Enclosure-IIB

Shree Manibhai Virani and Smt.NavalbenViraniScienceCollege, Rajkot (Autonomous)
Affiliated to SaurashtraUniversity, Rajkot
Department of Industrial Chemistry
M. Sc. INDUSTRIAL CHEMISTRY

OBJECTIVES OF THE PROGRAMME:

The curriculum is designed to accomplish the following program objectives which studentsshall accomplish by the end of their post-graduation study.

- To apply the knowledge of mathematics, engineering fundamentals, industrial chemistry, including organic, analytical and physical chemistry and an engineering specialisation to the solution of complex engineering problems.
- To able navigate the scientific literature and databases. This includes being able to find information from e-resources and prepare experimental setup for research. The opportunity to pursue dissertation research as postgraduate and capable to publish the outcomes of research in repute scientific journals.
- To work in a team using common tools and environments to achieve projects/organizational ideas.
- To train a personnel to take the challenges of chemical industries and inculcate the entrepreneurship among them.
- To communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

SCHEME OF INSTRUCTION AND EXAMINATIONS

For Students Admitted From A.Y. 2016-17 & Onwards

Semester-I							
Course Code	**Course**	**Hrs. of Instruction**	**Exam Duration (Hrs)**	**Max. Marks**			**Credit**
				CIE	**SEE**	**Total**	
Part-I							
16PICCC01	**Core 1:** Industrial Stoichiometry & Momentum Transfer Operation	4	3	30	70	100	4
16PICCC02	**Core 2:** Industrial Unit Operations	4	3	30	70	100	4
16PICCC03	**Core 3:** Industrial Unit Processes & Reagents	5	3	30	70	100	5
16PICCC04	**Core 4:** Organic Synthesis & Disconnection Approach	4	3	30	70	100	4
16PICCC05	**Core Practical-1** Fluid Mechanics Heat transfer operation Liquid liquid extraction, Organic Synthesis	12	12	80	120	200	6
		28				**600**	**23**
Part-II							
16PICCE01	Chemistry Software & Database	1	1	50	-	50	1
Part-III							
16PVE01	Value Education	1	Remarks				1
		30				**650**	**25**

Semester-II							
Part-I							
16PICCC06	**Core 5:** Chemical Reaction Engineering	4	3	30	70	100	4
16PICCC07	**Core 6:** Technologies In Chemical Industries	4	3	30	70	100	4
16PICCC08	**Core 7:** Heterocyclic Chemistry	4	3	30	70	100	4
16PICCC09	**Core 8:** Industrial Safety and Management	4	3	30	70	100	4
16PICCC10	**Core Practical-2** Chemical reaction engineering and nano particles,Physico chemical exercise, Multi stage synthesis, Industrial safety and management	12	12	80	120	200	6
		28				**600**	**22**
Part-II							
16PICCE02	Scientific Writing	1	-	50	-	50	1
	Industrial Training *	1	-	Evaluated at the end of Sem-III			-
		30				**650**	**23**

*Industrial Training for at least 4 weeks during II & III semesters.

Semester-III							
Part-I							
16PICCC11	**Core 9:** Mechanical Operations	4	3	30	70	100	4
16PICCC12	**Core 10**: Polymer Chemistry And Technology	4	3	30	70	100	4
16PICCC13	**Core 11**: Instrumental Techniques of Analysis	4	3	30	70	100	4
16PICCC14	**Core 12**: Computer Based Test	-	-	50	-	50	1
16PICDC01/ 16PICDC02	**DSE Core 1:** Chemical Technology-I **OR** Medicinal Chemistry-I	4	3	30	70	100	4
16PICCC15	**Core Practical-3** Mechanical Operations, Polymer Chemistry And Technology, Instrumental Techniques of Analysis	10	9	60	90	150	5
16PICDC03/ 16PICDC04	**DSE Core Practical-1** Chemical Technology-I **OR** Medicinal Chemistry-I	2	3	20	30	50	1
-	Dissertation	2	-	Evaluated at the end of Sem-IV			-
		30				**650**	**23**
Part-II							
16PICCE03	Industrial Training	-	-	50	-	50	1
		30				**700**	**24**

Semester-IV							
Part-I							
16PICCC16	**Core13:** Process Dynamics & Control	4	3	30	70	100	4
16PICCC17	**Core14:** Advance Organic Chemistry	4	3	30	70	100	4
16PICCC18	**Core 15:** Dissertation/Practical	16	-	60	90	150	11
16PICDC05/ 16PICDC06	**DSE Core 2:** Chemical Technology-II **OR** Medicinal Chemistry -II	4	3	30	70	100	4
		28				**450**	**23**
Part-II							
16PICCE04	Sophisticated Instrumental Training	2	-	50	-	50	1
		30				**500**	**24**
	TOTAL Sem.-I to IV					**2500** marks	**96** Credits

TOTAL MARKS AND CREDIT DISTRIBUTION

S.NO.	Part	Total Marks	Total Credit
1	**Part I : Core & DSE Core Courses**	**2300**	**91**
2	**Part II : Competency Enhancement Courses**	**200**	**04**
3	**Part III : Value Education**	**-**	**01**
	TOTAL	**2500**	**95+1=96**

DISTRIBUTION OF COURSE

Part-1: CORE, DSE-CORE (THEORY & PRACTICAL)

CORECOURSES:

S.No.	Semester	THEORY		PRACTICAL	
		Course Code	Course	Course Code	Course
1	I	16PICCC01	Industrial Stoichiometry & Momentum Transfer Operation	16PICCC05	Fluid Mechanics, Heat transfer operation, Liquid liquid extraction, Organic Synthesis.
2		16PICCC02	Industrial Unit Operations		
3		16PICCC03	Industrial Unit Processes & Reagents		
4		16PICCC04	Organic Synthesis & Disconnection Approach		
5	II	16PICCC06	Chemical Reaction Engineering	16PICCC10	Chemical reaction engineering and nano particles, Physic chemical exercise, Multi stage synthesis, Industrial safety and management
6		16PICCC07	Technologies In Chemical Industries		
7		16PICCC08	Heterocyclic Chemistry		
8		16PICCC09	Industrial Safety and Management		
9	III	16PICCC11	Mechanical Operations	16PICCC15	Mechanical Operations, Polymer Chemistry And Technology,Instrumental Techniques of Analysis
10		16PICCC12	Polymer Chemistry And Technology		
11		16PICCC13	Instrumental Techniques of Analysis		

12		16PICCC14	Computer Based Test		
13	IV	16PICCC16	Process Dynamics &Control	-	-
14		16PICCC17	Advance Organic Chemistry	-	-
15		16PICCC18	Dissertation/ Practical	-	-

DISCIPLINE SPECIFIC ELECTIVE-CORE COURSES-

Student shall select any one of the following courses as Elective in semesterIII & IV respectively

S.No.	Semester	THEORY		PRACTICAL	
		Course Code	Course	Course Code	Course
1	III	16PICDC01	Chemical Technology-I	16PICDC03	Chemical Technology-I
2		16PICDC02	Medicinal Chemistry-I	16PICDC04	Medicinal Chemistry-I
3	IV	16PICDC05	Chemical Technology-II	-	-
4		16PICDC06	Medicinal Chemistry-II	-	-

PART II:

COMPETENCY ENHANCEMENT COURSES:

S.No.	Semester	THEORY		PRACTICAL	
		Course Code	Course	Course Code	Course
1	I	16PICCE01	Chemistry Software & Database	-	-
2	II	16PICCE02	Scientific Writing	-	-
3	III	16PICCE03	Industrial Training	-	-
4	IV	16PICCE04	Sophisticated Instrumental Training	-	-

PART III:

VALUE EDUCATION

S.No.	Semester	Course Code	Course	PRACTICAL	
				Course Code	Course
1	I	16PVE01	Value Education	-	-

M.Sc. INDUSTRIAL CHEMISTRY
SEMESTER-I

16PICCC01	Core-1 INDUSTRIAL STOICHIOMETRY & MOMENTUM TRANSFER OPERATION	04 hrs/wk	04 Credit

Objectives:

1. To understand and apply the basic concept of fluid flow and its applications in chemical industries
2. To formulate material balance to solve for compositions and flow rates of process streams.
3. To understand fluid particles system and equipment's in chemical industries.
4. Derive energy balance for chemical processes and integrate with material balance calculations to solve the industrial problem.

Unit-I: Industrial Stoichiometry (With Chemical Reaction) (10 hrs)

- Material and Energy balance calculation for processes with chemical reactions recycle purge and by-pass operations
- Batch and continuous operations.

Unit-II: Industrial Stoichiometry (Without Chemical Reaction) (10 hrs)

- Material and Energy balance calculation for processes without chemical reactions recycle purge and by-pass operations
- Batch and continuous operations.

Unit-III: Transportation Of Fluids (09 hrs)

- Boundary layer concept, Types of fluid, flow pattern, Reynolds experiments.
- Construction, Working and power calculation for reciprocating and centrifugal pumps.
- Use of air vessels in pumps, Priming, Cavitation, Vapor locking and NPSH.
- Design of Flow meters, Pressure and Vacuum producing devices.

Unit-IV: Momentum Transfer Operations-I (09 hrs)

- Dimensionless analysis using Rayleigh's and Buckingham π method
- Motion of particles through fluids, calculations of Rayleigh's and Buckingham π method

Unit-V: Momentum Transfer Operations-II (10 hrs)

- Terminal settling velocity of particles settling under Stokes.
- Intermediate and Newton's range in free & hindered settling.
- Mechanism of fluidization.
- Design of fluidized bed columns.

Reference Books:

1. Bhatt, H.T. and Vora, S.M. 2004. *Stoichiometry*. India: Tata McGraw Hill. Co.
2. Sachdeva, R.C., 2009. *Fundamentals of Engg. Heat & Mass Transfer*. India: New Age Science
3. D.M., Himmelblau.1997. *Basic Principles and Calculations in Chemical Engineering.* New Delhi: Prentice Hall of India

16PICCC02	Core-2 Industrial Unit Operations	04 hrs/wk	04 Credit

Objectives:

1. Apply principles of heat and mass transfer to basic engineering systems.
2. Applies the concepts of diffusion mass transfer, mass transfer coefficients, and equipment for gas-liquid operations, absorption, and distillation.
3. Analyse and design heat exchanger.
4. Understand the fundamental principles of radiative emission and absorption.

Unit-I: Mass Transfer Unit Operations (09 hrs)

- Local and Overall Mass Transfer co-efficient:
- Gas Absorption: Choice of solvent for absorption, Minimum Liquid – gas ratio for absorbers, HETP in continuous contact equipments.
- Distillation: Use of McCabe Thiele method in the design of multistage tray towers, q-line equation, Effect of reflux ratio.
- Liquid Extraction: Choice of solvent for extraction Binodal solubility curves, Calculations for single stage and multi stage cross &countercurrent extraction.

Unit-II: Mass Transfer (09 hrs)

- Drying: Rate of batch drying, Calculations for cross and through circulation drying, Rate of drying for continuous driers, Hold up in rotary driers.
- Filtration: Theory of Filtration, Filtration, Filtration in centrifuges.

Unit-III: Heat Transfer – Conduction (10 hrs)

- Local and Overall heat transfer co-efficient: Introduction to thermal diffusivity, Thermal insulators, Critical Radius of insulation, Fourier's law of heat conduction.
- Three Dimensional heat conduction equations in rectangular, Effect of variable thermal conductivity, Heat transfer from extended surfaces.

Unit-IV: Heat Transfer – Convection (10 hrs)

- Newton's law of heat convection Free and Forced Convection Calculation involving convection mode of heat transfers in rectangular.
- Understanding of overall Heat transfer coefficient for combined conduction & convection mode.
- Dropwise and film condensation, Heat transfer in Condensation on vertical, horizontal, inclined plates.

Unit-V: Heat Transfer – Radiation (10 hrs)

- Terminologies in radiation mode of Application for Planck's distribution law, Stefan Boltzmann Law and Kirchhoff's law.
- Radiation Shields, LMTD correction factors, Design of single and multi-pass exchangers, Effectiveness and number of transfer units for heat exchangers.

Reference Books:

1. K. A. Gavhane, 2009. *Unit Operations – II*. Pune: NiraliPrakashan
2. Robert E Treybal, 1981. *Mass Transfer Operations*. USA: McGraw Hill
3. McCabe & Smith, 2001. *Unit Operations in Chemical Engineering*. USA: McGraw Hill

16PICCC03	Core 3: Industrial Unit Processes & Reagents	05 hrs/wk	05 Credit

Objectives:

1. To understand the manufacturing of various inorganic and organic chemicals, the process flow diagram and various process parameters.
2. To identify and solve engineering problems during production and understanding the mechanisms of various unit processes.
3. To be able understanding of preparation, structures, mode of actions and applications of reagents used in organic reactions and rearrangements including LAH, DEAD, NBS, Sodamide, DCC, DCI, TPP, LTA.

Unit-I: Halogenation, Alkylation & Acylation (12 hrs)

Principle, Reagents, Mechanism, Kinetics, Applications involving Industrial Product manufacturing using following Unit processes:

- Halogenation
- Alkylation
- Acylation

Unit-II: Oxidation, Hydrogenation & Reduction (12 hrs)

Principle, Reagents, Mechanism, Kinetics, Applications involving Industrial Product manufacturing using following Unit processes:

- Oxidation
- Hydrogenation
- Reduction

Unit-III: Nitration, Sulphonation & Esterification (12 hrs)

Principle, Reagents, Mechanism, Kinetics, Applications involving Industrial Product manufacturing using following Unit processes:

- Nitration
- Sulphonation
- Esterification

Unit-IV: Reagents-I (12 hrs)

Preparation, Properties, Mechanism of Action & Applications involving name reaction or rearrangement of following Reagents:

- $LiAlH_4$
- Dicyclohexylcarbodiimide (DCC)
- Diethylazodicarboxylate (DEAD)
- Carbonyldiimidazole (CDI)

Unit-V: Reagent-II (12 hrs)

Preparation, Properties, Mechanism of Action & Applications involving name reaction or rearrangement of following Reagents:

- N-Bromosuccinamide
- Sodamide
- Triphenylphosphene
- Lead tetra acetate

Reference books:

1. Agrawal, O. P., (1996). *Organic Chemistry: Reactions And Reagents*. India: GOELPublishing House.
2. Groggins, P. H. (1995). *Unit Processes in Organic Synthesis*. India: Tata McGraw Hill
3. Finar, I.,(2005). *Organic Chemistry*, 5th Edition, Delhi: Pearson education

16PICCC04	Core-4: Organic Synthesis & Disconnection Approach	04 hrs/wk	04 Credit

Objectives:

1. To Understand formation, stability and reactivity of reactive intermediates including carbocation, carbanion, free radical, nitrene, carbene, enamines, ylides and benzyne.
2. An Understanding the concept of nucleophiles, electrophiles, electronegativity, and resonance to draw mechanisms for organic reactions and rearrangements.
3. To understand basic fundamentals of disconnection including FGR, FGI, Synthon, Synthetic equivalents.
4. To be able design ROS of organic molecules using disconnection approach.

Unit-I: Free Radicals, Carbocation, Carbanions, Nitrene&Their Reactions (09 hrs)

Introduction, Formation, Stability and name Reactions involving following intermediates: Free radicals, Carbocation, Carbanions&Nitrene.

Intermediates	Name reactions
Free radicals	Birch Reduction
	Grignard Reaction
Carbocation	Baeyer-Villiger Oxidation
	Vilsmeier-Haack
Carbanions	Junjappa-Ila Annulation &Heteroannulation
	Dieckmann
Carbenes	Arndt-Eistert
	Reimer-Tiemann

Unit-II: Enamines, Carbenes, Phosphorus Ylides, Benzyne&Their Reactions(09 hrs)

Introduction, Formation, Stability and name Reactions involving following intermediates: Enamines, Carbenes, Phosphorus ylides&Benzyne

Intermediates	Name reactions
Phosphorus ylides	Mitsunobu reaction
	Wittig
	Appel
Nitrenes	Hofmann Bormamide
	Schmidt
Enamines	Mannich
	Pictet–Spengler
	StorkeEnamines
Benzyne	Diels Alder

Unit-III: Rearrangements (10 hrs)

Principles, Reactions, Mechanism and applications of following rearrangements

Claisen	Favorskii
Cope	Stevens
Pinacol- pinacolone	Wolff
Benzilic acid	1,2-Wittig

Fries	Schlosser
Curtius	Backmann
Lossen	

Unit-IV: Disconnection Approach Strategy I & II (10 hrs)

Basic principle: Synthesis of Aromatic Compounds.

- Strategy I: The order of events. One group C-X disconnections,
- Strategy II: Chemo selectivity

Unit-V: Disconnection Approach Strategy III & IV (10 hrs)

- Strategy III: Reversal of Polarity, Cyclisation reaction,
- Strategy IV: Protecting groups, one group C-C disconnection: Alcohols and Carbonyl compounds

Reference Book

1. Bansal, R.K.2007. *A Textbook of Organic Chemistry*. India: NEW AGEInternational Pvt Ltd.
2. Ahluwalia, V. K. 2010. *Organic Reaction Mechanism.*India: Narosa Publishing House.
3. Kürti, L. and Czakó, B. 2005. *Strategic Applications of Named Reactions in Organic Synthesis: Background and Detailed Mechanisms.* USA:Elsevier Academic Press.
4. Grossman, R. 2008. *Art of Writing reasonable organic reaction mechanism*, New York: Springer-Verlag.
5. Warren, S. and Wyatt, P. 2009. *Organic Synthesis – The disconnection approach, 2nd Edition*. Cambridge: Willey.

16PICCC05	Core Practical-1	12 hrs/wk	06Credit

Objectives:

1. To perform organic preparation using stoichiometric calculations, isolation, purification, identification and characterization by applying concepts of mole rations, limiting reagent, theoretical & practical yield, crystallization, liquid- liquid extraction, Mp, Bp, TLC.
2. To perform common laboratory techniques including reflux, distillation, crystallization, evaporation, vacuum filtration, liquid-liquid extraction, drying solids and liquids and thin-layer chromatography.
3. To validate the principles and fundamental laws of fluid mechanics with heat and mass transfer operations.
4. To understand nature of solvent for extraction of liquid from liquid mixture.
5. To perform organic preparation using selective reagents for reduction, oxidation, hydrogenation, nitration, halogenation, sulfonation, esterification, chlorosulfonation, acetylation and alkylation.
6. To apply safety rules in the practise of laboratory exercise.
7. Isolate, Purify & Identify the unknown mixture of Inorganic salts by applying principles of qualitative analysis
8. Develop synthetic skill (plan & produce) based on stoichiometric, reactivity, reaction condition optimization & separation technique principles.

Fluid Mechanics

1. To determine the Reynolds number for flowing fluid using a Closed Circuit Reynolds Apparatus.
2. To determine the coefficient of discharge for a flow meter using closed circuit venturimeter and orifice meter apparatus.
3. To verify Bernoulli's theorem using Bernoulli's apparatus.
4. To calculate and study the energy losses in pipe fittings such as sudden contraction, sudden enlargement, bends & elbows and to determine flow through a Rotameter.
5. To calculate and study the energy loss due to pipe friction.
6. To determine coefficient of discharge Cd for notches and weirs of different shapes.

Heat Transfer Operations

1. To find the critical radius of insulation thickness on a cylinder.
2. To determine the Emissivity measurement of grey surface at different temperatures.
3. To find out heat transfer coefficient and heat transfer rate from vertical in natural convection and to find emissivity of the cylinder surface.
4. To determine the Thermal conductivity of insulating powder (Asbestos) at various heat inputs.
5. To determine the thermal conductivity of poor conducting material, say asbestos sheet.
6. To determine the overall heat transfer coefficient of the composite wall & compare the same with that calculated from the equation.
7. To study and compare temperature distribution, heat transfer rate, overall heat transfer coefficient in parallel flow and counter flow heat exchanger.
8. To determine the value of Stefan Boltzmann constant for radiation heat transfer.

9. To plot the radial temperature distribution and to determine the thermal conductivity of pipe insulation.
10. To determine the thermal conductivity of a good conductor material, any brass.
11. To determine the variation of temperature along the length of pin fin under forced convection.
12. To determine the values of heat transfer coefficient under forced condition and to find theoretical values of temperature along the length of fin and effectiveness and efficiency of the pin-fin for insulated and boundary condition.
13. To determine and compare surface heat transfer coefficient for
    a) drop wise condensation & b) film wise condensation
14. To determine the average theoretical and experimental value of coefficient of heat transfer for forced convection for the fluid flowing through a pipe.

Liquid- Liquid Extraction (LLE)

1. To determine the distribution coefficients of carbon tetra chloride solvent for 20% aqueous acetic acid solution
2. To determine the distribution coefficients of Ethyl Acetate solvent for 20% aqueous acetic acid solution
3. To determine the distribution coefficients of Benzene solvent for 20% aqueous acetic acid solution
4. To develop solubility curve for the Ternary System Water(A) –CTC (B)-Acetic Acid(C)
5. To develop solubility curve for the Ternary System Water(A) –CHCl3 (B)-Acetic Acid(C)
6. To develop solubility curve for the Ternary System Water(A) –Benzene (B)-Acetic Acid(C)
7. To determine the theoretical number of stages required for extracting acetic acid from its 10% solution of acetic acid in chloroform (50 ml) using water as solvent so as to limit its concentration in the final Raffinate to almost zero % and % recovery of acetic acid from its mixture using calculated number of stages in multistage cross current extraction.
8. To determine the quantity of Oil Present in a Oil Bearing Material.

Organic Synthesis Exercise

1. To prepare Benzilic acid from Benzil (Benzil-Benzilic acid rearrangement)
2. To Prepare Hippuric acid from Glycine. (Benzoylation)
3. To Prepare Phenylurea from Aniline.
4. To Prepare 3-Methyl-1-phenyl-5-pyrazolone from Ethyl acetoacetate. (Cyclization)
5. To Prepare Resacetophenone from Resorcinol.
6. To Prepare m-Nitroaniline from m-Dinitrobenzene (Selective Reduction)
7. To Prepare p-Bromoacetanilide from Acetanilide (Bromination)
8. To prepare Acetanilide from Aniline (N-Acetylation)
9. To Prepare p-Bromo aniline from p-Bromoacetanilide (Hydrolysis)
10. To prepare p-Nitro acetanilide from Acetanilide (Nitration)
11. To Prepare p-Bromonitrobenzene from Bromobenzene (Nitration)
12. To Prepare p-Nitroaniline from p-Nitroacetanilide (Hydrolysis)
13. To prepare t-Butylchlrode from t-Butanol (Functional Grp Conv. Chlorination)
14. To Prepare Benzaldine aniline (Schiff Base) from Aniline. (Solvent free reaction)
15. To prepare Benzalacetophenone (Chalcone) from Acetophenone. (Carbanion)

16PICCE01	Chemistry Software & Database	01 hrs/wk	01 Credit

Objectives:

1. To be able to draw various chemical structure, various assembly, chrial compounds, laboratory apparatus using ChemBioDraw, Chem Sketch,
2. To understand the application of chembiodraw and chem sketch for drawing reactions in various scientific journals.
3. To do literature search using NLIST, Science Direct and various E-resource.
4. To understand the significance of Scifinder search for data searching and mining.

Unit-I: Chembiodraw Ultra Software-1 (02 hrs)

- Introduction of ChemDraw, Chem Sketch, Drawing chemical reaction, Structure drawing using templates, Structure to name and name to structure, Drawing mechanism of reaction,
- Diagram of Distillation Assembly, Chiral Structure Draw. Drawing apparatus used in laboratory. Reproducing reaction scheme from given research paper.
- Introduction of 3 D Chemdraw ultra, export chemical structure from 2D to 3D, run energy minimization of given molecule, predicting logp value & other physicochemical parameters for given set of molecules.

Unit-II: Chembiodraw Ultra Software-2 (02 hrs)

- Introduction of 3 D Chemdraw ultra, export chemical structure from 2D to 3D, run energy minimization of given molecule, predicting logp value & other physicochemical parameters for given set of molecules.

Unit-II: N-List (02 hrs)

- Introduction of NLIST website, available e-resources.
- Access of e-books and research articles.
- E-learning through NPTEL.

Unit-IV: Science Direct (03 hrs)

- Introduction to publishing house, various journals formats.
- Various search option, recent publication.
- Citation index, impact factor, h index.

Unit-V: Scifinder (03 hrs)

- Introduction, accessing scifinder.
- Keyword search, reaction search and data mining.
- Patent search and referencing.

Reference Books:

1. American Chemical Society. Division of Chemical Information, American Chemical Society. Meeting, (1989), Chemical structure information systems: interfaces, communication, and standards *Volume 400 of ACS symposium seriesChemical structure information systems: interfaces, communication, and standards*, American Chemical Society.

16PVE01	VALUE EDUCATION	01 hr/wk	01Credit

- Universal Human Value &Yog – Pranayam

16PICCC06	Core 5: Chemical Reaction Engineering	04 hrs/wk	04 Credit

Objectives:

1. To train students how to analyse chemical reactors and reaction systems
2. To provide practice at developing critical and creative thinking skills related to reaction engineering
3. To Designing experiments involving chemical reactors, and analyzing and interpreting data
4. To be Able to solve problems of mass transfer with reaction in solid catalyzed reactions

Unit-I: Fundamentals Of Reaction Engineering (09 hrs)

- Factors affecting reactor designing, Single and multiple Reactions.
- Elementary and Non-elementary reactions.
- Catalyzed and non-catalyzed reactions.

Unit-II: Kinetics Of Homogeneous Reactions (09 hrs)

- Molecularity and order of reactions.
- Kinetic Models for non-elementary reactions.
- Temperature dependency and reaction rate prediction from Arrhenius, transition and collision theories.

Unit-III: Reactor Desinging-1 (10hrs)

- Space velocity, space time, mean residence time.
- Flow patterns in reactor, Contacting pattern for two phase system.
- Design of ideal batch.
- CSTR and Plug Flow Reactors and RTD.

Unit-IV: Reactor Desinging-2 (10 hrs)

- Non ideal Reactors-Residence time distribution.
- E, C, F curves, segregation model, dispersion model.
- Chemical reaction and dispersion, tank-in- series model.

Unit-V: Kinetics Of Heterogeneous Reactions (10 hrs)

- Langmuir adsorption isotherm equation, BET theory.
- Effect of transport processes on selectivity in series and parallel reactions, Rate equation for surface reactions.
- Mechanism of solid catalysed gas phase reaction (LHHW model), Progressive conversion model.
- Unreacted core model, porosity, density and particle size of catalyst.

Reference Books:

1. KA Gavhane, 2013. *Chemical reaction engineering-II*. Pune: NiraliPrakashan
2. H. Scott Fogler, 2001. *Elements of Chemical Reaction Engineering.*USA: Prentice Hall
3. Octave Levenspeil, 2001, *Chemical Reaction Engineering*. New York:John Wiley & Sons
4. J.M. Smith, 1984. *Chemical Engineering Kinetics*. United states of America: McGraw Hill

16PICCC07	Core 6: Technologies In Chemical Industries	04 hrs/wk	04 Credit

Objectives:

1. Resources and need for membrane technology in water treatment in other process industrial plants.
2. To promote interests of the pesticide manufacture & formulators engaged in all sectors of agro industries.
3. To gain an understanding of the principles of nanotechnology; characterization of nanostructured materials; and tools and equipment for producing and assembling at the nano scale.
4. To cultivate interest in the research and development of nanotechnology for future advancement of the career.

Unit-I: Membrane Technology-I (09 hrs)

- Introduction of membrane technology.
- Classification of membranes and membrane processes.
- Basic operating principles and applications of various membrane processes – Micro filtration, Ultra filtration, Nano filtration, Reverse Osmosis, Dialysis.

Unit-II: Membrane Technology-Ii (09 hrs)

- Classification of membranes and membrane processes.
- Basic operating principles and applications of various membrane processes – Membrane Distillation, Pervaporation, gas permeation, liquid membranes.

Unit-III: Introduction To Nanotechnology (10 hrs)

- Introduction, Physical methods of synthesis of Nano materials.
- Mechanical &Vapor deposition, Chemical methods of synthesis of Nano materials.
- Colloids & Colliding solutions, Synthesis of Colloids, Synthesis of metal Nano particles, Properties and Applications.

Unit-IV: Industrial Formulations (10 hrs)

Study of Agrochemical Industries with respect to their Classification, Raw materials, manufacturing process of at least four products of each class with special emphasis on chemistry and manufacturing principles:

- Insecticides.
- Pesticides.
- Fungicides.
- Weedicides.

Unit-V: Fermentation Technologies (10 hrs)

- Process calculations and Stoichiometry.
- Metabolic engineering, Transport in reactors.
- Design & Working of Bioreactor.
- Types of reactors, Sterilization, utilities: steam air water, Specific industrial process involving microbes. Industrial Production processes of various biochemical.

Reference Books:

1. Nath, Kaushik. 2008. *Membrane Separation Processes*. New Delhi: Prentice Hall India Ltd.
2. C. Poole, F. Owens, 2009. *Introduction to Nanotechnology*, Panama: John Wiley and Sons
3. Strathmann, H. 2004. *Ion-Exchange Membrane Separation Processes*, Volume-9 : Amsterdam, Elesveir Science:.
4. Cardew PT & Le MS, 1998. *Membrane Processes: A Technology Guide*. ,London, Royal Soc. of Chemistry.

16PICCC08	Core 7: Heterocyclic Chemistry	04 hrs/wk	04 Credit

Objectives:

1. To understand basic concept of heterocyclic chemistry and nomenclature of heterocyclic compounds using systematic IUPAC nomenclature including Five member, Six member,Benzofused five membered and six membered heterocycle.
2. Demonstrate synthesis, reactivity and reactions of five membered heterocyclic compounds containing two heteroatoms and more than two heteroatoms.
3. To Understand and drawing the heterocyclic compound's structure from name and Name to structure using IUPAC system.

Unit-I: Five Membered Hetrocycles (09 hrs)

- Nomenclature, Synthesis, Reactivity and Reactions of: 5 membered Hetrocycles containing.
- TWO heteroatoms (Pyrazole, Imidazole, Thiazole, Isothiazole, Oxazole, Isooxazole).
- More than two hetero atoms (1,2,4-Triozole, 1,3,4- Oxadiazoles, 1,3,4- Thiadiazoles)

Unit-II: Six Membered Hetrocycles (09 hrs)

- Nomenclature, Synthesis, Reactivity and Reactions of:
- 6 membered Hetrocycles containing Nitrogen (Pyridine, Pyridazine, Pyrimidine, Pyrazine)

Unit-III: Benzofused 5 Member Heterocycles (10 hrs)

- Nomenclature, Synthesis, Reactivity and Reactions of:
- Benzofused 5 membered Heterocycles with ONE hetero atom (Benzo(b)pyrrole, Benzo(b)Furan, Benzo(b)thiophene)

Unit-IV: Benzofused 6 Member Heterocycles (10 hrs)

- Nomenclature, Synthesis, Reactivity and Reactions of:
- Benzo fused 6 member hetero cycles (Quinoline, Isoquinoline, Cinnoline, Quinazoline, Quinoxaline, Phthalazine)

Unit-V: Disconnection Of Aromatic Heterocycles (10 hrs)

- Disconnection approaches for
- Aromatic 5 & 6 membered Heterocyclic compounds.

Reference Books:

1. Parikh, Arun., Parikh, Hansa and Khunt, Ranja. 2013. *The essence of Heterocycles*. India: NEW AGE INTERNATONAL PUBLISHERS.
2. Warren, Stuart and Wyatt, Paul. 2009. *Organic Synthesis – The disconnection approach, 2nd Edition*. Cambridge: Willey.
3. Albert, Adrien, 1968. *Heterocyclic Chemistry: An Introduction*. London: The Athlone Press.
4. JOULE, JOHN. MILLS, KEITH. 2013. *Heterocyclic Chemistry at a Glance*, UK :John Wiley & Sons

16PICCC09	Core - 8: Industrial Safety And Management	04 hrs/wk	04 Credit

Objectives:

1. To Understand of Intrinsic & Extrinsic Safety rules including hazards-Toxicity, Flammability, Fire, Explosions, Sources of Ignition, Pressure, Hazard and Risk assessment methods and MSDS.
2. To understand and identifying safety devices including Pressure Relief Valve, Rupture Disks, Blow down Systems, Flare Systems, Flame arresters, Deflagration arresters and Explosion suppression, Personal Safety Devices.
3. To analysis Process Safety using basic fundamentals including HAZAN and HAZOP comparison, Risk analysis and Estimation, Safety check list and Computer based quantitative risk analysis.
4. To achieve knowledge of principles of GMP and GLP and its application in pharmaceutical industries including Guidelines, classification, Various Schedule (X, O, M), Violation of GMP and GLP

Unit-I: Process Safety (09 hrs)

- Intrinsic & Extrinsic Safety.
- The hazards-Toxicity, Flammability, Fire, Explosions.
- Sources of Ignition, Pressure.
- Hazard and Risk assessment methods and MSDS

Unit-II: Safety Devices & Process Safety Analysis (09 hrs)

- Pressure Relief Valve, Rupture Disks, Blow down Systems, Flare Systems, Flame arresters, Deflagration arresters and Explosion suppression, Personal Safety Devices.
- Process Safety Analysis: HAZAN and HAZOP comparison, Risk analysis and Estimation, Safety check list, Computer based quantitative risk analysis.

Unit-III: GLP &GMPin Pharmaceutical Industries (10 hrs)

- GMP: Introduction, Various Schedule (X, O, M), Guidelines, Violation of GMP.
- GLP: Introduction, Principles, Resources, Guideline, Violation.

Unit-IV: Shutdown Management (10 hrs)

- Shutdown Management: Introduction, Types of Shutdown, Resource Planning, activity detail, Material procurement, Preparation Pert/Bar chart, Pre-shutdown work,
- Evacuation of Plant and Handing over, Start of work & Review, Pressure testing and handing over, commissioning, Post-shutdown review.

Unit-V: Disaster Management (10 hrs)

- Disaster Management: Introduction, Classification, Disaster preparation, Prevention,
- Management, Natural disaster mitigation.

Reference Books:

1. S.Rao, 2009, *Energy Technology-Conventional &Non-Conventional Systems*, India: Khanna publishers

2. F.P. Less, 1980, *Loss Prevention in chemical process industries,* Butterworth: Heiremann
3. D.W. Perry, R.H. Perry, 2007, *Chemical Engineers Handbook,* NY: McGraw Hill
4. S. Willing, J. Stocker, 1997, Good Manufacturing Practices, USA: Marcel Dekker
5. J.J. Keller, 1999, *Safety Managers Handbook,* American Management Association International
6. R.E. Johnstone, 1957, *Pilot Plant Models and Scale up Methods in Chemical Engineering*, US: McGraw-Hill
7. P. Carson, C. Mumford, 1988, *Safe Handling of Chemicals in Industry*, NY: Longman scientific technical

16PICCC10	Core Practical -2	12 hrs/wk	06Credit

Objectives:

1. Effectively use the method of titration for simple analytical tasks in the laboratory to properly measure rate of reaction including first, second and third order reactions.
2. To apply the principles of kinetics to find rates of reactions and explore mechanisms of simple chemical changes. Use the principles of equilibrium to interpret behaviours of weak electrolytes, buffer solutions and solubilities of sparingly soluble salts.
3. To be able to perform calculations regarding concentrations of solutions in different units, prepare solutions of required concentrations in the laboratory using proper techniques.
4. To effectively use of equipment in the laboratory to properly measure the Potential , pH, Conductance, Angle of rotation of optical active compounds, Refractive Index , Concentration of various metals and organic as well as inorganic compounds present in water, acids and alkalis.
5. To characterize and synthesize nanoparticles of precious metal and its oxides using chemical method
6. To understand and identifying safety devices including Pressure Relief Valve, Rupture Disks, Blow down Systems, Flare Systems, Flame arresters, Deflagration arresters and Explosion suppression, Personal Safety Devices.
7. To analysis Process Safety using basic fundamentals including HAZAN and HAZOP comparison, Risk analysis and Estimation, Safety check list and Computer based quantitative risk analysis.
8. To achieve knowledge of principles of GMP and GLP and its application in pharmaceutical industries including Guidelines, classification, Various Schedule (X, O, M), Violation of GMP and GLP

Chemical Kinetics

1. To determine the reaction velocity constant for the reaction between acetone and iodine.
2. To determine heat and entropy of vaporization of a given liquid by a kinetic approach
3. To determine the kinetic parameters of the reaction and the temperature coefficient of the reaction between $KBrO_3$ and KI.
4. To determine the kinetic parameters of the reaction and the temperature coefficient of the reaction between $K_2S_2O_8$ and KI.

Physico- Chemical Exercise

1. To determine the amount of Paracetamol in a given tablet using Spectrophotometer.
2. To examine Lambert- Beer law in concentrated solutions using Spectrophotometer.
3. To scan the absorption spectrum of $KMnO_4$ and to determine the wave length of maximum absorption using Spectrophotometer.
4. To determine the concentration of an unknown solution of optically active compound using Polarimeter.
5. To determine the dissociation constant of saturated benzoic acid by pH metry.
6. To determine the concentration of sodium acetate by conductometry.
7. To determine the concentration and amount of acid in a mixture of HCl and CH_3COOH by pH metry.

8. To determine the specific and molecular rotation of cane sugar and intrinsic rotation using Polarimeter.
9. To determine the concentration of saturated benzoic acid by Conductometry.
10. To determine the normality and dissociation constant of the given saturated benzoic acid by Potentiometry.
11. To determine the concentration and amount of acid in a mixture of HCl and CH_3COOH by Potentiometry.
12. To determine the molar refraction and refractive index of a given NaCl salt using Refractometer.
13. To study the variation of refractive index with composition of given liquids and also to determine the composition of unknown mixture using Refractometer.

Multistage Synthesis:

1. To prepare Dihydropyridine derivative (Hantzch pyridine synthesis).
2. To prepare Dihydropyrimidine derivative (Biginelli reaction)
3. To prepare Benzanilide from Benzophenone (Beckmann rearrangement). (Two step)
4. To prepare Acredon from Phthalic acid. (Six step)
5. To prepare 2,3-diphenyl thiazolidine from benzalidine aniline (Schiff base). (Two step)
6. To prepare p-amino benzene sulfonamide (sulfanilamide) from acetanilide. (Three step)
7. To prepare 7-Hydroxy-4-methyl Coumarin from resorcinol. (Two step)
8. To prepare 2-phenyl indole from acetophenone.(Two step)
9. To prepare Benzilic acid from benzoin. (Two step)
10. To prepare 2-Formyl Pyrrole from Pyrrole (Vilsmeier-Haack)
11. To prepare 3-Formyl Indole from Indole (Vilsmeier-Haack)
12. To prepare N-Acetyl Indole from Indole.(Acetylation)
13. To prepare 3-Acetyl Indole from Indole. (Acetylation)

Nanoparticles:

1. To Prepare and characterize the ZnO nanoparticle
2. To Prepare and characterize the CuO nanoparticle
3. To Prepare and characterize the Fe_2O_3 nanoparticle
4. To Prepare and characterize the NiO nanoparticle

Industrial Safety & Management:

Case studies on followings:

- Process Safety
- Safety devices & Process safety Analysis
- GLP & GMP in Pharmaceutical Industries
- Shutdown & Disaster Management

16PICCE02	Scientific Writing	01 hr/wk	01 Credit

Objectives:

1. To learn literature and patent search using E-resources.
2. To understand variance between various Full paper, article, patent, communication and review article.
3. To search article using keywords, sentence.
4. To understand the IPR policy, patent filling, significance and Intellectual patent applications.

Unit-I:Database Search (02 hrs)

- Literature search, searching various scientific peer reviewed journals for given topics.
- Downloading research articles, review, patent etc.

Unit-II:Articles Review (02 hrs)

- Difference between Full article, letters, note, communication, mini review and review with case study.

Unit-III:Scientific Writing (02 hrs)

- Writing research article:
- Introduction, result & discussion, chemistry, Experimental section, acknowledgement & references.

Unit-IV:Patent (03 hrs)

- Introduction to IPR (Intellectual property rights), Patent searching, downloading, reading and filling.
- Difference between patent and provisional patent.
- Significance of Patent.

Unit-V:Seminar Presentation (03 hrs)

- Presentation (ppt) of recent research paper published in the SCI journals or Patent:
- Full article, letters or review, Patent.

Reference Books:

1. Francis J. Waller, (2002), Writing Chemistry Patents and Intellectual Property: A Practical Guide, Wiley