Gaussian elimination method, Jacobi method .

UNIT II **12 L + 3T**

Numerical Integration and Differentiation:

Basics of numerical differentiation and integration, Newton-Raphson method, Trapezoidal rule, Simpson's 1/3rd and 1/8th rules, Runga-Kutta method, Taylor series, Euler's method.

UNIT III ` **12 L + 3T**

Introduction to Computer Simulation:

Mathematical modelling, types of modular approaches, process flow diagrams, information flow diagrams, process flow sheets, conversion of information diagrams into process flow sheets, information matrices – process, stream connection, incidence and adjacency, simulation software for chemical engineering processes.

UNIT IV **12 L+ 3 T**

Simulation of Basic Equipment Using ASPEN Plus:

Steady state simulation of pumps, simulation of flash columns and heat exchangers, simulation binary distillation columns, simulation of reactors.

UNIT V ` **12 L+ 3 T**

Steady State Optimization and Sensitivity Analysis Using ASPEN Plus:

Steady state optimization of pumps, flash columns and heat exchangers, steady state sensitivity analysis of pumps, flash columns and heat exchangers.

TEXT BOOKS:

2. Gupta S.K., *Numerical Methods for Engineers*, 2003, New age international.
3. Jana A.K., *Process Simulation and Control using ASPEN*, 2nd edition, 2012, Prentice-Hall.

REFERENCE BOOKS:

4. Steven C Chapra. Raymond P. Canale, *Numerical Methods for Engineers with Personal Computer Applications*, 2nd edition, 1990, Mc-Graw Hill.
5. Roger G. E. Franks *Modeling and Simulation in Chemical Engineering*, 1972, John Wiley and Sons.

WEB RESOURCES:

1. http://nptel.ac.in/courses/103106074/
2. https://ocw.mit.edu/courses/materials-sciences-and-engineering/3-021j-introduction-to-modeling-and-simulation-spring-2012/part-i-lectures-readings/

ELECTIVE-II

MEMBRANE TECHNOLOGY

CHE 325(C) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Introduction to Chemical Engineering

Course Objectives:

- To acquaint with the new technologies and modelling approach of membrane technology and their application in real practical problems.

Course Outcomes:

By the end of the course, the student will be able to

1. Understand the principles and properties of membrane materials.
2. Know the techniques of preparation of synthetic membranes.
3. Understand the transport phenomena in membranes.
4. Comprehend the mechanisms for membrane processes.
5. Gain the knowledge of various membrane configurations and about membrane fouling.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	1	2	1	2		1			1	1			1	1
	2	1	1	3	1	2		1			1	1		2	1	1
	3	2	3	1	2	2		1			1	1		2	2	1
	4	2	2	1	1	2		1			1	1		2	2	1
	5	2	1	2	1	2		1			1	1		2	1	1

SYLLABUS

UNIT I **12 L+ 3 T**

Introduction: Definition of membrane, membrane types, membrane separation processes, advantages and limitations of membrane technology compared to other separation processes, membrane materials and properties.

UNIT II **12 L+ 3 T**

Preparation of Synthetic Membranes: Phase inversion membranes, preparation techniques for immersion precipitation, synthesis of asymmetric and composite membranes, influence of various parameters on membrane morphology and synthesis of inorganic membranes.

UNIT III **12 L+ 3 T**

Transport In Membranes: Introduction, driving forces, transport through porous membranes, transport through non-porous membranes, transport through ion-exchange membranes.

UNIT IV **12 L+ 3 T**

Membrane Processes: Pressure driven membrane processes, concentration as driving force, electrically driven membrane processes.

UNIT V **12 L+ 3 T**

Modules, Polarisation Phenomena and Fouling: Introduction, membrane modules, comparison of the module configuration**,** concentration polarization, membrane fouling.

Text Books:

1. Mulder M, *Basic Principles of Membrane Technology*, Kluwer Academic Publishers, London, 1996.
2. Kaushik Nath, *Membrane Separation Processes*, Prentice-Hall Publications, New Delhi, 2008.

Reference books:

1. Munir Cheryan, *Ultrafiltration and Microfiltration*, 2nd edition, Technomic Publishing Co(1998).
2. J.D.Seader and Ernest J. Henley , *Separation process principles*, 2nd edition, Wiley India
3. R. E. Kesting, *Synthetic Polymeric membranes*, , 2nd edition, McGraw Hill (1985)
4. Richard W. Baker, *Membrane Technology and Research*, Inc. (MTR), Newark, California, USA, 2004.

ELECTIVE-II

CATALYSIS

CHE 325 (D) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Fundamentals of Chemical Reaction Engineering

Course Objectives:

1. To understand the fundamentals of catalysts
2. To have a knowledge of various catalytic reactors
3. To have an awareness of biocatalysts and bioreactors

Course Outcomes:

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

1. Know different types of catalysts and determination of their characteristic properties
2. Understand the mechanism and determine the rate limiting step
3. Design various industrial catalytic reactors
4. Acquire knowledge on catalyst deactivation and methods of regeneration
5. Correlate catalysis to biosystems

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	1	2	1	1		1			1	2			2	1
	2	2	3	3	2	2		1			2	2		2	2	1
	3	2	3	1	2	1		1			1	2		3	2	1
	4	2		2	1	1		1			1	2		1	2	1
	5	1	1	1	1	3		1			1	1		1	2	3

SYLLABUS

UNIT I **12 L+ 3 T**

Introduction to Catalysis:

Catalyst properties, homogeneous and heterogeneous catalysts, catalyst preparation, estimation of catalyst properties, determination of surface area, porosity, pore volume, solid density, different types of adsorption isotherms.

UNIT II **12 L+ 3 T**

Catalyst Mechanisms:

Steps in a catalytic reactions, synthesizing rate law, mechanism, rate limiting step

UNIT III **12 L+ 3 T**

Design Of Catalytic Reactors:

Design equations, heterogeneous data analysis: deducing, finding mechanism and evaluation of rate law parameters, chemical vapour deposition.

UNIT IV **12 L+ 3 T**

Catalyst Deactivation:

Types of catalyst deactivation, catalyst poisons, catalyst inhibitors, temperature time trajectories, moving bed reactors, determining the order of deactivation, catalyst regeneration

UNIT V **12 L+ 3 T**

Biocatalysis:

Enzymes, mechanism of enzyme-substrate reactions, immobilized enzyme kinetics, production and applications of various biocatalysts

Text books:

1. J. M. Smith., *Chemical Engineering Kinetics*, 3rd edition., Mc-Graw Hill, Inc. (**Unit-I**)
2. H. Scott Fogler., *Elements of Chemical Reaction Engineering*, 5th edition., PHI Learning Private Ltd (**Unit-II, III & IV**)
3. Michael L. Shuler ., Fikret Kargi, *Bioprocess Engineering*, 2nd edition., PHI Learning Private Ltd (**Unit -V**)

Reference books:

1. Martin Schmal., *Chemical reaction Engineering*, 2014., CRC Press
2. G. Bond., *Heterogeneous catalysis*., 2nd edition., Oxford University Press

ELECTIVE-II

INDUSTRIAL POLLUTION AND CONTROL

CHE 325(E) **Credits:4**

Instruction : 4 Lectures & 1 Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Prerequisites:

Introduction to Chemical Engineering

Course Objectives:

- To understand the concept, analysis and control of pollution and its effect on man and environment in real scenario.

Course Outcomes:

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

1. Understand the various types of pollution and their effects on man as well as on environment.
2. Analyze the sources and meteorological aspects of air pollution.
3. Comprehend the sampling and control methods of air pollution.
4. Understand the sampling and control methods of water pollution.
5. Gain the knowledge of management of solid and hazardous wastes.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	1			1	1		1			1			1	1	1
	2	2			1	2		2			1			1	1	1
	3	2			2	3		2			1			1	1	1
	4	2			2	3		2			1			1	1	1
	5	2			2	3		2			1			1	1	1

SYLLABUS

UNIT I **12 L+ 3 T**

Introduction: Biosphere, hydrological cycle, nutrient cycle, consequences of population growth, pollution of air, water and soil.

UNIT II **12 L+ 3 T**

Air Pollution: Air pollution sources and its effects-classification and properties of air pollutants, emission sources, behaviour and effect of air pollution.

Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, wind velocity and turbulence, plume behaviour, dispersion of air pollutants, estimation of plume rise.

UNIT III **12 L+ 3 T**

Air Pollution Sampling, Measurement and Control: Types of pollutant sampling and measurement, ambient air sampling, stack sampling, analysis of air pollutants.

Air pollution control methods and equipment: Control methods, source correction methods, cleaning of gaseous effluents, particulate emission control, selection of a particulate collector, control of gaseous emissions, design methods for control equipment.

UNIT IV **12 L+ 3 T**

Water Pollution: Water resources, origin of wastewater, types of water pollutants and there effects.

Waste Water Sampling, Analysis and Treatment: Sampling, methods of analysis, determination of organic matter, determination of inorganic substances, physical characteristics, bacteriological measurement, basic processes of water treatment, primary treatment, secondary treatment, advanced wastewater treatment, recovery of materials from process effluents.

UNIT V **12 L+ 3 T**

Solid Waste Management: Sources and classification, public health aspects, methods of collection, disposal methods, potential methods of disposal.

Hazardous Waste Management: Definition and sources, hazardous waste classification, treatment methods, disposal methods.

Text Books:

1. Rao C.S., *Environmental Pollution Control Engineering*, Wiley Eastern Limited, India, 1993.
2. Mahajan. S.P., *Pollution Control in Process Industries*, Tata-McGraw Hill, New Delhi, 1985.

Reference books:

1. Glynn Henry J. and Gary W. Heinke, *Environmental Science and Engineering*, 2nd Edition, Prentice Hall of India, 2004.
2. Rao M.N. and Rao H.V.N, *Air Pollution*, Tata – McGraw Hill Publishing Ltd., 1993.
3. De A.K, *Environmental Chemistry*, Tata – McGraw Hill Publishing Ltd., 1999.
4. Noel de Nevers,*Air Pollution and Control Engineering*, McGraw Hill, 2000.

MASS TRANSFER LABORATORY

CHE 326 **Credits: 2**

Instruction: 3 Practical hours/week Sessional Marks: 50

End Exam: 3 Hours End Exam Marks: 50

Prerequisites: Mass Transfer Operations

Course Objectives:

1. To implement the knowledge acquired in mass transfer theory in the laboratory
2. To get acquainted with various mass transfer equipment

Course Outcomes:

By the end of the course, the student will be able to,

1. Understand the basic principles of diffusion, distillation, leaching, adsorption, extraction, drying and equilibrium conditions
2. Use different types of mass transfer equipment to achieve hands on experience.

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	1	3	2	2		1			1			3	3	2
	2	3	1	3	2	2		1			1			3	3	2

List of Experiments:

1. Liquid Diffusion Coefficient
2. Vapor Diffusion Coefficient
3. Vapor Liquid Equilibria
4. Steam Distillation
5. Differential Distillation
6. Height Equivalent to Theoretical Plate (HETP)
7. Height of Transfer Unit (HTU)
8. Surface Evaporation
9. Liquid-Liquid Extraction in Packed Tower
10. Gas-Liquid Absorption Column
11. Tray Drier
12. Wetted wall column
13. Adsorption isotherms

Prescribed Books:

1. W. L. McCabe, J. C. Smith and P. Harriot, *Unit Operations of Chemical Engineering*, 7th edition, 2005, McGraw-Hill.
2. Robert E. Treybal, *Mass transfer Operations*, 3rd edition, McGraw-Hill.

CHEMICAL REACTION ENGINEERING LABORATORY

CHE 327 **Credits: 2**

Instruction: 3 Practical hours/week Sessional Marks: 50

End Exam: 3 hrs End Exams Marks: 50

Prerequisites: Chemical Reaction Engineering

Course Objectives:

1. To impart knowledge on the determination of the kinetics of a chemical reaction
2. To enable the students to understand the principles involved in designing of chemical reactors

Course Outcomes:

By the end of the course, the student will be able to

1. Determine the kinetics of a chemical reaction in various reactors
2. To acquire hands on experience on the operation of various ideal and non-ideal reactors

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3	1	3	2	2		1			1			3	3	2
	2	3	1	3	2	2		1			1			3	3	2

List of Experiments:

1. Determination of the order of a reaction and rate constant using a batch reactor by analyzing the data by different methods.
2. Determination of the activation energy of a reaction using a batch reactor.
3. To determine the effect of residence time on conversion and estimate the rate constant using a CSTR.
4. To determine the effect of residence time on conversion and estimate the rate constant using a PFR
5. Determination of RTD and Dispersion number in a Tubular reactor using a tracer.
6. Mass transfer with chemical reaction (solid-liquid system) - Determination of Mass Transfer Co-efficient.
7. Determination of RTD and the dispersion number for a packed-bed using a tracer
8. Langmuir Adsorption Isotherm: Determination of surface area of activated charcoal.
9. Performance of a PFR followed by a CSTR
10. Performance of a CSTR followed by a PFR.
11. Performance of two CSTRs in series.
12. Determination of M-M kinetics for an enzyme catalyzed reaction.

Prescribed Books:

1. Octave Levenspiel, *Chemical Reaction Engineering*, 3rd edition, 1999, John Wiley
2. J. M. Smith., *Chemical Engineering Kinetics*, 3rd edition., McGraw-Hill, Inc.
3. H. Scott Fogler., *Elements of Chemical Reaction Engineering*, 5th edition, PHI Learning Private Ltd.

CHEMICAL TECHNOLOGY LABORATORY

CHE 328 **Credits: 2**

Instruction: 3 Practical hours/week Sessional Marks: 50

End Exam: 3 hrs End Exams Marks: 50

Prerequisites: Chemical Technology, Engineering Chemistry

Course Objectives:

1. To impart the knowledge on analyzing water and other compounds
2. To familiarize with the production of different industrial products on laboratory scale

Course Outcomes:

By the end of the course, the student will be able to

1. Analyze water and other compounds
2. Prepare different industrial products on laboratory scale

CO – PO – PSO Matrix:

		PO												PSO		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO	**1**	3		3	3	2		1			1			2	3	2
	2	3		3	3	2		1			1			2	3	2

List of Experiments:

1. Total solids, dissolved solids, pH
2. Chlorides and sulphates
3. Temporary, permanent and total hardness.
4. Analysis of oils: Acid value, Iodine value, Saponification value
5. Analysis of coal: Proximate analysis
6. Analysis of lime: Estimation of acid insolubles, available lime and calcium carbonate
7. Analysis of bleaching powder: Estimation of chlorine content.
8. Analysis of starch/glucose: Estimation of total reducing sugars
9. Analysis of saw dust: Estimation of total cellulose
10. Preparation of soap
11. Preparation of copper pigment
12. Preparation of chrome yellow pigment
13. Preparation of phenol formaldehyde resin
14. Estimation of COD

Prescribed books:

1. Sunitha Rattan, *Experiments in Applied Chemistry"* 2nd edition, 2004, S. K. Kattaria & Sons .
2. Gopala Rao, M. and Marshall Sitting, *Dryden's out lines of Chemical Technology*, 3rd edition, East West Press Pvt. Ltd.
3. Kirk R .E. and Othmer D. F., *Encyclopedia of Chemical Technology, 4th edition,* Inter Science.