ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES

(UGC AUTONOMOUS)
(Affiliated to AU, Approved by AICTE& Accredited by NBA & NAAC)
Sangivalasa 531 162, BheemunipatnamMandal, Visakhapatnam Dist

DEPARTMENT OF CHEMICAL ENGINEERING

R-20 regulations w.e.f. 2020-21 admitted batch

	I Year – I Semester									
Code	**Title of the Course**	**Category**	**L**	**T**	**P**	**Total**	**Max. Marks**		**Total Marks**	**Credits**
							Sess.	**End Exam.**		
CHE111	Engineering Mathematics – I	BS	3	0	0	3	40	60	100	3
CHE112	Engineering Physics	BS	3	0	0	3	40	60	100	3
CHE113	Engineering Chemistry	BS	3	0	0	3	40	60	100	3
CHE114	Introduction to Chemical Engineering	PC	3	0	0	3	40	60	100	3
CHE115	Engineering Drawing	ES	2	0	3	5	40	60	100	3.5
CHE116	Engineering Physics Lab	BS	0	0	3	3	50	50	100	1.5
CHE117	Engineering Chemistry Lab	BS	0	0	3	3	50	50	100	1.5
CHE118	Engineering Workshop	ES	0	0	3	3	50	50	100	1.5
CHE119	Human Values and Professional Ethics (Mandatory non-credit course)	MC	3	0	0	3	50	0	50	0
	Total		**17**	**0**	**12**	**29**	**400**	**450**	**850**	**20**

	I Year – II Semester									
Code	**Title of the Course**	**Category**	**L**	**T**	**P**	**Total**	**Max. Marks**		**Total Marks**	**Credits**
							Sess.	**End Exam.**		
CHE121	Engineering Mathematics – II	BS	3	0	0	3	40	60	100	3
CHE122	Communicative English	HS	3	0	0	3	40	60	100	3
CHE123	Basic Mechanical Engineering	ES	3	0	0	3	40	60	100	3
CHE124	Basic Electrical and Electronics Engineering	ES	3	0	0	3	40	60	100	3
CHE125	Problem solving with C	ES	3	0	0	3	40	60	100	3
CHE126	English Language Lab	HS	0	0	3	3	50	50	100	1.5
CHE127	Problem solving with C Lab	ES	0	0	3	3	50	50	100	1.5
CHE128	Environmental Science (Mandatory non-credit course)	MC	3	0	0	3	50	0	50	0
	Total		**18**	**0**	**6**	**24**	**350**	**400**	**750**	**18**

	II Year –I Semester									
Code	**Title of the Course**	**Category**	**L**	**T**	**P**	**Total**	**Max. Marks**		**Total Marks**	**Credits**
							Sess.	**End Exam.**		
CHE211	Engineering Mathematics – III	BS	3	0	0	3	40	60	100	3
CHE212	Organic Chemistry	BS	3	0	0	3	40	60	100	3
CHE213	Biology for Engineers	ES	2	0	0	2	100	-	100	2
CHE214	Chemical Process Calculations	PC	3	0	0	3	40	60	100	3
CHE215	Mechanical Operations	PC	3	0	0	3	40	60	100	3
CHE216	Organic Chemistry Lab	BS	0	0	3	3	50	50	100	1.5
CHE217	Mechanical Operations Lab	PC	0	0	3	3	50	50	100	1.5
	Total		**14**	**0**	**6**	**20**	**360**	**340**	**700**	**17**
	II Year –II Semester									
CHE221	Engineering Mathematics – IV	BS	3	0	0	3	40	60	100	3
CHE222	Humanities Elective	HS	3	0	0	3	40	60	100	3
CHE223	Engineering Thermodynamics	ES	3	0	0	3	40	60	100	3
CHE224	Momentum Transfer	PC	3	0	0	3	40	60	100	3
CHE225	Numerical Methods for Chemical Engineers	SC	3	0	0	3	40	60	100	3
CHE226	Professional Elective – I	PE	3	0	0	3	40	60	100	3
CHE227	Momentum Transfer Lab	PC	0	0	3	3	50	50	100	1.5
CHE228	Computational Lab	SC	0	0	3	3	50	50	100	1.5
CHE229	Seminars	SC	0	0	2	2	100	---	100	1
	Total		**18**	**0**	**8**	**26**	**390**	**510**	**900**	**22**

	III Year –I Semester									
Code	**Title of the Course**	**Category**	**L**	**T**	**P**	**Total**	**Max. Marks**		**Total Marks**	**Credits**
							Sess.	**End Exam.**		
CHE311	Open Elective-I	OE	3	0	0	3	40	60	100	3
CHE312	Chemical Engineering Thermodynamics	PC	3	0	0	3	40	60	100	3
CHE313	Heat Transfer	PC	3	0	0	3	40	60	100	3
CHE314	Mass Transfer – I	PC	3	0	0	3	40	60	100	3
CHE315	Chemical Technology	PC	3	0	0	3	40	60	100	3
CHE316	Professional Elective – II	PE	3	0	0	3	40	60	100	3
CHE317	Heat Transfer Lab	PC	0	0	3	3	50	50	100	1.5
CHE318	Chemical Technology Lab	PC	0	0	3	3	50	50	100	1.5
CHE319	Quantitative and Verbal Aptitude – I	HS	0	0	3	**3**	100	0	100	1.5
CHE 310	Summer Internship - I	PR	0	0	0	**0**	0	100	100	2
	Total		**18**	**0**	**6**	**24**	**340**	**460**	**800**	**24.5**
	III Year –II Semester									
CHE321	Open Elective – II	OE	3	0	0	3	40	60	100	3
CHE322	Mass Transfer – II	PC	3	0	0	3	40	60	100	3
CHE323	Chemical Reaction Engineering – I	PC	3	0	0	3	40	60	100	3
CHE324	Process Dynamics and Control	PC	3	0	0	3	40	60	100	3
CHE325	Professional Elective-III	PE	3	0	0	3	40	60	100	3
CHE326	Professional Elective - IV	PE	3	0	0	3	40	60	100	3
CHE327	Mass Transfer Lab	PC	0	0	3	3	50	50	100	1.5
CHE328	Process Dynamics and Control Lab	PC	0	0	3	3	50	50	100	1.5
CHE329	Quantitative Aptitude – II & Soft Skills	HS	0	0	3	3	100	0	100	1.5
	Total		**18**	**0**	**6**	**24**	**340**	**460**	**800**	**22.5**

	IV Year –I Semester									
Code	**Title of the Course**	**Category**	**L**	**T**	**P**	**Total**	**Max. Marks**		**Total Marks**	**Credits**
							Sess.	**End Exam.**		
CHE411	Open Elective – III	OE	3	0	0	3	40	60	100	3
CHE412	Chemical Reaction Engineering – II	PC	3	0	0	3	40	60	100	3
CHE413	Transport Phenomena	PC	3	0	0	3	40	60	100	3
CHE414	Chemical Process Economics and Equipment Design	PC	3	0	0	3	40	60	100	3
CHE415	Process Modeling and Simulation	SC	3	0	0	3	40	60	100	3
CHE416	Professional Elective-V	PE	3	0	0	3	40	60	100	3
CHE417	Chemical Reaction Engineering Lab	PC	0	0	3	3	50	50	100	1.5
CHE418	Process Modeling and Simulation Lab	SC	0	0	3	3	50	50	100	1.5
CHE419	Project Phase – I	PR	0	0	3	3	100	0	100	2
CHE410	Summer Internship - II	PR	0	0	0	0	0	100	100	2
	Total		**18**	**0**	**9**	**27**	**400**	**500**	**900**	**25**
	IV Year –II Semester									
CHE421	Open Elective – IV (MOOCS)	OE	3	0	0	3	40	60	100	3
CHE422	Project Phase-II	PR	0	0	9	9	100	100	200	8
	Total Credits		**9**	**0**	**9**	**12**	**140**	**160**	**500**	**11**

R -2020 regulations – List of electives

CHE 222 Humanities Elective	
CHE 222(A)	Industrial Management
CHE 222(B)	Managerial Economics and Financial Analysis
CHE 222(C)	Operations Research
CHE 226 Professional Elective - I	
CHE 226 (A)	Polymer Technology
CHE 226 (B)	Entrepreneur Engineering
CHE 226 (C)	Design Thinking
CHE 316 Professional Elective – II	
CHE 316 (A)	Industrial safety
CHE 316 (B)	Fertilizer Technology
CHE 316 (C)	Pharmaceutical Technology
CHE 316 (D)	Electrochemical Engineering
CHE 325 Professional Elective – III	
CHE 325 (A)	Industrial pollution and control
CHE 325 (B)	Membrane technology
CHE 325 (C)	Catalysis
CHE 325 (D)	Electrochemical energy
CHE 326 Professional Elective – IV	
CHE326 (A)	Material Science and Engineering
CHE326 (B)	Petrochemicals
CHE326 (C)	Energy engineering
CHE 326 (D)	Biochemical engineering

CHE 416 Professional Elective – V	
CHE 416 (A)	Petroleum Refinery Engineering
CHE 416 (B)	Nanotechnology
CHE 416 (C)	Process optimization
CHE 416 (D)	Computational fluid dynamics
CHE 311 Open Elective - I	
CHE 311(A)	Food Processing Technology
CHE 311(B)	Engineering Biology
CHE 311(C)	Fuel Cell Technology
CHE 311(D)	Design of experiments
CHE 321 Open Elective - II	
CHE 321(A)	Fundamentals of Industrial Safety and Health
CHE 321(B)	Bioinformatics
CHE 321(C)	Corrosion Engineering
CHE 321(D)	Computational tool for Engineers
CHE 411 Open Elective – III	
CHE 421 Open Elective – IV	

CHEMICAL ENGINEERING THERMODYNAMICS

Course Code – Category: CHE 312 – PC

L	T	P	E	O	Credits: 3
3	0	0	1	4	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Physical Chemistry, Chemical Engineering Thermodynamics–Iand Chemical Process Calculations.

Course Objectives:

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

Course Outcomes:

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

1. Refrigerate and liquefy the products.
2. Calculate pressure, temperature and compositions when phases are in equilibrium.
3. Apply the fugacity concepts to non-ideal solutions.
4. Estimate the activity coefficients.
5. Compute 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
CO	1	3	2	2	2					1	1		1	2	3
	2	3	2	2	2					1	1		1	2	3
	3	3	2	2	2					1	1		1	2	3
	4	3	2	3	3					1	1		1	2	3
	5	3	2	3	3					1	1		1	2	3

SYLLABUS

UNIT I **9L + 3T**

Refrigeration and Liquefaction: Carnot Refrigerator, vapour compression cycle, choice of refrigerant, absorption refrigerant, heat pump, liquefaction process.

Learning Outcomes:

At the end of this unit, student will be able to

- Design a refrigerator.
- Apply the liquefaction techniques to liquefy the gas.

UNIT II **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the compositions of the phases in equilibrium.
- Identify the equilibrium diagrams of different phases

UNIT III **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply the concepts of partial properties to estimate the properties in a solution
- Estimate the compositions of non-ideal gas mixtures

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.

Learning Outcomes:

At the end of this unit, student will be able to

- Estimate the compositions of non-ideal liquid mixtures
- Model the excess Gibbs free energy.

UNIT V **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Evaluate the equilibrium constants.
- Analyze the effect of temperature, pressure and concentration on equilibrium constant.

Text books:

1. J.M. Smith, H.C. Van Ness, M.M. Abbott and B. I. Bhatt, Introduction to Chemical EngineeringThermodynamics,7th ed., 2009, McGraw Hill 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's Outlines of Theory and Problems of Thermodynamics, 3rd ed., 2013, McGraw Hill education.
3. K.V. Narayanan, A Text book of Chemical Engineering Thermodynamics, 2013, PHI learning.

HEAT TRANSFER

Course Code – Category: CHE 313 – PC

L	**T**	**P**	**E**	**O**	**Credits: 3**
3	**0**	**0**	**1**	**4**	**Sessional Marks: 40**
End Exam: 3 Hours					**End Exam Marks: 60**

Prerequisites: Engineering Mathematics, Chemical Process Calculations.

Course Objectives:

- To familiarize with three modes of heat transfer and to know about steady state and unsteady state heat conduction.
- To know about heat transfer involving phase change and without phase change.
- To familiarize the operation of different heat transfer equipments.
- To understand the fundamental principles of radiation.
- 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. Implement the basic laws of conduction to steady state and unsteady state problems.
2. Predict convective heat transfer coefficients at various conditions.
3. Compute heat loss / gain due to radiation.
4. Classify various heat transfer equipments.
5. Determine the performance of different Evaporators.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9L + 3T**

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.

Learning Outcomes:

At the end of this unit, student will be able to

- Classify the various modes of heat transfer
- Calculate heat transfer rate for steady state conduction
- Construct heat transfer rate for steady state conduction

UNIT II **9L + 3T**

Convection: Principles of heat flow in fluids – typical heat exchange equipment, counter current 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

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate heat transfer by forced convection in laminar flow and turbulent flow
- Calculate heat transfer by natural convection
- Understands the analogies of fluid mechanics and heat transfer
- Classify types of condensation process of heat transfer

UNIT III **9L + 3T**

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

Learning Outcomes:

At the end of this unit, student will be able to

- Categorize the laws of radiation
- Calculate radiation between the surfaces
- Compute combined heat transfer by conduction-convection and radiation

UNIT IV **9L + 3T**

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.

Learning Outcomes:

At the end of this unit, student will be able to

- Understands the design of heat exchanger
- Estimates heat transfer coefficients in shell and tube heat exchanger
- Categorize types of heat exchangers

UNIT V **9L + 3T**

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.

Learning Outcomes:

At the end of this unit, student will be able to

- Compute capacity and economy of evaporators
- Classify the feeding methods of feeding 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. ssNecatiOzisik, *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

Course Code – Category: CHE 314 – PC

L	T	P	E	O	Credits:3
3	0	0	1	4	SessionalMarks: 40

EndExam:3Hours **End ExamMarks: 60**

Prerequisites: Introduction to Chemical Engineering, Chemical Process Calculations.

CourseObjectives:

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

Course Outcomes:

Bythe endofthe course,studentwillbe able to

1. Estimate the flux of molecules and diffusivity of gases, liquids and solids
2. Predictthe masstransfercoefficientsandknowitsimportance
3. Designanabsorptioncolumn
4. GenerateVLEdataandestimatethenumber ofstagesforadistillationcolumn
5. Identifytheequipment fordifferent gas-liquidoperations.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9L+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.

Learning Outcomes:

At theend ofthisunit,studentwillbeableto

- Describe the importance of various mass transfer operations and their classification
- Derive diffusion equation in steady state
- Compute the diffusivity of gases, liquids and solids

UNIT II **9L + 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.

Learning Outcomes:

At theend ofthisunit,studentwillbeableto

- Describe diffusion between phases
- Estimatethemass transfer coefficients in laminar and turbulent flows

UNIT III **9L+ 3T**

Absorption and Stripping: Solubility of gases in liquids, two component systems, ideal andnon-ideal solutions, choice of solvent for absorption, single component absorption materialbalances in steady state co-current and counter current multistage operations, dilute gas mixtures, tray efficiency, HETP, HTU, NTU concepts for single operation absorption with chemicalreaction.

Learning Outcomes:

At theend ofthisunit,studentwillbeableto

- Identify a suitable solvent for absorption process
- Apply the concept of absorption over single component materialbalances on various stages
- Estimatethetray efficiency, HTU, NTU.

UNIT IV **9L +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.

Learning Outcomes:

At theend ofthisunit,studentwillbeableto

- Make material balances for a binary multistage distillation column.
- Estimatetheideal equilibrium stages with McCabe-Thiele Construction
- Calculate minimum reflux ratio and minimum number of stages.

UNIT V **9L+ 3T**

Equipment for Gas- Liquid Operations:

Sparged vessels (Bubble columns), mechanically agitated vessels for single phase liquids and gas-liquid mixtures, tray towers, sieve trays, packed towers, comparison between tray towers and packed towers, venturi scrubbers, wetted wall towers, packed humidifiers, dehumidifiers and cooling towers, spray chambers.

Learning Outcomes:

At theend ofthisunit,studentwillbeableto

- Classify various equipments for gas liquid operations.
- Differentiate tray tower and packed tower.

TextBooks:

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

Reference Books:

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

CHEMICAL TECHNOLOGY

Course Code – Category: CHE 324 – PC

L	**T**	**P**	**E**	**O**
3	**1**	**0**	**0**	**4**

Credits:3
Sessional Marks: 40

End Exam: 3 Hours

End Exam Marks: 60

Prerequisites: Engineering chemistry, Organic chemistry.

Course Objectives:

- To know about the inorganic chemical manufacturing processes of sulphur, nitrogen phosphorus, chloro-alkali and cement industries.
- 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. Outline the manufacturing of sulphur and nitrogen product industries.
2. Describe the manufacturing of phosphoric acid, chloro-alkali and cement industries.
3. Understand the manufacture of coal chemicals and petroleum products.
4. Acquire the knowledge on extraction of vegetable oils and manufacture of paints and varnishes.
5. Describe the manufacture of pulp, 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**
CO	**1**	2					1	1		1	1		1	2	3
	2	2					1	1		1	1		1	2	3
	3	2					1	1		1	1		1	2	3
	4	2					1	1		1	1		1	2	3
	5	2					1	1		1	1		1	2	3

SYLLABUS

UNIT I **9 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, manufacture of nitrogen and oxygen gases

Learning Outcomes:

At the end of this unit, student will be able to

- Understand the productions of inorganic products
- Differentiate the best suitable method for these fertilizer products

UNIT II **9 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Understand the productions of various inorganic products and its importance to the socio-economic conditions
- Select suitable method for the production of phosphorous, alkali compounds as well as cement

UNIT III **9 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Recognize the fossil fuel importance to the society
- Extract various products from distillation coal and petroleum

UNITIV **9L+ 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Adopt the techniques for the production of edible oils
- Utilize the paints and varnish to requirement of specific applications

UNITV **9 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.

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

Learning Outcomes:

At the end of this unit, student will be able to

- Select suitable method to increase the yield of paper, sugar and ethanol
- Produce various hydrocarbons by polymerization technology.

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.

PROFESSIONAL ELECTIVE - II

INDUSTRIAL SAFETY

Course Code– Category: CHE316(A)–PE

L	T	P	E	O	Credits:3
3	0	0	1	3	SessionalMarks: 40

EndExam:3Hours **End ExamMarks: 60**

Course Objectives:

- To know about Industrial safety programs and toxicology, Industrial laws, regulations and source models
- To understand about fire and explosion, preventive methods, relief and its sizing methods
- To analyse industrial hazards and its risk assessment.

Course Outcomes:

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

1. Analyze the effect of release of toxic substances
2. Understand the industrial laws, regulations and source models.
3. Apply the methods of prevention of fire and explosions.
4. Understand the relief and its sizing methods.
5. Understand the methods of hazard identification and preventive measures.

CO –PO – PSO Matrix:

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

SYLLABUS

UNIT I **9 L+ 3 T**

Introduction: Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, Nature of the Accident Process, Inherent Safety, Seven Significant Disasters.

Toxicology: Effect of Toxicants on Biological Organisms, Toxicological Studies, Dose versus Response, Models for Dose and Response Curves, Relative Toxicity, Threshold Limit Values, National Fire Protection Association (NFPA) Diamond.

Learning Outcomes:

At the end of this unit, student will be able to

- Explain the nature of accidents and safety programs
- Asses the effect of toxicants on biological organisms.

UNIT II **9 L+ 3 T**

Industrial Hygiene: Government Laws and Regulations, OSHA: Process Safety Management, EPA: Risk Management Plan, DHS: Chemical Facility Anti-Terrorism Standards (CFATS) Industrial Hygiene: Anticipation and Identification, Evaluation, Control.

Source Models: Introduction to Source Models, Flow of Liquid through Holes, and Pipes, Flow of Gases or Vapors through Holes and Pipes, Flashing Liquids, Liquid Pool Evaporation or Boiling, Conservative Analysis

Learning Outcomes:

At the end of this unit, student will be able to

- Differentiate process safety management and risk management plan
- Anticipation of hazards and their evaluation
- Formulate the different models for hazard representation.

UNIT III **9 L+ 3 T**

Fires and Explosions: The Fire Triangle, Distinction between Fires and Explosions, Definitions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram, Ignition Energy, Autoignition, Auto-Oxidation, Adiabatic Compression, Ignition Sources, Sprays and Mists, Explosions

Concepts to Prevent Fires and Explosions: Inerting, Static Electricity and its Control, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems, Miscellaneous Concepts for Preventing Fires and Explosions.

Learning Outcomes:

At the end of this unit, student will be able to

- Compare fires and explosions
- Represent the fire triangle and flammability diagram
- Choose suitable methods to prevent fires and explosions

UNIT IV **9 L+ 3 T**

Introduction to Reliefs: Relief Concepts, Definitions, Location of Reliefs, Relief Types and Characteristics, Relief Scenarios, Data for Sizing Reliefs, Relief Systems.

Relief Sizing : Conventional Spring-Operated Reliefs in Liquid and in Vapor or Gas Services, Rupture Disc Reliefs in Liquid in Vapor or Gas Services, Two-Phase Flow during Runaway Reaction Relief, Pilot-Operated and Bucking-Pin Reliefs, Deflagration Venting for Dust and Vapor Explosions,

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the reliefs and location of reliefs
- Represent the types of relief systems
- Compute the area for relief systems

UNIT V **9 L+ 3 T**

Hazards Identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews, Other Methods,

Risk Assessment: Review of Probability Theory, Event Trees, Fault Trees, QRA and LOPA

Learning Outcomes:

At the end of this unit, student will be able to

- Demonstrate various hazard identification methods
- Construction of event trees and fault trees

Text Book:

1. D.A. Crowl and J.F. Louvar, *Chemical Process Safety (Fundamentals with Applications)*, Prentice Hall, 2011.

Reference Books:

1. R.K. Sinnott, Coulson & Richardson's, *Chemical Engineering*, Vol. 6, Elsevier India, 2006.
2. Fawcett H.H. and W.S.Wood, *Safety and accident prevention in Chemical operations* 2nd editon John Wiley and Sons Inc. (1982).

PROFESSIONAL ELECTIVE-II

FERTILIZERTECHNOLOGY

Course Code– Category: CHE316(B)–PE

L	T	P	E	O	Credits:3
3	0	0	1	3	SessionalMarks: 40

EndExam:3Hours **End ExamMarks: 60**

Prerequisites: Engineering Chemistry

CourseObjectives:

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

CourseOutcomes:

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

1. Classifytherawmaterialsforfertilizerproductionandtheirimportance.
2. Identifymanufacturingprocessesofnitrogenousfertilizers.
3. Describe the production of N, P, K fertilizers.
4. Applytheknowledgeofdesignofreactorsforthemanufacturingprocesses.
5. Acquaintwithvariousmethodsofstorageandhandlingoffertilizers.

CO–PO –PSO Matrix:

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

SYLLABUS

UNITI **9L+3T**

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

LearningOutcomes:

At the end of this unit, student will be able to

- Justify the need for synthetic fertilizer.
- Explain role of essential elements for plant growth
- Identify various raw materials for N, P, K fertilizers.

UNITII **9L+ 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.

LearningOutcomes:

At theend ofthisunit,studentwillbeableto

- Explain with flow diagram the manufacturing of given type of fertilizers.
- Identify proper storage and handling of given type of fertilizers with justification.

UNITIII **9L+3T**

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

Potassic Fertilizers: Potassium chloride, potassium sulphate.

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

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

LearningOutcomes:

At theend ofthisunit,studentwillbeableto

- Explain with flow diagram the manufacturing of P, K & Complex fertilizers.
- Justify the need of bio-fertilisers.

UNITIV **9L+ 3T**

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

LearningOutcomes:

At theend ofthisunit,studentwillbeableto

- Explain the different aspects of ammonia synthesis converters.
- Give justification for modernization of existing plants.

UNITV **9L+3T**

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

LearningOutcomes:

At theend ofthisunit,studentwillbeableto

- Select proper storage and handling of given type of fertilizers.
- Determine the probable corrosion type in fertilizer plants.

Text Books:

1. *Hand book of Fertilizer Technology*, Fertilizer Association of India, New delhi

Reference books:

1. *Production of Fertilizers(Booklets1to8)*, European Fertilizer Manufacturers Association.
2. *Mineral Fertilizer Production and the Environment(Part1&2)*, International Fertilizer Industry Association.
3. *Pollution Prevention and Abatement Handbook*, The world Bank Group

PROFESIONAL ELECTIVE-II

PHARMACEUTICAL TECHNOLOGY

Course Code– Category: CHE316(C)–PE

L	T	P	E	O	Credits:3
3	0	0	1	3	SessionalMarks: 40
End Exam : 3 Hours					End Exam Marks: 60

Prerequisites:

Engineering Chemistry, Organic Chemistry

Course Objectives:

- To know about various forms of drug development
- To get acquaintance with semi solid and pharmaceutical aerosols
- 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. Analyse 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**
CO	**1**	2								1	1		1	3	2
	2	2	1	1	1					1	1		1	3	2
	3	2	1	1	1					1	1		1	3	2
	4	2	1	1	1					1	1		1	3	2
	5	2	1	1	1			1		1	1		1	3	2

SYLLABUS

UNIT I **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Describe the materials and equipments used in tablet production.
- Illustrate the production of tablets and capsules.

UNIT II **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Describe the advances in materials and equipments used in liquid dosage form production.
- Illustrate the production of liquid dosage form.

UNIT III **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Enumerate the production of parenterals.
- Illustrate the production of eye drops & eye Lotions.

UNIT IV **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Enumerate the production of semisolid forms.
- Illustrate the production of aerosols.

UNIT V **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Explain technology transfer from R&D to pilot plant for manufacture of pharmaceuticals.
- Apply scale up process to unit operation and unit process equipments.

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.

PROFESSIONAL ELECTIVE-II

ELECTROCHEMICAL ENGINEERING

Course Code– Category: CHE316(D)–PE

L	T	P	E	O	Credits:3
3	0	0	1	3	SessionalMarks: 40

EndExam:3Hours **End ExamMarks: 60**

Prerequisites: Basic Science and Mathematics

Course Objectives:

- Tounderstandtheprinciples and working of batteries

Course Outcomes:

At theendofthecourse,thestudent will beableto:

1. Apply the concepts and principles of electro-chemical cell
2. Analyze the materials of cell and its performance
3. Acquaint the primary and reserve batteries
4. Acquaint the secondary batteries
5. Design the battery based on application

CO–PO –PSO Matrix:

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

SYLLABUS

UNIT I **9L+3T**

Basic Concepts: Components of cells and batteries, Classification of cells and batteries, Operation of cell, theoretical cell voltage, capacity and energy, specific energy and energy density of practical batteries.

Electrochemical principles and reactions: Thermodynamic background, electrode processes, electrical double-layer capacity and ionic adsorption, mass transport to the electrode surface.

Learning Outcomes:

At the end of this unit, student will be able to

- Differentiate the various parameters of electrochemical cell and batteries
- Apply the principles of electrochemical engineering

UNIT II **9L+ 3T**

Characterization: X-ray diffraction, scanning electron microscope, mass spectroscopy, conductivity measurements, potential measurements, surface area measurement – BET method

Factors affecting battery performance: Voltage level, current drain of discharge, mode of discharge, temperature of battery during discharge, service life, type of discharge, duty cycles, charging voltage, battery age and storage condition

Learning Outcomes:

At the end of this unit, student will be able to

- Characterize the electrochemical cells
- Improve the battery performance by understanding the material characteristics

UNIT III **9L+ 3T**

Primary Batteries: Introduction, general characteristics, types and characteristics of primary batteries, comparison of the performance characteristics of primary battery systems, recharging primary batteries, Chemistry, construction and performance characteristics of Lithium primary batteries

Reserve Batteries: Introduction, characteristics of reserve batteries, Chemistry, construction and performance characteristics of Zinc / Silver oxide reserve batteries

Learning Outcomes:

At the end of this unit, student will be able to

- Differentiate primary and reserve batteries
- Analyze the performance of Lithium primary batteries and Zinc / silver oxide reserve batteries

UNIT IV **9L+3T**

Secondary batteries: Introduction, general characteristics, types and characteristics of secondary batteries, comparison of the performance characteristics of secondary battery systems. Chemistry, construction and performance characteristics of Lead / acid batteries and Lithium ion batteries.

Learning Outcomes:

At the end of this unit, student will be able to

- Differentiate primary and secondary batteries
- Analyze the performance of Lead acid and Lithium-ion secondary batteries

UNIT V **9L+3T**

Battery Design: Battery construction, design of rechargeable batteries, electronic energy management and display – smart batteries.

Application of batteries: General characteristics, major considerations in selecting a battery, battery applications, portable applications

Learning Outcomes:

At the end of this unit, student will be able to

- Design the battery
- Select the type of battery for specific applications

TextBooks:

1. David Linden and Thomas B. Reddy, "Handbook of Batteries", 3rd edition, McGraw Hill publications, 2002.
2. Said Salaheldeen Elnashaie, Firoozeh Danafar, Hassan Hashemipour Rafsanjani, *Nanotechnology for Chemical Engineers*, Springer, 2015. (**UNIT-II**)

Referencebooks:

1. An Introduction to Electrochemistry by Samuel Glasstone, Maurice Press (2007).
2. Electro Chemical Engineering by David J.Picket, Prentice Hall Inc., Publications (1979)
3. Electrochemical Power sources Primary and Secondary Batteries by M.Barak and L.K.Steverge, Publisher: The Institution of Engineering And Technology (1980).
4. Electro Chemical Engineering Science and Technology in Chemical and other industries by H.Wendt and G.Kreysa, Springer links publications (1999).

HEAT TRANSFER LABORATORY

Course Code– Category: CHE 317 **Credits: 1.5**

Instruction: 3 Practical hours /week Sessional Marks: 50

End Exam: 3 Hours End Exam Marks: 50

Prerequisites: Heat Transfer

Course Objectives:

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

Course Outcomes:

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

1. Determine the heat transfer coefficients.
2. Operate various heat transfer equipments.

CO – PO – PSO Matrix:

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

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.

CHEMICAL TECHNOLOGY LABORATORY

Course Code– Category: CHE 318 **Credits: 1.5**

Instruction: 3 Practical hours/week Sessional Marks: 50

End Exam: 3 hrs End Exams Marks: 50

Prerequisites: Chemical Technology, Engineering Chemistry

Course Objectives:

- To impart the knowledge on analyzing water and other compounds
- 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**
CO	**1**	3	3	3	3		2	2		3	2		1	2	3
	2	3	3	3	3		1			3	2		1	2	3

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.

MASS TRANSFER – II

Course Code – Category: CHE 322 – PC

L	T	P	E	O	Credits: 3
3	0	0	1	4	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Mass Transfer-I.

Course Objectives:

- To understand liquid-liquid operations
- To understand the solid-liquid, solid-gas operations
- To understand the membrane separation processes

Course Outcomes:

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

1. Plot Ternary liquid equilibrium and process design of extractors.
2. Classify different leaching equipments and compute material balance.
3. Understand adsorption isotherms and evaluate the process design aspects of adsorption column.
4. Estimate total time for drying operation and understand different types of drying equipment.
5. Identify the importance of crystallization and membrane separation processes.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9L + 3T**

Liquid-Liquid Extraction: Ternary liquid systems and its applications, 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, equipment for liquid-liquid extraction operation: mixture-settler cascades, rotating disc contactors (RDC), mechanically agitated extractor and centrifugal extractor.

Learning Outcomes:

At the end of this unit, student will be able to

- Explain equilibrium using triangular coordinates
- Describe the material balances over single, multi cross and counter current systems
- Compute the minimum solvent requirement for insoluble liquids

UNIT II **9L + 3T**

Leaching: Fields of applications, preparation of solid for leaching, types of leaching, leaching equilibrium, single stage and multi stage leaching calculations, Unsteady state operation equipment – percolation tanks, shank system, steady state operation equipment: Continuous Counter-current Decantation(CCD), leaching of vegetable seeds: Bollman extractor, continuous horizontal extractor and Kennedy extractor.

Learning Outcomes:

At the end of this unit, student will be able to

- Understand the leaching equilibrium
- Explain material balances in single and multi-stages
- Summarize the various steady and unsteady state equipments for leaching

UNIT III **9L + 3T**

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

Learning Outcomes:

At the end of this unit, student will be able to

- Classify various adsorption isotherms
- Apply the concept of adsorption over material balances single and multistage operations
- Estimate the minimum solvent requirement for multistage cross current system.

UNIT IV **9L + 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, batch and continuous drying equipment.

Learning Outcomes:

At the end of this unit, student will be able to

- Infer different moisture contents.
- Describe the batch drying equilibrium curve.

- Compute the batch drying time for constant and falling rate periods
-

UNIT V **9L + 3T**

Crystallization and Membrane Separation Processes:

Crystallization: Nucleation and crystal growth, controlled rate of crystals, crystallization equipments.

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

Learning Outcomes:

At the end of this unit, student will be able to

- Explain Super saturation, Nucleation and Crystal growth
- Describe about various industrial crystallizers.
- Classify various membrane separation processes.

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

Text Books:

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

Reference Books:

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

CHEMICAL REACTION ENGINEERING - I

Course Code – Category: CHE 323 – PC

L	**T**	**P**	**E**	**O**	**Credits: 3**
3	**0**	**0**	**1**	**4**	**Sessional Marks: 40**
End Exam: 3 Hours					**End Exam Marks: 60**

Prerequisites: Engineering Mathematics, Physical Chemistry, Chemical Process Calculations.

Course Objectives:

- To learn principles of reaction engineering
- To understand various mechanisms of chemical reactions
- To gain knowledge on different reactors and their design

Course Outcomes:

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

1. Predict various mechanisms for various 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

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9L + 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 non-elementary reactions –Temperature dependent term –Arrhenius law, activation energy, collision theory, transition state theory Searching for a mechanism

Learning Outcomes:

At the end of this unit, student will be able to

- Estimate the rate constant for a reaction
- Estimate the mechanism for a reaction

UNIT II **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the batch reactor data by integral and differential methods.
- Analyze the batch reactor data by half-life methods.

UNIT III **9L + 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.

Learning Outcomes:

At the end of this unit, student will be able to

- Derive the performance equations for various reactors
- Calculate the exit concentrations for various reactors

UNIT IV **9L + 3T**

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

Learning Outcomes:

At the end of this unit, student will be able to

- Compare the reactors in terms of volume
- Design a multiple reactors

UNIT V **9L + 3T**

Design of Reactors with Multiple Reactions: Design for parallel and series reactions –Qualitative and quantitative discussion about product distribution.

Learning Outcomes:

At the end of this unit, student will be able to

- Estimate the product composition for parallel reactions
- Estimate the product composition for series reactions

Text books:

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

Reference Books:

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

PROCESS DYNAMICS AND CONTROL

Course Code – Category: CHE 324 – PC

L	T	P	E	O	Credits: 3
3	0	0	1	4	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Engineering Mathematics

Course Objectives:

- To know about linear chemical process problems and control configurations
- To understand control strategies

Course Outcomes:

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

1. Formulate and solve linear chemical processes
2. Develop block diagram and transfer function for a closed loop system.
3. Analyze the response of processes for various controllers
4. Analyze stability of control systems
5. Acquire the knowledge on advanced control strategies, controller tuning and control valves.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT- I **9L + 3T**

Linear open loop systems: Simple first order systems, physical examples of first of first order system, response of first order systems in series.

Learning Outcomes:

At the end of this unit, student will be able to

- Develop transfer function for first order system.
- Calculate response of first order system.

UNIT II **9L + 3T**

Higher order systems: Simple second order systems, physical examples of second order systems transportation lag.

Linear closed loop systems: The control systems, controllers, final control element, block diagram of chemical reactor control systems,

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the response of second order system.
- Develop block diagram for control system.

UNIT III **9L + 3T**

Analysis and design of feedback control systems: closed loop transfer functions, effect of proportional, integral and derivative control action on the response of a control process, control valves.

Learning Outcomes:

At the end of this unit, student will be able to

- Develop transfer function for closed loop system.
- Analyse the effect of controller on response of control process.

UNIT IV **9L + 3T**

Stability: Stability, root locus, frequency response, control system design by frequency response, Bode diagram, Bode stability criteria

Learning Outcomes:

At the end of this unit, student will be able to

- Plot root locus and bode diagrams.
- Analyse the stability of control system.

UNIT V **9L + 3T**

Advanced controller strategies: Cascade control, feed forward control, ratio control, dead time compensation.

Introduction to process applications: Controller tunings, controller mechanisms.

Learning Outcomes:

At the end of this unit, student will be able to

- Describe the advanced controllers.
- Design controller parameters for a process.

Text Books:

1. Donald R. Coughnowr, Steven E. LeBlanc *Process Systems Analysis and Control*, 3rdEd., McGraw-Hill Education India Pvt. Ltd., 2013.

Reference Books:

1. G. Stephanopoulos, *Chemical Process Control: An Introduction to Theory & Practice*, PHI, 1983
2. W. B. Bequette, *Process Control: Modelling, Design and Simulation*, Prentice Hall, 1998
3. D. Seborg, T.F. Edgar Duncan, A. Mellichamp, *Process Dynamics and Control*,3rd Ed., John Wiley & Sons, Inc, 2010

PROFESIONAL ELECTIVE-III

INDUSTRIALPOLLUTION ANDCONTROL

Course Code – Category: CHE 325(A) – PE

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites:IntroductiontoChemicalEngineering

CourseObjectives:

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

CourseOutcomes:

Bythe endofthecourse,the studentwillbe able to:

1. Understand the various types of pollution and their effects on man and 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. Acquire knowledge on 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**
CO	**1**	2					2	2		1	1		1	3	2
	2	3	3	2	2		2	2		1	1		1	3	2
	3	2	3	2	2		2	2		1	1		1	3	2
	4	2	3	2	2		2	2		1	1		1	3	2
	5	2	1	1	1		2	2		1	1	1	1	3	2

SYLLABUS

UNITI **9L+3T**

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

LearningOutcomes:

At theendofthisunit,student will beableto

- Identify different types of scavenging paths of nutrients.
- Predict the effects of population growth on pollution.

UNITII **9L+3T**

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

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

LearningOutcomes:

At theendofthisunit,student will beableto

- Classify primary and secondary pollutants.
- Explain the effects of pollution on Health, Vegetation and Materials.

UNITIII **9L+ 3T**

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

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

LearningOutcomes:

At theendofthisunit,student will beableto

- Classify different sampling techniques for gaseous and particulate pollutants.
- Suggest control equipments for gaseous and particulate pollutants.

UNITIV **9L+3T**

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

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 waste water treatment, recovery of materials from process effluents.

LearningOutcomes:

At theendofthisunit,student will beableto

- Determine D.O, B.OD, COD& TOC.
- Describe various methods used for recovery of materials from process effluents.
- Suggest proper equipment for treating waste water.

UNITV **9L+3T**

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.

LearningOutcomes:

At theendofthisunit,student will beableto

- Classify hazardous and non –hazardous

TextBooks:

1. Rao C.S., *Environmental Pollution Control Engineering*, Wiley Eastern Limited, India, 1993.

Referencebooks:

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–McGrawHillPublishingLtd.,1999.
4. Noelde Nevers, *Air Pollution and Control Engineering*, McGraw Hill,2000.
5. Mahajan.S.P., *Pollution Control in Process Industries*, Tata-McGraw Hill, New Delhi,1985.

PROFESIONAL ELECTIVE-III

MEMBRANE TECHNOLOGY

Course Code – Category: CHE 325 (B)- PE

L	T	P	E	O
3	0	0	1	3

Credits:3
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:

At 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. Acquaintance with various membrane configurations and about membranefouling.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9 L+ 3 T**

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

LearningOutcomes:

At the end of this unit, student will be able to

- Describe the function and applications of the membrane
- acquaintance of membrane technology dominance over the other technologies

UNIT II **9 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.

LearningOutcomes:

At the end of this unit, student will be able to

- Get the knowledge for the preparation of membranes using various precursors as well as techniques.
- Understand the various parameters effected the morphology of membranes

UNIT III **9 L+ 3 T**

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

LearningOutcomes:

At the end of this unit, student will be able to

- Identify the concept of fouling and its classification at constant pressure.
- Differentiate the feasibility of transport mechanism with other separations

UNIT IV **9 L+ 3 T**

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

LearningOutcomes:

At the end of this unit, student will be able to

- Bifurcate low and high pressure driven processes based on pressure and average pore size.
- Differentiate pressure and electrically driven membrane processes.

UNIT V **9L+ 3 T**

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

LearningOutcomes:

At the end of this unit, student will be able to

- Understand the concentration polarization and its effect on membrane fouling
- Classify membrane modules and their configuration.

Text Books:

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

Reference books:

1. MunirCheryan, *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.

PROFESIONAL ELECTIVE-III

CATALYSIS

Course Code – Category: CHE 325(C) – PE

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Fundamentals of Chemical Reaction Engineering

Course Objectives:

- To understand the fundamentals of catalysts
- To have a knowledge of various catalytic reactors
- To have an awareness of biocatalysts and bioreactors

Course Outcomes:

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

1. Determine the characteristic properties of catalysts
2. Determine the rate limiting step
3. Design various industrial catalytic reactors.
4. Apply 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**
CO	**1**	3	1							1	1		1	3	2
	2	3	2	2	1					1	1		1	3	2
	3	3	2	2	1					1	1		1	3	2
	4	3	2	2	1					1	1		1	3	2
	5	3	2	2	1					1	1		1	3	2

SYLLABUS

UNIT I **9L + 3T**

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

Learning Outcomes:

At the end of this unit, student will be able to

- Estimate the catalyst properties.

- Calculate the surface area, porosity, pore volume and solid density.

UNIT II **9L + 3T**

Catalyst Mechanisms: Steps in a catalytic reaction, synthesizing rate law, mechanism, rate limiting step

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the steps in catalytic reactions
- Identify the rate limiting step

UNIT III **9L + 3T**

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

Learning Outcomes:

At the end of this unit, student will be able to

- Design the performance equations for catalytic reactors.
- Evaluate the rate law parameters

UNIT IV **9L + 3T**

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

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the catalyst deactivation.
- Determine the order of deactivation

UNIT V **9L + 3T**

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

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the mechanisms of enzyme substrate reactions
- Determine the immobilized enzyme kinetics

Text Books:

1. J. M. Smith., Chemical Engineering Kinetics, 3rdedition., Mc-Graw Hill, Inc. (Unit-I)
2. H. Scott Fogler., Elements of Chemical Reaction Engineering, 5thedition.,PHI Learning Private Ltd (Unit-II, III & IV)
3. Michael L. Shuler ., FikretKargi, Bioprocess Engineering, 2ndedition., PHI Learning Private Ltd (Unit -V).

Reference Books:

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

PROFESIONAL ELECTIVE-III

ELECTROCHEMICAL ENERGY

Course Code – Category: CHE 325(D) – PE

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Basic Science and Mathematics

Course Objectives:

- To impart the knowledge of application of electrochemical cells

Course Outcomes:

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

1. Analyze conventional batteries – Lead acid battery
2. Analyze Li-ion batteries
3. Acquaint knowledge on batteries for electric vehicles
4. Impart principles of portable fuel cells
5. Impart principles of small fuel cells

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9L + 3T**

Lead Acid, Ni-Cd & Zn-AgO Batteries: Introduction, general characteristics, chemistry, constructional materials, manufacturing methods, SLI automotive batteries, deep-cycle and traction batteries, stationary batteries, charging equipment, maintenance safety and operational features, applications.

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the various characteristics of Lead acid battery
- Infuse the manufacturing methods and its maintenance for Lead acid batteries

UNIT II **9L + 3T**

Lithium ion batteries & Battery Management System (BMS): Introduction, general characteristics, chemistry, construction, performance, charge characteristics, safety testing, polymer Li-ion batteries, thin film, solid state Li-ion batteries, Applications.

BMS – Introduction to functions of BMS, constructions and working.

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the various characteristics of Li-ion batteries
- Analyze the Li composite batteries

UNIT III **9L + 3T**

Advanced Batteries: Introduction, performance requirements, characteristics and developments, near-term rechargeable batteries, advanced rechargeable batteries (Metal–ion batteries, Metal air Batteries)

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the characteristics of batteries for electric vehicles
- Analyze Zinc / air battery

UNIT IV **9L + 3T**

Portable fuel cells: Introduction, general characteristics, operation of fuel cell, sub-kilowatt fuel cell, innovative designs for low voltage cells.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the operation of fuel cell
- Analyze designs for low voltage cells

UNIT V **9L + 3T**

Small Fuel Cells & Super Capacitor: Introduction, Applicable fuel cell, system requirements, fuel processing and storage technologies, fuel cell stack technology, hardware and performance.

Super Capacitor: Introduction to super capacitors and types of super capacitors.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the system requirements for small fuel cells
- Analyze the fuel cell stack technology

TextBooks:

1. David Linden and Thomas B. Reddy, “Handbook of Batteries”, 3rd edition, McGraw Hill publications, 2002.
2. B. Viswanathan and M. Aulice Scibioh, “Fuel Cells: Principles and Applications”, CRC press, 2008.

Referencebooks:

1. An Introduction to Electrochemistry by Samuel Glasstone, Maurice Press (2007).
2. M. Mench, “Fuel Cell Engines”, John Wiley, New York, 2008.
3. Electro Chemical Engineering by David J.Picket, Prentice Hall Inc., Publications (1979)
4. Gholam Abbas Nazri, “Lithium Batteries – Science and Technology”, Springer, New York, 2009.
5. D. Pavlov, “Lead – Acid Batteries: Science and Technology”, Elsevier, Amsterdam, 2011.

PROFESIONAL ELECTIVE-IV

Material Science and Engineering

Course Code – Category: CHE 326(A) – PE - IV

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

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

Course Objectives:

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

Course Outcomes:

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

1. Depict the crystal structure and their properties based on the structure.
2. Calculate the imperfections in a crystal
3. Analyze the mechanical properties of engineering materials
4. Determine the type of fracture and the importance of composite materials in engineering design.
5. Analyze the phase transformations 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**
CO	**1**	3	1							1	1		1	2	3
	2	3	1							1	1		1	2	3
	3	3	1							1	1		1	2	3
	4	3	1							1	1		1	2	3
	5	3	1							1	1		1	2	3

SYLLABUS

UNIT I **9L + 3T**

Atomic Structure and Inter Atomic Bonding: Electrons in atoms: Rutherford model, Bohr atomic model, wave mechanical model; bonding forces and energies, primary inter atomic 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.

Learning Outcomes:
At the end of this unit, student will be able to

- Calculate the bonding forces and energies for the atoms.
- Estimate the density of a crystal by identifying the crystal system.

UNIT II **9L + 3T**

Imperfections: 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.

Learning Outcomes:
At the end of this unit, student will be able to

- Determine the type of imperfection in a crystal.
- Estimate the number of point imperfections in a crystal.

UNIT III **9L + 3T**

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.

Learning Outcomes:
At the end of this unit, student will be able to

- Apply the hardness test to estimate the hardness number.
- Determine the behavior of a material.

UNIT IV **9L + 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.

Learning Outcomes:
At the end of this unit, student will be able to

- Determine the type of fracture in a material.
- Analyze the type of composite material to be used.

UNIT V **9L + 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-Fe3C-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.

Learning Outcomes:

At the end of this unit, student will be able to

- Determine the eutectic and peritectic points and reactions in a phase diagram.
- Identify the types of steels used in chemical industries.

Text books:

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 Company of India, Delhi.

PROFESIONAL ELECTIVE-IV

PETROCHEMICALS

Course Code – Category: CHE326 (B) – PE

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites:
Engineering chemistry and organic chemistry

Course Objectives:

- To make a thorough understanding of the availability of petroleum feed stocks for petrochemicals.
- To understand the methods to produce various petrochemicals fromC_2, C_3, C_4 and higher carbon atoms.
- 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. Understand petrochemical industry feedstocks, various chemicals produced from methane.
2. Describe the production of different chemicals from C_2 carbon atoms
3. Outline the production of different chemicals from C_3, C_4 and higher carbon atoms and production of various polymers.
4. Acquire the knowledge on 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
CO	1	2								1	1		1	3	2
	2	2								1	1		1	3	2
	3	2								1	1		1	3	2
	4	2								1	1		1	3	2
	5	2								1	1		1	3	2

SYLLABUS

UNIT-I **9L+3T**

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

Learning Outcomes:
At the end of this unit, student will be able to

- Recognize the scenario of petroleum refining and future prospects in India and worldwide
- Understands the origin and formation of petroleum

UNIT II **9L+3T**

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

Learning Outcomes:
At the end of this unit, student will be able to

- Know the various testing methods for petroleum fractions
- Understands dehydration and desalting of crudes
- Acquires knowledge on distillation of crude oil

UNIT III **9L+3T**

Chemicals From C3,C4 and Higher Carbon Atoms: Isopropylalcohol, 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.

Learning Outcomes:
At the end of this unit, student will be able to

- Categorize various treatment techniques for petroleum fractions
- Predict the suitable treatment techniques for the gasoline, kerosine and lubes

UNIT IV **9L+3T**

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

Learning Outcomes:

At the end of this unit, student will be able to

- Classify various cracking operations
- Comprehends process variables
- Understand coking and visbreaking processes

UNIT V **9L+3T**

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).

Learning Outcomes:

At the end of this unit, student will be able to

- Classify different refinery value addition processes
- Acquires knowledge on hydrotreating and air blown asphalt methods

Textbooks:

1. B. K. BhaskaraRao, *Modern Petroleum Refining Processes*, 5th Edition, Oxford & IBH Publishing, 2011.

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

PROFESIONAL ELECTIVE-IV

ENERGY ENGINEERING

Course Code – Category: CHE 326 (C) – PE_IV

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites: Chemical Technology, Engineering chemistry.

Course Objectives:

- To provide knowledge to conventional and non-conventional energy resources and their applications, concept of fuel cells, nuclear energy, energy storage and conservation.

Course Outcomes:

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

1. Explain the various conventional and non-conventional energy resources available, production and use.
2. Identify the scenario of oil and gases, characteristics and applications.
3. Discuss the sustainability in application of non-conventional energy resources
4. Elucidate the concept of fuel cells, biofuels and nuclear energy with future applications.
5. Substantiate the Energy Storage, Distribution and conservation methodology for sustainability.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT-I **9L+ 3T**

Introduction: Conventional energy resources, the present scenario, scope for future development.

Coal: Origin, occurrence and reserves, classification, ranking, analysis and testing, coal carbonization, manufacture of coke, coal gasification, coal liquefaction.

Learning Outcomes:

At the end of this unit, student will be able to

- State various conventional energy sources
- Explain the manufacturing process of coke and coal gasification process

UNIT-II **9L+ 3T**

Oil and Gases: Origin and formation of petroleum and gases, reserves and deposits of world, Indian Petroleum Industry, Fractionation of petroleum. Fuels derived from oil and gases, Characteristics, production methods and uses.

Learning Outcomes:

At the end of this unit, student will be able to

- Summarize the petroleum reserves and deposits across the world.
- Describe the fractionation process of petroleum.

UNIT-III **9L+ 3T**

Non-conventional energy sources: Solar energy, solar radiation, principles of heating and cooling, photo voltaic cells. Wind energy, hydrogen energy, geothermal and ocean thermal energy.

Learning Outcomes:

At the end of this unit, student will be able to

- Explain the applications of various non conventional energy sources
- Classify solar energy and solar radiation.

UNIT-IV **9L+ 3T**

Bio Fuels: Introduction, Bio mass conversion technologies, Wet processes, dry processes, Bio-gas generation, Factors affecting bio-digestion, Classification of biogas plants, Production methods, characteristics, uses of biodiesel, bio-ethanol, Second generation biofuel feed stocks.

Fuel Cells: Working principle, Types, Advantages, Current and Future Applications.

Nuclear Energy: Nuclear fuel processing, nuclear reactions and nuclear reactors.

Learning Outcomes:

At the end of this unit, student will be able to

- Infer the Biomass conversion technologies and Bio gas generation processes.
- Enumerate the current and future applications of Fuel cells
- Describe nuclear reactions and nuclear reactors.

UNIT-V **9L+ 3T**

Energy Storage and Distribution: Mechanical Energy Storage, Hydroelectric Storage, Compressed Air Storage and Energy Storage via Flywheels, Electric Storage, Chemical Storage and Thermal Energy Storage.

Energy Conservation: Conservation methods in process industries, Theoretical analysis, practical limitations, equipment for energy saving / recovery.

Learning Outcomes:

At the end of this unit, student will be able to

- Summarize different energy storage methods.
- Identify and characterize energy conservation methods in process industries

Text Books:

1. S. Rao, B. B. Parulekar,*Energy Technology*, 3rd Ed., Khanna Publishers, 1994. **(UNIT-I &V)**
2. G. D. Rai,*Non-Conventional energy sources*, 18thEd.,Khanna Publisher, 2017.**(UNIT- III)**
3. S. Sarkar,*Fuels and Combustion*, Universities Press, 3rdEd., 2009.**(UNIT-IV)**
4. Nelson. W. L,*Petroleum refining Engineering*, 4thEd.,McGraw Hill, New York, 1969.**(UNIT-II)**

Reference books:

1. S.B.Pandy,*Conventional Energy Technology*, Tata McGraw Hill.
2. S. Srinivasan,*FuelCells: From Fundamentals to Applications*, Springer, 2006 .
3. O. P. Gupta,*Fundamentals of Nuclear power reactors*, Khanna Publishers, New Delhi, 1983.
4. Harker and Backhusst,*Fuels and energy,* Academic press, London 1981.

PROFESIONAL ELECTIVE-IV

BIOCHEMICAL ENGINEERING

Course Code – Category: CHE 326 (D) – PE-IV

L	T	P	E	O	Credits: 3
3	0	0	1	3	Sessional Marks: 40
End Exam: 3 Hours					End Exam Marks: 60

Prerequisites:

Course Objectives:

- To enhance interdisciplinary skills
- To understand basic concept of life sciences
- To have knowledge on different bioreactors and their design
- To have knowledge on production of different bioproducts and their analytical procedures

Course Outcomes:

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

1. Distinguish various microorganisms and biomolecules
2. Classify different enzymes and its kinetics
3. Design various bioreactors
4. Model various transport phenomena mechanisms
5. Describe the production of biomolecules and its quantification

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT-I **9L+ 3T**

Introductionto biochemical engineering: Comparison of chemical and biochemical processes, industrially important microbial strains used for different bio products

Chemicals of life: Carbohydrates, proteins, lipids, nucleic acids, their classification and biological functions

Biology of microbes: Protist kingdom, classification and structure of different cells

Learning Outcomes:

At the end of this unit, student will be able to

- Classify the biomolecules and their biological functions
- Classify the types of microbial cells

UNIT-II **9L+ 3T**

Introduction to enzymes: Classification, kinetics of enzyme catalyzed reactions, derivation of MichaelisMenten equation for single substrate, determination of M.M parameters, enzyme inhibition – types, immobilization of enzymes, methods, immobilized enzyme kinetics, applications of immobilized enzymes and soluble enzymes

Learning Outcomes:

At the end of this unit, student will be able to

- Find the rate expressions for enzymatic reactions
- Identify the type of enzyme inhibition
- Apply the type of immobilization techniques for enzymes

UNIT-III **9L+ 3T**

Kinetics of cell growth: Growth phases, yield coefficient, Monod growth kinetics, ideal bioreactors – batch –mixed flow and plug flow reactors, chemostat with recycle and their analyses

Learning Outcomes:

At the end of this unit, student will be able to

- Apply Monod growth kinetics for continuous production of biomass
- Apply various bioreactors for manufacture of different bioproducts

UNIT-IV **9L+ 3T**

Transport phenomenon across the cell: Active, passive and facilitated diffusion, gas liquid mass transfer in cellular systems, determination of k_La values

Sterilization: Media and air, methods of continuous sterilization of media

Learning Outcomes:

At the end of this unit, student will be able to

- Determine the mass transfer coefficients in cellular systems
- Apply the sterilization techniques for media

UNIT-V **9L+ 3T**

Downstream processing: Special reference to membrane separation and chromatographic techniques like Gas chromatography, thin layer and paper chromatography, HPLC, affinity, gel, adsorption and ion exchange chromatography.

Important industrial bio products: ethanol – penicillin – citric acid – acetic acid, effluent treatment, production of biogas.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply the downstream processing techniques for the purification of bioproducts
- Produce the various microbial products

Text Books:

1. M. L. Shuler and F. Kargi, *Bioprocess Engineering: Basic Concepts*, 2nd edition, Prentice Hall India, New Delhi, 2003

Reference books:

1. J. E. Bailey and D. F. Ollis, *Biochemical Engineering Fundamentals*, 2nd edition, McGraw-Hill Publishers, Newyork, 1986
2. D.G. Rao, *Biochemical engineering*, Tata McGraw-Hill Publishers, New Delhi
3. J.M. Lee, *Biochemical engineering*, Prentice Hall, Englewood Clifts, 1992.

MASS TRANSFER LABORATORY

Course Code – CHE 328 **Credits: 1.5**

Instruction: 3 Practical hours/week Sessional Marks: 50

End Exam: 3 Hours End Exam Marks: 50

Prerequisites: Mass Transfer Operations

Course Objectives:

- To implement the knowledge acquired in mass transfer theory in the laboratory
- To get acquainted with various mass transfer equipment

Course Outcomes:

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

1. Determine the diffusion an mass transfer coefficient.
2. Operate the various distillation equipments.
3. Evaluate the performance of mass transfer operations.

CO – PO – PSO Matrix:

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

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.

PROCESS DYNAMICS AND CONTROL LABORATORY

CHE 329 **Credits:1.5**

Instruction: 3 Practical hours/week Sessional Marks: 50

End Exam: 3 Hours End Exam Marks: 50

Prerequisites: Engineering Mathematics, Process dynamics and control

Course Objectives:

- To impart knowledge on the determination of time constants of a process.
- To enable the students in designing a controller.

Course Outcomes:

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

1. Determine the response and time constants of various process
2. Acquire hands on experience on the operation of various Controllers

CO – PO – PSO Matrix:

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

List of experiments

1. Response of mercury-in glass thermometer
2. Response of mercury-in glass thermometer with thermal well.
3. Response of manometer
4. Response of single tank liquid level system
5. Response of two tank non-interacting liquid level system
6. Response of two tank interacting liquid level system
7. Study of control valve coefficient.
8. Valve characteristics of a control valve
9. Response of pressure control trainer for sinusoidal input
10. Pressure control trainer
11. Temperature control trainer
12. Level control trainer

Prescribed Books:

1. Donald R. Coughnowr, Steven E. LeBlanc Process Systems Analysis and Control, 3rdEd., McGraw-Hill Education India Pvt. Ltd., 2013.
2. G. Stephanopoulas, Chemical Process Control- An Introduction to Theory and Practice, Prentice Hall of India Pvt. Ltd., New Delhi, 2008.
3. B. Wayne Bequette, Process Control – Modeling Design and Simulation, Prentice Hall, 1st edition, 2003.