ಮಂಗಳೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

MANGALORE UNIVERSITY

(Accredited by NAAC Grade)

ಕ್ರಮಾಂಕ/No. : MU/ACC/CR.26/2025-26/A2

ಕುಲಸಚಿವರಕಛೇರಿ
ಮಂಗಳಗಂಗೋತ್ರಿ – 574 199
Office of the Registrar
Mangalagangothri – 574 199
ದಿನಾಂಕ/Date:31.07.2025

NOTIFICATION

Sub: Revised syllabus of M.Sc. in Industrial Chemistry Programme.

Ref: Academic Council approval vide agenda No.:ಎಸಿಸಿ:ಶೈ.ಮ.ಸಾ.ಸ.1:1 (2025-26) dtd 18.07.2025.

*****

The revised syllabus of M.Sc. in Industrial Chemistry Programme which has been approved by the Academic Council at its meeting held on 18.07.2025 is hereby notified for implementation with effect from the academic year 2025-26 and onwards.

Copy of the Syllabus shall be downloaded from the University Website (www.mangaloreuniversity.ac.in)

REGISTRAR

To,

1. The Registrar (Evaluation), Mangalore University.
2. The Chairman, PG Board of Studies in Industrial Chemistry, Dept. of Industrial Chemistry, Mangalore University.
3. The Chairman, Dept. of Industrial Chemistry, Mangalore University.
4. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
5. The Director, DUIMS, Mangalore University – with a request to publish in the website.
6. Guard File.

Mangalore University

M.Sc. Industrial Chemistry Program under

(CHOICE BASED CREDIT SYSTEM-SEMESTER SCHEME)

SYLLABUS

DEPARTMENT OF INDUSTRIAL CHEMISTRY

MANGALORE UNIVERSITY

MANGALGANGOTHRI

MANGALORE-574199

STATE: KARNATAKA, INDIA.

(Revised from the Academic Year 2025-2026 onwards)

MANGALORE UNIVERSITY
DEPARTMENT OF INDUSTRIAL CHEMISTRY

M.Sc. DEGREE PROGRAMME IN INDUSTRIAL CHEMISTRY
(Effective from the Academic Year 2025-26)

Two years Master Degree program (Four Semesters**)** M.Sc. Industrial Chemistry (CBCS)

PREAMBLE
Revision of syllabi for the two-year master's degree (Choice Based Credit System-Semester Scheme) program in industrial chemistry

The postgraduate Board of Studies (BOS) in Industrial Chemistry has revised and prepared the syllabi (CBCS-based) for the PG course in Industrial Chemistry by giving certain guidelines to offer hard core, soft core, and open elective courses, with credits totalling **90** for the entire program.

There are a total of **9** theory courses and one semester-long industrial project in the IV semester, all assigned as hard-core courses, with a total of 52 credits. Students are required to study **3** soft core courses each in the I, II, and III semesters. A choice of soft-core courses is provided in these semesters (I, II, and III semesters) for Industrial chemistry postgraduates. All 9 practical courses will be taught as soft-core courses, each carrying 2 credits in the I and II semesters, whereas practical courses in the III semester carry 3 credits each. The total soft-core credits amount to 32. The Board of Studies in Industrial Chemistry has chosen two open elective courses for the students from other disciplines, one each in the II and III semesters, with a total of 6 credits. Therefore, the grand total of credits for the program is **90.**

A detailed skeleton of the entire programme is tabulated for the benefit of aspiring postgraduates. Other important aspects, such as the university question paper pattern, internal assessment examinations, allotment of marks, and approximate dates of the internal assessments, are also discussed and tabulated in the Board of Studies meeting.

Program Objectives:
The M.Sc. Industrial Chemistry course aims to impart both theoretical knowledge of chemistry and hands-on experience to the students. The program includes an in-depth study of various areas in the chemical sciences, introduced at the core curriculum level. It emphasises both theoretical and experimental solutions to problems and prepares students for careers in contemporary industries. Key areas covered include agrochemicals, pharmaceutical chemistry and petrochemicals. In addition to the theoretical and laboratory-based curriculum, students undertake advanced project work in the final semester of the programme, carried out in an industrial sector.

The degree provides a solid foundation in core chemical sciences, fostering critical thinking, analytical skills, problem-solving skills, self-directed, lifelong learning, ethics and professionalism. Throughout the academic programme, students also develop strong written and oral communication abilities, learn teamwork, and acquire project management skills.

The objectives of this Postgraduate program include:

- To provide the highest level of education in chemical sciences and provide competent, creative and imaginative scholars
- To encourage free will and objective oriented enquiry for knowledge
- To make a significant contribution towards the development of skilled technical manpower Thus cater to the need of growing demand of intellectual reservoir in the nation.
- The program is designed to achieve the objectives and to inculcate in the students' concepts and intellectual skills, courage, integrity, awareness and sensitivity towards the needs and aspirations of the society

BASIS FOR INTERNAL ASSESSMENT

Rules for an internal assessment

Internal assessment marks in the theory papers of I, II and III semesters shall be based on average of two tests conducted between 10^{th} and 14^{th} weeks after the start of a semester.

Internal assessment in the I Semester shall be awarded as: 20 marks for the test and 10 marks for an assignment written on a given industrially related topic.

Internal assessment in the II Semester shall be awarded as: 20 marks for Test and 10 marks for seminar/ assignment/ report on attended National/ International conference/ workshop/training program for hard core subjects, and an assignment for softcore subject.

Internal assessment in the III Semester shall be awarded as: 20 marks for Test and 40 marks for industrial visit report which will be equally distributed between three hard core and one soft core paper.

Practical internal assessment (IA) marks shall be based on Practical test (20 marks), Viva-voce (05 marks) and record (05marks) for I, II, and III semesters.The practical test may be conducted towards the end of the semester.

THEORY QUESTION PAPER PATTERN FOR HARD CORE, SOFT CORE AND OPEN ELECTIVE COURSES

Question Papers in all the four semesters shall consist of Parts A and B.

Part A shall contain eight (8) very short answer questions carrying 2 marks each drawn from all the four units of the syllabus (2 questions per unit). Five (5) questions are to be answered. There may be a maximum of two sub-divisions per question, carrying one (1) mark per sub-division.

Part B shall contain eight (8) brief and/or long answer questions carrying 12 marks each drawn from all the units of the syllabus (minimum 2 questions per unit). There may be a maximum of three sub-divisions per question, carrying 3 or more marks per sub-division. Five (5) out of eight (8) questions are to be answered, it is compulsory to attempt one full question from each unit in Part B, and any one question any of the four units. The total marks awarded to each course is 70.

PRACTICALS EXAMINATION PATTERN

In all the semesters 70 marks shall be awarded based on the experiment. All the three semesters I, II and III semesters, out of 70 marks, 20 marks are for the viva-voce to be conducted during practical and 50 marks for the experiment and the scheme of evaluation can be decided by the examiners during examination.

Candidates of IV semester shall undergo a compulsory project work in an industry for four months and prepare a report on their work. The Project Report shall be evaluated by two examiners as in the case of theory papers. Internal Assessment marks shall be allotted by project supervisors at the industry. The progress of the project work of a student will be evaluated time to time by internal guide from the department. Viva-Voce examination is to be conducted as per the University regulations.

Two-year Master's Degree Course (Four Semesters) M.Sc. Industrial Chemistry (CBCS)

Sl. No.	Semester	Hard core credits	Soft core credits	Open elective credits	No. of Practical Paper/ Project*	No. of Theory Paper	Total credits
1.	I Semester	12	9	-	3 (S)	3(H) +1(S)	21
2.	II Semester	12	9	3	3 (S)	3(H)+1(S)	24
3.	III Semester	12	12	3	3(S)	3(H)+1(S)	27
4.	IV Semester	16	02	--	Industrial Project (H)	-----	20
	Total	**52**	**32**	**6**			**90**

Details of the credit distribution of the program

Description of course	Courses (Hard Core/ Soft core)	Teaching Hrs./week	Credits	Hrs. of exam	Max Marks: Exam + IA =Total
I SEMESTER					
ICH 401: Inorganic Chemistry	H	4	**4**	3	70+30=100
ICH 402: Organic Chemistry-I	H	4	**4**	3	70+30=100
ICH 403: Physical Chemistry	H	4	**4**	3	70+30=100
ICS 404: Environment Health and Safety Measures	S	3	**3**	3	70+30=100
ICS 405: Paper and Textile technology	S				
ICP 406: Inorganic Chemistry Practical's-I	S	4	**2**	4	70+30=100
ICP 407: Organic Chemistry Practical's-I	S	4	**2**	4	70+30=100
ICP 408: Physical Chemistry Practical's-I	S	4	**2**	4	70+30=100
Total	3 (H), 4 (S)	27	**21**		**700**
II SEMESTER					
ICH 451: Analytical Chemistry	H	4	**4**	3	70+30=100
ICH 452: Advanced organic Chemistry	H	4	**4**	3	70+30=100
ICH 453: Energy Systems, Colloids and Petrochemicals	H	4	**4**	3	70+30=100
ICS 454: Chemical Engineering Technology	S	3	**3**	3	70+30=100
ICS 455: Chemical analysis in agro and food industries	S				
ICP 456:Techniques in quantitative analysis	S	4	**2**	4	70+30=100
ICP 457:Estimations and extractions in organic chemistry	S	4	**2**	4	70+30=100
ICP 458:Electroanalytical techniques	S	4	**2**	4	70+30=100
ICE460: Chemistry and preparation of household chemicals and cosmetics	OE	3	3	2	70+30=100

Total	3 (H), 4 (S), 1 (OE)	30	24		**800**
III SEMESTER					
ICH 501: Spectroscopic Techniques	H	4	4	3	70+30=100
ICH 502: Industrial Catalysis and green chemistry	H	4	4	3	70+30=100
ICH 503: Synthetic, Heterocyclic and Medicinal Chemistry	H	4	4	3	70+30=100
ICS 504: Computer aided drug design	S	3	3	3	70+30=100
ICS 506: Polymers and display materials	S				
ICP 506: Synthesis of complexes, catalysts and estimation of alloys	S	6	3	5	70+30=100
ICP 507: Systematic qualitative analysis and identification of organic compounds	S	6	3	5	70+30=100
ICP 508: Synthesis, characterization and applications of Polymersand composites	S	6	3	5	70+30=100
ICE510: Pesticides and their environmental impact assessment	OE	33	3	2	70+30=100
Total	3 (H), 4 (S), 1 (OE)		**27**		**800**
IV SEMESTER **Project Work (4 Months)**					350+150
ICH 551: Project dissertation	1 (H)	16	**16**		100
ICH 552: Viva-voce Examination	1(S)	02	**02**		**Total= 600**
Total	1(H), 1 (S),	20	**90**		**Grand Total=2900**

Programme Outcome for M.Sc. in Industrial Chemistry

SL. NO	Details
PO1	**Analytical Skills:** Graduates will gain the ability to collect, analyze, interpret, and apply data in a variety of contexts. They might also learn and understand to use specialized software or equipment
PO2	**Problem-Solving Skills:** Graduate will acquire the skills necessary to utilize their knowledge in order to identify, analyze, and address issues pertinent to their area of study
PO 3	**Disciplinary Knowledge:** Graduates will gain an in-depth comprehension of their selected subject. mastering both essential principles and theories, as well as advanced concepts. In addition to that, they will apply a strong theoretical and practical understanding developed through the specific program in their area of work
PO4	**Ethics and Professionalism**: Graduates may learn about the ethical and professional standards in their field, and how to apply then in real-world situations
PO5	**Research Skills and Scientific temper:** Depending on the field, graduates might learn how to design and conduct experiments or studies, analyze results, and draw conclusions in addition to that graduates might also learn how to review and understand

	academic literature.
PO6	**Communication Skills:** Graduates may learn to present complex information clearly and succinctly, write detailed reports, and collaborate with others
PO7	**Self –directed and Lifelong Learning:** The capacity to operate autonomously, recognize the necessary resources for a project, and oversee the project until its completion, while also being able to participate in independent and lifelonglearning within the extensive frame work of socio-technological transformations
PO8	**Critical thinking:** Graduate may able to employ analytical thinking within a body of knowledge and also can assess and appraise evidence, claims and beliefs based on empirical data, recognize pertinent assumptions, and critically assess policies, theories by adhering to a scientific methodology for knowledge advancement

Program Specific Outcomes for M.Sc. Industrial Chemistry

SL. NO.	Details
PSO1	The two years course of M.Sc. program helps the students to understand the essential concepts, principles, and theories associated with organic, inorganic, physical chemistry and its applications, also can demonstrate skill, hands on experience in conducting experiments within laboratory in chemical industries **(PO3)**
PSO2	The program helps the studentsto examine intricate issues, assess data, and implement theoretical principles in real-world contexts, recognize assumptions, and make judicious decisions and convey ideas proficiently **(PO8)**
PSO3	The program helps the students to utilize theoretical concepts and critical reasoning with technical skill to address the issues, and can gather data, investigate novel design opportunities **(PO8)**
PSO4	The program helps the students to devise research inquiries, perform literature reviews, organize and implement research studies in collaboration with chemical industries and academic research institutions**(PO5)**
PSO5	The program helps the students to cultivate diverse communication skill which include writing, listening, and speaking to facilitate the successful articulation of ideas and perspectives **(PO6)**
PSO6	The program helps the students to get jobs in chemistry and its related area, additionally, students will also learn how to start their own business in chemistry filed, so they can create their own jobs in the future **(PO1)**
PSO7	The program helps the students to develop analytical skill capacity to operate in research and development center in chemical industries as well as the ability to apply procedural knowledge to conduct scientific experiments with proficiency labs and **(PO2)**
PSO8	The program helps the students will be well-versed in ethical issues in professional practice and research, as well as chemical safety procedures, additionally, students will be dedicated to sustainable and green chemistry techniques and aware about how chemical operations affect the environment **(PO4)**

I SEMESTER

Course Name: **INORGANIC CHEMISTRY**
Course Code: ICH-401
Course Type: Hard core
Contact Hours/Week: 4L **Course Credit:** 04

Course Objectives

- To understand the fundamental principles of coordination chemistry, including structure bonding, and reactivity of coordination compounds.
- To analyze various metallurgical processes and their industrial significance.
- To explore the chemistry and applications of organometallic compounds
- To apply symmetry concepts to predict molecular properties and understand electronic transitions.
- To correlate theoretical models (VBT, CFT, MOT) with the properties of coordination complexes.

Course Content

UNIT I: Coordination Chemistry **14 hr**.
Introduction and important terms pertaining to coordination compounds and naming of coordination compounds, Isomerism in coordination compounds (types of stereo isomerism and structural isomerism examples), theories of coordination chemistry : postulates and defects of Werner's theory, Sidgwick's electronic concept theory (Effective Atomic Number Rule), Valence bond theory, Crystal field theory (crystal field splitting in octahedral and tetrahedral coordination entities), Molecular orbital theory of coordination complexes, thermodynamic and kinetic stability, Ligand field effects on reaction rates. Magnetic properties, colors of coordination compounds, factors affecting the stability of coordination compounds, significance and applications**.**

UNIT II: Organometallics **14 hr.**
Historical development, classification and nomenclature, stability, 16 and 18 electron rules,Transition metal alkyls and aryls- types, routes of synthesis, stability and decomposition pathways, Nucleophilic and electrophilic cleavage of metal-carbon sigma bonded compounds. Alkane activation. Transition metal to carbon multiple-bonded compounds-carbonyls, nitrosyls, metal-alkene, metal cyclopentadiene, metal-arene complexes.

UNIT III: Bioinorganic Chemistry **14 hr.**
Transport and storage of dioxygen- heme proteins, oxygen uptake, functions of haemoglobin, myoglobin, hemerythrin and hemocyanin's, synthetic oxygen carriers. Metal storage and transport – ferritin, transferrin and ceruloplasmin. Electron transfer proteins-cytochromes, iron-sulphur proteins. Metalloproteins as enzymes–carboxy peptidase, carbonic anhydrase, alcohol dehydrogenase, catalases, peroxidases, cytochrome P450, superoxide dismutase, copper oxidases, vitamin B12 coenzyme.

UNIT IV:Molecular Symmetry and Group Theory:**14 hr.**
Symmetry elements and operations, Group theory- Concept of a group, definition of point group. Classification of molecules, Group multiplication tables. Matrix representations of symmetry operations, class similarity transformation, reducible and irreducible representations. The great orthogonality theorem. Character tables, relationship between representations and wave functions. Group theory and hybrid orbitals. Group theory and MO's. Molecular vibrations- Symmetry types of normal modes of vibrations. Selection rules for fundamental vibrational transitions, symmetry considerations to determine IR active and Ramanactivelines.

Books and References

1. Carter Robert I: Molecular Symmetry and Group Theory, JohnWiley,2005
2. Agarwala U C Et Al., Molecular Symmetry in Chemistry Via Group Theory, Ane Books,2013.
3. V. Ramakrishnan and M.S. Gopinathan: Group Theory in Chemistry,Vishal,1988
4. Heine, Volker: Group Theory in Quantum Mechanics an Introduction to Its Present Usage, Pergamon,1964.
5. F.A. Cotton: Chemical Applications of Group theory, Wiley, NewYork,1993.
6. Bodsworth C: Metallurgy and metallurgical engineeringseries, CBS,1988
7. Johnson, Carl G: Metallurgy, The times ofindia,1956.
8. Chemistry of the Elements, N.N. Greenwood& A. Earnshaw, Butterman-Hellmann, 2005.
9. Principles of Extractive Metallurgy, H. S. Ray and A.Ghosh.
10. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International, 1999.
11. Principles of Bioinorganic Chemistry by S J Lippard and J M Berg. pp 411. University Science Books, Mill Valley, California. 1994.
12. Bioinorganic Chemistry, Asim Das, Mahua Das, Ankita Das, 2007.
13. Introduction to Bioorganic Chemistry and Chemical Biology, David Van Vranken, Gregory A. Weiss, Garland Science, 2012.
14. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, Wiley, 1991.
15. Concise Inorganic Chemistry, J.D. Lee, Fifth edition,2008.
16. Advanced Inorganic Chemistry, Gurdeep Raj Vol I and Vol II First edition 2019.
17. Textbook of Inorganic Chemistry, G.S Sodhi. First edition 2013.
18. Inorganic Chemistry, J.E. Huheey, E.A. Keiter, and R.L Keiter, 4th Ed.1993.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Integrate theoretical knowledge to solve mechanistic and structural problems in coordination chemistry and apply this knowledge in research or industrial contexts-**Apply**
CO 2: Analyze the electronic structures and reactivity patterns of organometallic complexes using MO theory and oxidation state consideration -**Analyse**
CO 3: Evaluate the role of organometallic compounds in industrial and synthetic processes. Evaluate
CO 4: Interpret the function and coordination chemistry of metal complexes in photosynthesis, respiration and electron transfer process -**Understand**
CO 5: Discuss the application of bioinorganic principles in medicine-Understand
CO 6: Apply concepts of point groups to classify molecules –**Apply**
CO 7: Utilize group theory to analyze molecular vibrations and predict IR and Raman activity. Analytical skill -**Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH 401	Program Outcomes (POs)							
Course outcome	1	2	3	4	5	6	7	8
CO 1	✓		✓					
CO 2								
CO 3		✓						
CO 4					✓			
CO 5			✓		✓			✓
CO 6		✓						✓
CO 7		✓		✓			✓	

Course Name: **ORGANIC CHEMISTRY-I**
Course Code: ICH-402
Course Type: Hard Core
Contact Hours/Week: 4L **Course Credit:** 04

Course Objectives

- To study and discuss the fundamentals concept of acid and bases used in organic synthesis
- To understand the characteristics of reaction intermediates and the influence of reaction conditions, including the type of solvent, isotopic effect, and the effect of salts
- To study the various types of reactions along with their kinetics, as well as the thermodynamic principles and the influence of thermodynamic parameters on reactions in relation to kinetic factors
- To comprehend the mechanisms of aliphatic and aromatic nucleophilic and electrophilic substitution reactions, along with the influence factors and associated with its various types of named reactions
- To comprehend and implement the diverse elements of stereochemistry and the applications of chirotechnology in asymmetric synthesis
- An exploration of aromaticity through various concepts, the assessment of aromaticity using different parameters, and a study of annulenes and the classification of aromaticity

Course Content

UNIT I: Reaction mechanism and its intermediates 14 hr.
Acids and Bases: Introduction to acids and bases, Bronsted-Lowry and acid-bases concept, organic acids and bases, Pearson's HSAB concept, pKa and pH, effect of solvent on acid and base strength, effect of structure of organic compound on acid and base strength. Reactivity in relation to molecular structure and conformation
Reaction intermediates: Generation, structure, stability, reactivity & detection of classical & non-classical carbocations, carbanions, free radicals, carbenes, nitrenes & arynes. N, S & P ylides &enamines.

Organic Reactions and Mechanism: Reaction mechanism & types, types of organic reactions, reaction profile diagrams, thermodynamic & kinetic control, leaving group and solvent. Methods of determining reaction mechanisms: Kinetic & non-kinetic methods-identification of products, detection of intermediates, isotopic labelling, stereo chemical evidences, crossover experiments, kinetic evidences & kinetic isotopic effects. The Hammond postulate. Principle of microscopic reversibility and Marcus theory. Steric effects. F strain, B-strain. Bond angle strain. The Hammett equation and its applications, Ortho effect, Taft equation, Linear free energy relationships

UNIT II: Organic Reactions and Mechanism (Part-I) 14 hr.

Aliphatic Nucleophilic Substitution reactions: Mechanisms Nucleophilic substitution: Substitution reactions of ambident nucleophiles, neighbouring group participation of O, S, N, halogens, aryl groups, alkyl and cycloalkyl groups in nucleophilic substitution reactions. Sigma, Pi bond participation in acyclic and bicyclic systems (non-classic carbocations) Substitution at allylic, trigonal and Vinylic carbons, Meyer's synthesis of aldehydes, ketones and carboxylic acids, alkylation with trialkyl boranes.
Aliphatic Electrophilic substitutions: SE1, SE2and SEi mechanisms hydrogen exchange, migration of double bonds, halogenations of aldehydes, ketones, acids, acyl halides sulphoxides and sulphones, aliphatic diazonium coupling, nitrosation at carbon and nitrogen diazo transfer reaction. Decarboxylation of aliphatic acids. Haloform reaction and Haller-Bauer reaction.

UNIT III: Organic Reactions and Mechanism (Part-II) 14 hr.
Aromatic nucleophilic substitution: A general introduction to different mechanisms of aromatic substitution SN Ar, AN and aryne, Von Richter rearrangement, Sommlet, Hauser rearrangement Smiles rearrangement. Radical substitution Mechanism: Reaction at sp3 carbon: Reactivity in aliphatic substrates reactivity at bridged position, reactivity at sp2 carbon. Reactivity in aromatic substrates neighbouring group assistance in free radical reactions, effect of reactivity in the attacking radical, effect of solvent on reactivity halogenations at an alkyl carbon and allylic carbon, hydroxylation at aromatic carbon by means of Fenton's reagent, oxidation of aldehydes to carboxylic acids, formation of cyclic ethers with Pb $(OAC)_4$ Reed reaction, Sandmeyer reaction, Kolbe reaction and Hunsdiecker reaction.

Addition Elimination Mechanisms: (a) Addition to carbon multiple bonds- Addition reactions involving electrophiles, nucleophiles and free radicals, cyclic mechanisms, orientation and stereochemistry, hydrogenation of double and triple bonds, hydroboration, Reformatsky reaction, Tollen'sreaction, witting reaction, Prins reaction: (c) Elimination reactions: Stereochemistry of eliminations in acyclic and cyclic systems, orientation in eliminations - Saytzeff and Hoffman elimination propolitic elimination.

UNIT IV: Stereochemistry 14 hr.
Concept of chirality, optical isomerism, D, L-; R, S- designations, geometrical isomerism and E, Z designations, Stereo selective and stereo specific reactions, Racemization, mechanism of racemization, resolution of racemic mixtures, Asymmetric synthesis-definition, importance, mechanism, energy consideration, advantages and limitations, methods of determination of enantiomeric excess. Enantioselective reactions, The chiral pool, chiral auxiliaries and chiral reagents. Conformational isomerism and analysis in acyclic and simple cyclic systems - substituted ethanes, cyclopentane, cyclohexane and decalins, Aromaticity: Aromaticity and Huckel's rule, Aromaticity in benzenoid and non-benzenoid compounds, annulenes, and fullerenes. Alternant and non-alternant hydrocarbons, energy level of molecular orbital's, antiaromaticity, homoaromaticity, non-aromatic compounds.
Course Outcomes:
Books and References

1. Robert B. Grossman: The Art of Writing Reasonable Organic Reaction MechanismsSecond Edition, © 2003, Springer-Verlag New York, Inc. 1999.

2. Daniel E. Levy: Arrow Pushing in Organic Chemistry an Easy Approach to Understanding Reaction Mechanisms John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
3. Audrey Miller, Philippa H. Solomon: Writing Reaction Mechanisms in Organic Chemistry, Elsevier Science & Technology Books, ISBN: 0124967124, 1999
4. Organic Chemistry-P.Y. Bruice (Pearson Education Pvt. Ltd., New Delhi),2002.
5. Advanced Organic Chemistry-Reactions, mechanisms & structure-J.March (Wiley, NY)2000.
6. Organic Chemistry-Vol. -1,2 &3- Mukherji, Singh and Kapoor. (Wiley Eastern,) 1994.
7. A guide book of mechanisms in Organic Chemistry-P.Sykes (Orient- Longman) 1985.
8. Organic Chemistry-R.T. Morrison and R.N. Boyd (Prentice Hall, New Delhi) 1994.
9. Organic Chemistry 4thEdn.–S.H. Pine et al (McGraw-Hill, London) 1987.
10. Advanced Organic Chemistry- R.A. Carey and R.J. Sundberg (Plenum, New York)1990.
11. Modern Concepts of Advanced Organic Chemistry-R.P. Narein (Vikas, Delhi) 1997.
12. A Textbook of Organic Chemistry-Tewari, Vishnoi and Mehrotra (Vikas, New Delhi) 1998.
13. A Textbook of Organic Chemistry-3rdEdn.-R.K. Bansal, (New Age, New Delhi) 1997.
14. Organic Chemistry-3rdEdn- F.A. Carey (Tata McGraw Hill, New Delhi) 1996.
15. K. Mislow: Introduction to Stereochemistry, Published by W.A.BENJAMIN, 1965, Bookbarn International (Bristol, SOM, United Kingdom).
16. Stereochemistry, Conformation and Mechanism-P.S.Kalsi (Wiley Eastern, New Delhi) 1993.
17. Stereochemistry of Carbon Compounds-E.L.Eliel (Tata McGraw Hill, New. Delhi) 1994.
18. Lowry T.M. and Richardson K.S., Mechanism and Theory in Organic Chemistry, 3rd ed, Addison-Wesley-Longman, 1998. Current literature.
19. Anslyn, E.V., and Dougherty, D.A., Modern Physical Organic Chemistry, University Science Books, 2006.
20. Wyatt P. and Warren S, Organic Synthesis, Strategy and Control,; Wiley 2007.
21. Carbohydrates: The essential molecules of life, R. V. Stick, S. J. Williams, Elsevier, Oxford, 2001 3.
22. Organic synthesis with carbohydrates, G.-J. Boons, K. J. Hale, Blackwell Science, Inc., Malden, 2000
23. F. A. Carroll, Perspectives on structure and mechanism in Organic Chemistry,Wiley, 2011.
24. J. McMurry, Organic Chemistry, 5th ed., Brooks/Cole, 2000.
25. R. Bruckner, Advanced organic chemistry: Reaction Mechanisms. Academic Press, 2001.
26. P. Sykes, Guidebook to Mechanism in Organic Chemistry, 6th ed., Prentice Hall, 1986.
27. J. Clayden, N. Green, S. Warren and P. Wothers: Organic Chemistry, 2nd Ed., Oxford University Press, 2012.
28. S. H. Pine: Organic Chemistry, 5th Ed., McGraw Hill, 2008.
29. M. B. Smith, Organic Synthesis, 2nd ed., McGraw-Hill, 2000.
30. Structure and Mechanism in Organic Chemistry C.K. Ingold, Cornell University Press 1893-. Publication date: 1969.
31. Text book of Organic Chemistry, Fessendon and Fessendon. American Chemical Society (ACS) 1987
32. Mechanism and theory in organic chemistry, Thomas H Lowry, K.S. Richardson, Harper & Row, Publishers. 1976
33. Strategic applications of named reactions in organic synthesis: Laszlo Kurti & Barbara Czako; Elsevier Academic Press. 2005
34. Organic Chemistry (3/e) by J. B. Hendrickson, Donald J. Crem and George S. Rammond McGraw-Hill Book Co. & Kogekusha Co. Ltd., 1970.
35. Basic organic stereochemistry; By Ernest Ludwig Eliel, Samuel H. Wilen, Michael P. Doyle, Published by Wiley-Interscience.
36. Introduction to Stereochemistry; By Kurt Martin Mislow, Dover Publication INC.2012

37. Basic Stereochemistry of Organic; By SubrataSen Gupta, First edition, Published by Oxford University Press.2014.

Course Outcome

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Evaluate the reactivity and strength of different acids and bases. Analyze

CO 2: Utilize strategies and tactics to investigate organic reaction processes. Apply

CO 3: Put forward a reasonable mechanism for a given organic reaction. Evaluate

CO 4: Provide examples of the various types of reactions and rearrangement processes and mechanistic pathways. Analyze

CO 5: Determine the process and end result of a certain addition, Elimination and CO nucleophilic substitution reaction. Analyse

CO 6: Recognize the idea of organic compound configuration and conformation Understand

CO 7: Apply the concepts of stereochemistry and conformation of outcome of a reaction Apply

CO 8: To acquire knowledge on the generation of reactive intermediates, their mechanisms along with their applications in organic synthesis and industrial context. Apply

CO 9: Describe strategies for the stereo specific/stereo selective organic transformations towards chiral target molecules. Apply

CO 10: Identify chirality in molecular structures, and recognize the relationship between enantiomeric and distereomeric structures Analyze

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH 402	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓					✓
CO 2	✓	✓	✓					
CO 3			✓		✓			
CO 4			✓		✓			
CO 5			✓					
CO 6			✓					✓
CO 7			✓		✓			
CO 8	✓	✓	✓		✓			✓
CO 9	✓	✓	✓		✓			✓
CO 10	✓		✓		✓			

Course Name: PHYSICAL CHEMISTRY
Course Code: ICH-403
Course Type: Hard Core
Contact Hours/Week: 4L **Course Credit:** 04

Course Objectives

- To provide a comprehensive understanding of the fundamental principle of quantum mechanics and thermodynamics as applied to chemical system.
- To develop the ability to analyze and interpret reaction kinetics, including the mechanisms and factors influencing chemical reactions
- To impart the knowledge on the causes, types and prevention methods of corrosion and the importance of corrosion control in industry.
- To know metal finishing processes, their technological aspects, and industrial applications.
- To introduce the application of electrochemistry in the chlor-alkali industry, electrosynthesis, and electrochemical engineering, emphasizing modern technological developments.

Course Content

UNIT I: Quantum mechanics 14 hr.

Quantum mechanics: Quantum theory and atomic spectra; the Bohr model, Photoelectric effect, de Broglie's hypothesis and wave-particle duality of material particles, Heisenberg's uncertainty principle, theory of wave motion, the wave function and its physical meaning, operators, Eigen values and Eigen functions, basic postulates of quantum mechanics, time independent Schrodinger wave equation, Application of Schrodinger wave equation to particle in a ID box.

UNIT II: Thermodynamics and Chemical kinetics 14 hr.

Thermodynamics: Terminology, Laws of thermodynamics. Heat changes in chemical reaction-Born-Haber cycle, bond energy, Kirchhoff's equation, flame and explosion temperature, calculation of heat of reaction. Free energy change and work function. Entropy-Evaluation, dependence on variables of a system, degradation of entropy. Entropy changes in chemical reaction. Thermodynamics of mixing. Theory and determination of Chemical Potential. Liquid mixtures. Excess functions for non-ideal solutions.

Chemical kinetics: A brief review of basic concepts and terminologies in reaction kinetics. Rate law and factors effecting rate law. Steady state approximation. Complex reactions-reversible, parallel, consecutive and chain reactions, Explosive reaction (H_2-O_2,) [qualitative aspects only].

UNIT III: Corrosion 14 hr.

Corrosion: Fundamentals of corrosion. Corrosion related damage, Types of corrosion (Galvanic, atmospheric, microbiological & stress). Methods of prevention & control (organic & inorganic coating, inhibitors, cathodic & anodic protection, material selection & design improvement). Corrosion problems in practice, passivity. Thermodynamics & kinetics of corrosion. Corrosion rate measurement (weight loss, Tafel extrapolation, polarization resistance) & monitoring. Concept & analysis of corrosion failure. Metal Finishing & Processing: Metal finishing & technological importance, Essentials of metal finishing, fundamentals of electrodeposition, effect of plating variables on the nature of electrodeposit, electroplating process, electroplating of copper, nickel, chromium & gold. Principles & applications of electroless plating, electrochemical etching, electrophoretic painting & electroforming.

UNIT IV: Chloro-alkali Industry, Electrosynthesis, Electrochemical Engineering 14 hr.

Chlor-alkali Industry: General concepts of brine electrolysis, modern technological developments, chlorine cell technologies, production of potassium hydroxide.

Electrosynthesis: Fundamentals of electro-organic& electro-inorganic synthesis, Kolbe's synthesis, electroreduction and oxidation of hydrocarbons, electroreduction of nitro compounds, synthesis of adiponitrile. Electro-inorganic synthesis of fluorine, chlorate and ozone.

Electrochemical Engineering: Qualitative aspects of general considerations, costing of an electrolytic process, performance and figures of merit, electrolysis parameters, principles of cell design, laboratory data and scale up.

Books and References

1. Basic Quantum Chemistry, Harish Kumar Pandey Bookwomb Publisher 2018.
2. Quantum Chemistry, Ira N. Levine, 5thedn., Prentice Hall of India Pvt. Ltd., 2006.
3. Quantum Chemistry, R. K. Prasad, 4th revised edition, New Age International (P) Ltd., New Delhi.
4. Quantum Chemistry, Donald A. McQuarine, Viva Student Edition.
5. Principles of Quantum Chemistry, Ram Yatan Prasad & Pranitha, Cambridge University Press.
6. Thermodynamics for Chemists, S Glasstone, East-west Editon, New Delhi, 2003.
7. Chemical Thermodynamics-Basic Theory and Methods, 4thEdn., Klotz, Rosenbeg, Benjamin, 1986
8. Principles & Applications of Electrochemistry, D R Crow, 3rdEdn., Chapman & Hall,1987.
9. Chemical Kinetics, K J Laidler, Harper & Raw.
10. Chemical Kinetics-Hareesh Mehra, Alfa publishing, New Delhi, 2006
11. Industrial electrochemistry by and Walsh, F.C. II ed, Chapman and Hall (1990)
12. Modern Electrochemistry, Vol I, IIA &IIB(1998) J.O.M. Bockries and A.K.N.Reddy Pentium. Press, New York (1970).
13. Engineering Chemistry by Jain and Jain 16 th ed, 2017.
14. Corrosion Engineering by Fontana, Mars G., McGraw-Hill international 1978

Course Outcomes:

CO 1: Apply mathematical tools like Schrodinger's equation to solve basic quantum mechanical problems- **Apply**

CO 2: Understand the terminology, laws of thermodynamics and complex reaction mechanisms, including explosive reactions- **Understand**

CO 3 : Evaluate methods for prevention and control of corrosion, including inhibitors and passivation. – **Evaluate**

CO 4: Analyse the industrial production and applications of various electrochemically synthesized compounds. -**Analyse**

CO 5: Apply electrochemical principles to industrial processes, including electrosynthesis and electroplating- **Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH 403	**Program Outcomes (POs)**							
Course outcome	1	2	3	4	5	6	7	8
CO 1	✓	✓	✓					✓
CO 2	✓		✓		✓	✓		✓
CO 3		✓			✓			✓
CO 4	✓	✓	✓					✓
CO 5			✓		✓			✓

Course Name: ENVIRONMENT, HEALTH AND SAFTEY MEASURES.
Course Code: ICS-404
Course Type: Soft core
Contact Hours/Week: 4L **Course Credit: 03**

Course objectives

- To impart knowledge of environmental pollution and control measures
- To create awareness of occupational health hazards, risks, and personal protection methods
- To introduce waste management techniques, including hazardous waste and biomedical waste
- To educate students on laws and related to environment and occupational safety
- To develop skills in implementing safety audits, risk assessments

Course Content

UNIT I: Air Pollution, Analysis and Control Methods 10 hr.
Qualitative study of environmental segments, air pollutants, prevention & control, greenhouse gases & acid rain. Carbon monoxide, sources and control techniques. SO_x-sources, control techniques-scrubbing, limestone injection process. Ozone hole & CFCs. Photochemical smog & PAN. NO_x - Sources, NO_x, control techniques. Particulates: Size distribution, particulate collection-settling chambers, centrifugal separators, wet scrubbers, electrostatic precipitators & fabric filters. Analysis of air pollutants, Dispersion of air pollutants-weather, wind speed and acidity.

UNIT II: Water, Waste Water Treatment and Analysi: 10 hr.
Hydrologic cycle, sources, criteria & standards of water quality- safe drinking water, maximum contamination levels of inorganic & organic chemicals, radiological contaminants, and microbial contaminants. Public health significance & measurement of color, turbidity, total solids, acidity, fluoride, alkalinity, hardness, chloride, residual chlorine, sulphate, fluoride, phosphate & different forms of nitrogen in natural & polluted water.

UNIT III: Quality Control and Quality Assurance 12 hr.
Role, Government standards like ISI, MINAS, Agmark, I.P., ASTM. Concepts of quality and quality control, the nature of variabilities. Specification and tolerances, sampling inspection, cost reduction and quality improvement experiments. Optimization.
Basic concepts of quality assurance, quality acceptance, sampling, reliability, cost aspects of quality decisions. Quality control in raw materials, production (in process) and finished product. Current trends in quality control, ISO 9000 and ISO 14000 series. Laws related to quality control. ISO17025.
Chemical Warfare Convention**:** Definitions and schedules. Toxic chemicals tear gas, chemical weapons, ocean dumping of chemical weapons.
UNIT IV: **Good Laboratory Practice**s **10 hr.**
Safety equipment's, personal protective equipment's, compressed gas safety, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.
Emergency response-Chemical spills, radiation spills, biohazard spills, fires, medical emergency accident reporting, Safety rules of laboratory acquaintance of experimental set up and instruments, Intellectual property and intellectual property rights. Data management, importance of safety and security of data. Experimental process and risk assessment.

Books and References

1. Environmental Chemistry, A.K. Dey, 7th ed, New Age international Publishers, 2012.
2. Environmental Chemistry, S.K.Banerji, Prentice Hall India,1993.

3. Environmental Chemistry, B. K. Sharma.4th edition, GOEL Publishing House, New Delhi, 1998.
4. Chemistry of Water Treatment, S.D. Faust and O.M. Aly, Butterworths,1983.
5. Environmental chemistry, Ahluwalia V. K., Anne Books India,2008.
6. Chemistry for Environmental Engineering, Sawyer and McCarty, McGraw Hill,1978.
7. Environmental Chemistry, I.Williams, John Wiley,2001
8. Statistical Quality Control, 2nd Edn., Manohar Mahajan Dampat Rai and Sons,1995.
9. Quality management: a process improvement approach,Fryman Mark A, Cengage learning,2002.
10. Quality Control, Paranthaman D, Tata, McGrawHill,1987.
11. Gupta R. N. Chemical warfare and casualty management2011
12. Vyas M. N. Safety and hazards management in chemical industries 2013.Atlantic publication.
13. Dikshith T.S.S Safety evaluation of environmental chemicals. New Age International, 1996.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Explain different types of environmental pollution and evaluate pollution control techniques in Industry and laboratory setting.Evaluate

CO 2: Identify occupational health hazards and implement appropriate personal protective equipment and safety measures.Implementation

CO 3: Classify industrial, hazardous and implement appropriate personal protective equipment and safety measures. Apply

CO 4: Classify industrial, hazardous and biomedical wastes and suggest suitable treatment and disposal methods.

CO 5: Interpret national and international EHS regulations and apply them in workplace compliance strategies.**Apply**

CO 6: Conduct safety audits and risk assessments, and develop emergency response protocol effectively. **Implementation**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 404	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1			✓	✓	✓		✓	
CO 2		✓	✓	✓	✓	✓	✓	✓
CO 3			✓	✓	✓		✓	✓
CO 4	✓		✓	✓	✓		✓	✓
CO 5	✓		✓	✓			✓	
CO 6	✓		✓		✓		✓	

Course Name: PAPER AND TEXTILE TECHNOLOGY
Course Code: ICS-405
Course Type: Soft core
Contact Hours/Week: 4L **Course Credit: 03**
Course Objectives

- To explore different pulping methods; mechanical, chemical, and semichemical
- To provide foundational understanding of natural and synthetic textile fibres
- To assess the sustainability and circular economy aspects in the industry
- To understand raw materials, chemistry and processes involved in pulp production

Course Content

UNITI: 12 hr.
Pulp and Paper Science: Raw materials for paper, Important fiber producing plants, woody & non woody fibers used in paper industry, physical and chemical characteristics. Structure of wood, structural elements of wood and bark, cell wall & fiber morphology, chemical components of wood; **Pulp Manufacture:** Mechanical pulping, Thermomechanical and Refiner mechanical pulping, Semichemical and chemical pulping. Kraft pulping. **Papermaking:** Beating and refining of pulp.

UNIT II: 10 hr.
Textile Technology: Brief history on origin of textiles. Introduction to textile fibers and basic requirements of textile fibers. Manufacture of eco-friendly regenerated fiber. Brief study of physical & chemical properties of cotton, wool, silk & bast fibers. Importance and need of ginning. Impurities in the cotton and remedies to minimize impurities incotton.

UNIT III: 10 hr.
Introduction to blending techniques and its types. Blends of Polyester/cotton and polyester/viscose. Introduction to synthetic fibers. Raw materials for productions of PET, modified viscose rayon and their applications. Brief out line on production of acetate and cupramonium rayon and their applications.

UNITIV: 10 hr.
Coating and Recycling of paper and textile: Introduction to coating of Paper and metal foils. Fillers used in papermaking. Pressing: Objectives, types of presses, Drying: Theory and types, Finishing: Unwinding and rewinding. Evaluation of Paper: Physical, optical, electrical properties and Chemical properties of paper.
Objects of mixing and blending. Introduction to textile testing & quality control. Sampling techniques. Frictional, optical, electrical and thermal properties of textile. Recycling of paper and textile.

Books and References

Bleaching of Pulp, R. P. Singh, TAPPI Pres Atlanta, 1979.
Joint Text Book Committee of the Paper Industry, Vol. I to X, Technical Editor Benjamin A. Thorp Series Editor Michael J. Kocurek, Published by the technical section Canadian Pulp and Paper Association 1962.
Hand Book for Pulping and Papermaking, Christopher J.Biermann, Academic Press, Second Edition, 1996.
Hand Book for Pulp and Paper Technologists, Gary A.Smook, Formation of synthetic fibres, Walczalk.K. Gordon &Sci.London.
Manual of Cotton Spinning, Coulson. A.F.W. (Ed.), Vol. I toIV, Textile Institute Pub., Manchester,1989.
Spun Yarn Technology, Osteby, Butterworths, London,1987.
Physical Testing of Textiles, B.P. Soville, WoodHead,1999.

Principles of Textile Testing, Booth J. E., Butterworth, Wendon III Edition. 1968
Technology of Textile Processing, Technology of Dyeing, Shenai, V.A. 4th Edn., Sewak publications, Bombay,1988.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Understand the raw materials, chemistry and processes involved in pulp production- **Understand**

CO 2**:** Evaluate pulp quality using appropriate analytical techniques. – **Evaluate**

CO 3: Analyze the physical and chemical properties of common textile fibers. –**Analyse**

CO 4: Apply principles of green chemistry to optimize coating and recycling processes. **Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 404	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1			✓	✓	✓		✓	
CO 2		✓	✓	✓	✓	✓	✓	✓
CO 3			✓	✓	✓		✓	✓
CO 4	✓		✓	✓	✓		✓	✓

COURSE NAME: INORGANIC CHEMISTRY PRACTICAL'S -I

Course Code: ICP-406

Course Type: Chemistry practical

Contact Hours/Week: 4H **Course Credit: 2**

Course objectives:

- To develop proficiency in classical quantitative analytical techniques
- To impart the basic analytical and technical skills to work effectively in different fields of chemistry
- To perform accurate quantitative measurements with an understanding of the theory and use of contemporary chemical instrumentation, interpret experimental results, perform calculations on these results and draw reasonable, accurate conclusion
- To gain hands on experience in volumetric and gravimetric analysis with statistical analysis of data

Course Content

1. Analysis of Haematite-insoluble residue by gravimetry & Iron by volumetric method.
2. Analysis of Dolomite-insoluble residue by gravimetry & Ca, Mg by complexometric method.
3. Pyrolusite-Insoluble residue by gravimetry and Manganese content by oxalate method.
4. Estimation of percentage of copper inbrass.
5. Determination of iron using potassium dichromate.
6. Preparation of pure sample of ferrous ammonium sulphate (Mohr'ssalt)[$FeSO_4.NH_4)_2SO_4.6H_2O$]

7. Preparation of pure sample of potash alum (Fitkari) [$K_2SO_4.Al_2(SO_4)_3.24H_2O$]
8. Complexometric determination of Mn, Cu, Ni and Fe-Cr mixture
9. Determination of Hardness of water.
10. Analysis of Halide Mixture - Iodide by KIO_3 and total halide by gravimetrically.
11. Colorimetric Determination of Iron by thiocyanate and Cu by aqueous ammonia.
12. Gravimetric Determinations of Mn, Ni, Mo, Pb/Cr, sulphide,thiocyanate.
13. Spot test for the detection of inorganic ions (any ten cations).
14. Statistical analysis of data.

Books and References

1. G.H.Jeffrey, J.Bassette, J.Mendham and R.C.Denny, Vogel's TextBook of Quantitative Chemical Analysis ,5th Edition, Longman, 1999.
2. Vogel, "Textbook of Qualitative Inorganic Analysis", 3 Edition, ELBS. 1976.
3. D.A.Skoog and D.M.West, Fundamentals of Analytical Chemistry, IV Edition, Old Reinhord& Winston, Publication, 1982.
4. B.K. Sharma, Instrumental methods of Chemical analysis, Goel Publishing House, 24th Edition, 2005.
5. Gurdeep R. Chatwal, Sham K. Anand, Instrumental Methods of Chemical Analysis, Himalaya Publication, 1979.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Apply principles of colorimetry for the quantitative estimation of metal ions- **Apply**
CO2: Analyse coordination and solubility equilibria involved in colorimetric and gravimetric estimations of transition metal ions. -**Analyse**
CO3: Interpret experimental data draw conclusions about the chemical behavior and analytical properties of transition metal ions in aqueous solution. -**Evaluate**
CO4: Use laboratory skill to determine metal ion concentration in various samples, following safe laboratory practices. **Analyse**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICP 406	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓	✓	✓		✓	✓
CO 2	✓	✓	✓		✓		✓	✓
CO 3	✓	✓	✓	✓	✓		✓	✓
CO 4	✓	✓	✓	✓	✓	✓		✓

Course Name: ORGANIC CHEMISTRY PRACTICALS-I
Course Code: ICP-407
Course Type: Practical
Contact Hours/Week: 4H **Course Credit:** 02
Course Objectives

- To acquire knowledge of laboratory methodologies and safety protocols, as well as the necessary precautions for conducting reactions
- To receive instruction on the planning and implementation of both single and multistep synthesis of organic molecules
- To refine and characterize the products utilizing physical and chromatographic techniques
- To understand the mechanisms involved in the formation of the desired products
- To learn various types of named reactions and mechanisms
- To provide fundamental knowledge for conducting prepartions, comprehend the nature of reactions and established reaction conditions along with their mechanisms
- To understand the calculations of mole and mole ratio for each reaction
- To isolate the products from individual steps and purify them through crystallization

Course Content
Single and two stage organic preparations, purification and characterization:
Preparation of 1,2,3.4- tetrahydo carbazole, 7-hydroxy -4-methyl-coumarin,aspirin,adipic acid para red and methyl red preparations of p-Bromo & p-Nitroaniline from acetanilide, Ehyl resorcinol from resecinol, ε-caprolactum from cyclohexene, p-aminobenzoic acid from p-nitro toluene, 5-tribromobenzene from aniline, benzylic acid from benzoin, p-chloro toluidine from toluidine, 2,4-Diphenyl hydrazine from chlorobenzene, o-Aminobenzoic acid from phthalic anhydride hydantoin from benzyl p-amino azobenzene from aniline thiazoles from acetophenones, pyrimidines from aldehydes/ketones and thiourea, eosin from resorcinol & phthalic anhydride, Indigo from anthanilic acid, methyl orange from aniline, 5-hydroxy-1,3-benzothiazole from hydroquinone, benzimidazole from urea, Benzocaine from p-nitrotoluene, Dibenzyl from benzil, Benzil from Benzoin, Benzalacetophenone dibromide from acetophenone.
Books and References:

1. Vogel's Textbook of Practical Organic Chemistry including Qualitative Organic analysis-B.S. Furnis et al., Longmann ELBS, London 1989.
2. Experimental Organic Chemistry-Vol I&II P.R. Singh et al., TMH New Delhi-1981
3. Laboratory Manual in Organic Chemistry-Dey & Sitharaman Allied Publishers New Delhi 1992
4. Organic Analytical Chemistry, Theory and Practice-Jagmohan, Nersa,2003
5. Practical Organic Chemistry by F.G. Mann& B.C. Saunders,4th Edition, Longman,
6. 1970
7. Laboratory Maua of Organic Chemistry-Raj K Bansal 2nd edition Wiley 1990.
8. Systematic Lab Experiments in Organic Chemistry-Arun Sethi, New Age International
9. publishers,2006,
10. Advanced Practical Organic Chemistry-Jagmohan, Himalya Publishing house, 1992

Course Outcomes:
Thinking and learning level of the student
Upon successful completion of the course, the students will be able to
CO 1: Conduct reactions while adhering to appropriate safety protocols and to purify and characterize the products using physical and chromatographic techniques. **Apply**
CO 2: gain practical hands-on experience in executing the reaction and understanding the mechanism behind the formation of the products. **Understanding**
CO 3: learn the skills about synthesis, purification, and analysis. **Apply**

CO4: synthesis of organic compounds using various techniques such as reflux, crystallization, distillation, and understand the mechanisms involved in reactions like nitration, bromination reactions etc.**understand**
CO5: Apply green chemistry principles in synthesis of assess the sustainability and atom economy of organic reactions **Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 407	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓		✓	✓	✓		✓	✓
CO 2	✓	✓	✓		✓		✓	✓
CO 3	✓	✓	✓		✓		✓	
CO 4	✓		✓	✓	✓		✓	✓
CO 5	✓	✓	✓		✓	✓		✓

Course Name: PHYSICAL CHEMISTRY PRACTICALS-I
Course Code: ICP-408
Course Type: Practical
Contact Hours/Week: 4 H **Course Credit: 02**
Course Objectives

- To develop an understanding of experimental methods in physical chemistry through hands on experience.
- To emphasize the importance of precision, accuracy,and safety in chemical experimentation.
- To cultivate analytical and data interpretation skills, including error analysisand graphical evaluation of experimental data.
- To determine physical constants using refractometry, adsorption experiment and viscometry.

Course Content
Any 12 experiments are to be carried out

1. Analysis of a binary mixture and determination of molar refraction of a solid and the composition of chloroform and acetone in its azeotropic mixture by refractometry.
2. Analysis of a binary mixture of two miscible liquids by viscometry and the relation between viscosity of a solution and the electrical conductivity.
3. Study of variation of viscosity of a liquid with temperature.
4. Determination of parachor value for CH_2 group by S.T method, the composition of a solution by S.T measurement and the CMC of a soap solution by S.T measurement.
5. Surface tension - concentration correlation for solutions (Gibbs equation).
6. Verification of F and L adsorption isotherms for acetic & oxalic acids on activated charcoal.

7. Analysis of a binary mixture by surface tension method.
8. Adsorption of iodine on charcoal from alcoholic solution.
9. Study of adsorption of picric acid on charcoal using a calorimeter.
10. Acid catalyzed hydrolysis of methyl acetate and determination of catalytic strength of an acid.
11. Saponification of ethyl acetate by conductivity method.
12. Reaction between potassium persulphate and potassium iodide (including the study of salt effect and catalysis by Ag^{+}, Fe^{2+} and Cu^{2+} ions).
13. Decomposition of diacetone alcohol by NaOH & Hydrolysis oft-Butylchloride.
14. Reaction between hydrogen peroxide and HI.
15. Determination of solubility of lead iodide at different Temperature and hence molar heat of solution.
16. Determination of heat of solution of a sparingly soluble solute.

Books and References:

1. B. P. Levitt, Longman, Findlay's Practical Physical Chemistry, J Wiley, London,1954.
2. Experimental Physical Chemistry, Das & Behera, Tata McGraw Hill, New Delhi,1983.
3. J.B. Yadav, 16th edition of Advanced Practical Physical Chemistry, Goel publishers,1989.
4. Experiments in Physical Chemistry, J.C. Ghosh, Bharathi Bhavan,1974.
5. D.A.Skoog and D.M.West, Fundamentals of Analytical Chemistry, IV Edition, Old Reinhord& Winston, Publication, 1982.
6. B.K. Sharma, Instrumental methods of Chemical analysis, Goel Publishing House, 24th Edition, 2005
7. Gurdeep R. Chatwal, Sham K. Anand, Instrumental Methods of Chemical Analysis, Himalaya Publication, 1979.

Course Outcomes: **Thinking and learning level of the student upon successful completion of the course, the students will be able to**

CO 1: Understand the concept of surface tension and its dependence on intermolecular forces- **Understand**

CO 2: Analyse the relationship between temperature, molecular size, and fluid flow behavior-**Analyze**

CO 3: Present scientific and technical information resulting from laboratory experimentation in both written and oral formats-**Understand**

CO 4: Calculate the rate constant for the reaction and determine the catalytic strength of different acids based on reaction kinetics- **Calculate**

CO 5: Interpret refractive index with molecular structure and composition. – **Analyze**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 408	Program Outcomes (POs)							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓	✓	✓			✓
CO 2	✓		✓					✓
CO 3						✓	✓	
CO 4	✓	✓	✓					✓
CO 5		✓						✓

II SEMESTER

Course Name: ANALYTICAL CHEMISTRY
Course Code: ICH-451
Course Type: Hard Core
Contact Hours/Week: 4L **Course Credit: 04**
Course Objectives:

- To understand the principles behind various type of titrations, indicators and error analysis
- To learn and apply chromatographic techniques for separation and analysis
- To acquire knowledge of electroanalytical and spectroscopic techniques
- To explore the application of solvent extraction and chelometric titrations in complex sample analysis
- To understand the fundamentals and instrumentation of diffraction and molecular spectroscopy techniques.

Course Content

UNIT I **14 hr.**

Preparation of samples for analysis, nature of errors, statistical treatment of errors, the t- and F-tests, significant figures, rejection of data. Precipitation phenomena: Precipitation from homogeneous solutions, organic precipitants in inorganic analysis. Solvent extraction of metal ions, nature of extractant, distribution law, partition coefficients, types of extractions and applications. Theories of redox indicators, titration curves, feasibility of redox titrations. Chelometric titrations-titration curves with EDTA, feasibility of EDTA titrations, indicators for chelometric titrations, selective masking and demasking techniques, industrial applications of masking.

UNIT II **14 hr.**

Chromatographic Techniques: Principles, classifications and theory of chromatographic separations.
Column chromatography: Principles, Differential migration, Separation of a mixture of o/p-nitroanilines
Gas Chromatography: Principles, columns, detectors-TCD, FID, ECD and column efficiency, capacity factors, resolution. Practical aspects of GC-Hypernatedtechniques.Liquid Chromatography HPLC: Principles, equipment, columns, detectors, choice of column, materials GC, GCMS and LCMS.
Ion exchange chromatography: Structures of resins, Types, Theory and apparatus, selectivity,

Applications. Thin layer chromatography: Principles, selection of stationary and mobile phases, Preparative TLC, Applications Paper chromatography: Theory and principle. Techniques: one, two-dimensional and circular paper chromatography. Mechanism of separation, structure of cellulose and types of paper. Methodology- Factors affecting Rf values. Advantages and applications.

UNIT III **14 hr.**

Electroanalytical Techniques

Introduction, theory, principle, methodology, instrumentation and application of the following techniques: Conductometry, Potentiometry, Coulometry, Voltammetry.

Light-Scattering methods: Nephelometry & turbidimetry theory, effects of concentration, particle size & wavelength on scattering, instrumentation & application.

Fluorometry and Phosphorimetry: Introduction, fluorescence and phosphorescence, factors affecting fluorescence and phosphorescence, internal conversion, intersystem crossing (radiationless processes) quenching. theory, relationship between intensity of fluorescence and concentration, instrumentation– basic differences in the measurement of fluorescence and phosphorescence, spectrofluorometers, advantages and disadvantages

UNIT IV: Advanced instrumental techniques **14 hr**.

Spectrophotometry, Atomic spectroscopy

Surface probe microscopy: Atomic force microscopy, Scanning tunnelling microscopy, Field emission scanning electron microscopy, Transmission electron microscopy.

Thermal Analysis - TGA, DTA and DSC- Principles, instrumentation and applications.

X-ray diffraction techniques- Powder and single crystal XRD, principle, techniques andapplications.

Books and References

1. Inorganic Chemistry, 3rdedn., G.L. Miessler and D.A. Tarr, Pearson Education inc.2014.
2. Inorganic Chemistry, 4thedn., J.E. Huheey, R.L.Keiter and A.L.Keiter, Addison Wesley,1993.
3. G.D. Christian, Analytical Chemistry, John Wiley,1986.
4. Analytical chemistry-problems and solutions by S.M.Khopkar , New Delhi : New Age International (P) Ltd., 2002.
5. Analytical chemistry by G.L.DavidKrupadanam,D.VijayPrasad,K.VaraprasadRao,K.L.NReddy,C.Sudhakar, Universities Press India Ltd,2002.
6. R.A. Day and A.L. Underwood: Quantitative Analysis, (Prentice Hall, India),1998.
7. H.H. Wlliard, L.L. Merrit and J.J. Dean, Instrumental methods of analysis,1988.
8. B.K. Sharma, Instrumental methods of chemical analysis, Goel publishing House, 2000.
9. Skoog, Holler and Nieman: Principles of Instrumental Analysis, Harcourt Acta,2001.
10. Brown D R, Chromatogarphy, Ivy PublishingHouse,2001.
11. B.K. Sharma, Chromatogarphy, Krishna Prakashan media,1997.
12. Bier, Milan E D, Electrophoresis: Theory methods and applications, Academic1967.
13. A K Tareen and Kutty, Crystallpgraphy, University Press,2002.
14. F.C. Ladd Mark & Palmer, R.A.: Structure Determination by X-ray Crystallography,2003.
15. S. K. Chatterjee , X-Ray Diffraction theory and application, ISTE,2007.
16. S. M Cannon, Comprehensive Inorganic Chemistry, ,Newyork, 1972.
17. J.H. Kennady, Analytical Chemistry: Principles , Cengage Learning IndiaPvt.Ltd.
18. Dhanaraj, G., Byrappa, K., Prasad, V., Dudley, M. (Editors): Springer Handbook of Crystal Growth. ©2010.
19. A.G. Jackson: Handbook of Crystallography For Electron Microscopists and Others 1991.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Explain the statistical treatment of analytical data and identify sources of error in qualitative analysis- **Knowledge**
CO 2: Apply principles of redox precipitation and chemometric titrations including the use of appropriate indicators and masking agents-**Application**
CO 3: Describe and implement various chromatographic techniques including column chromatography, GC and HPLC- **Understanding and application level**
CO 4: Analyze the instrumentation and working principles of gas and liquid -chromatography and understand the role of detectors such as TCD, FID and ECD- **Analyze**
CO 5: Evaluate physical methods such as solvent extraction and discuss their applications in chemical analysis. -**Evaluate**
CO 6: Integrate spectroscopic and diffraction methods in the characterization and identification of chemical substances. - **Analyse**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH 451	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓		✓		✓	✓
CO 2	✓		✓		✓			✓
CO 3			✓		✓		✓	✓
CO 4	✓		✓	✓				
CO 5		✓	✓					✓
CO 6	✓	✓	✓					✓

Course Name: ADVANCED ORGANIC CHEMISTRY
Course Code : ICH-452
Course Type: Hard Core
Contact Hours/Week: 4L **Course Credit: 04**

Course Objectives

- To acquire knowledge and comprehension regarding the function of organic reagents in organic synthesis and their applications in elucidating reaction mechanisms
- To examine the categorization of natural products, their extraction, and their significance in biological contexts
- To acquire an understanding of the reaction mechanisms associated with different named reactions and their applications in organic synthesis

- To acquire essential knowledge regarding carbohydrates and their industrial and biological significance across various types

Course Content

UNIT I: Reagents in Organic Synthesis **14 hr.**

Uses of 1,3-dithiane, organoboranes, Trimethyl silyl iodide, Tri-n-butyl tin hydride, Selenium dioxide, Lead tetra acetate, Lithium aluminium hydride, Sodium borohydride, Organolithium, organomagnesium and Organo zinc compounds in organic synthesis and functional group transformations. Synthetic applications of, LDA,DCC, Gilman's reagent.

UNIT II:Organic Named Reactions and Rearrangements **14 hr.**

Reactions, mechanisms and synthetic uses of Mannich reaction, Barbier-Wieland degradation, Oppenauer oxidation, Birch reduction, Cope and Hoffmann elimination, Vilsmeier-Haack reaction, Suzuki coupling, Woodward-Prevost hydroxylation, Swern oxidation and Mitsunobu reaction. Classification and general mechanistic treatment of nucleophilic, electrophilic & free radical rearrangements, Intermolecular & intramolecular migration, nature of migration & migratory aptitudes, Mechanisms of Favorskii, Beckmann, Neber & Smiles rearrangement

UNIT III: Natural product chemistry **14 hr.**

Introduction to primary and secondary metabolites in plants. Extraction methods of chemical constituents from plants, such as fractionation using solvents, specific extraction of alkaloids and supercritical fluid extraction. Characterizations of isolated compounds (terpenes, sterols, alkaloids, carbohydrates, flavonoids and poly phenols) by colour reactions and spray reagents. Structure elucidation and synthesis of ocimene monoterpene, classification of pigments, structure elucidation of β –carotene. Biosynthesis of terpenes from mevalonic acid. Structure elucidation and synthesis of quercetin. Structural elucidation of testosterone, androsterone, estrone and progesterone. Determination of carbon skeleton of alkaloids (Hofmann, Emde and Von Braun degradation methods). Structural elucidation and synthesis of ephedrine, nicotine.

UNIT IV: Carbohydrates

14 hr.

Introduction, Ring size determination of Monosaccharide's, conformational and configuration representations of monosaccharide's, Mechanism of mutarotation, Base catalyzed isomerization of aldoses and ketoses, Epimerization, Anomeric effect, Glycosides,ether and ester derivative of carbohydrate, Deoxy sugars,oxidation and reduction reaction of carbohydrate. Disaccharides: Lactose, Maltose, and sucrose. Polysaccharides: Structure and degradation of starch, cellulose and glycogen.Industrial importance and biological importance of cellulose, starch, glycogen, dextran, hemicellulose, pectin, agar agar.

Books and References

1. Organic Chemistry, Vol-II, I. L. Finar. 3rd. ed., Longmans Green & Co. 1964.
2. Schaum's outline of theory and problems of Organic Chemistry, Harbert Meislich, Howard Nechamkin and Jocob Sharefkin.2nd ed.,Tata McGrow-Hill NewDelhi 2003.
3. Natural products: Their chemistry and biological significance, J. Mann, R. S. Davidson, J. B. Banthorpe and J. B. Harborne. Longman Scientific & Technical,1994.
4. A text book of synthetic drugs, O. D. Tyagi and M. Yadav Modern Concepts of Advanced Organic Chemistry-R.P. Narein (Vikas, Delhi)1997.
5. Name Reactions and Reagents in Organic Synthesis, Second EditionBradford P. Mundy, Michael G. Ellerd,Frank G. Favaloro Jr.,First ed, John Wiley & Sons, 2005.
6. Transition Metal Reagents and Catalysts: Innovations in Organic Synthesis, Jiro Tsuji, Wiley-Blackwell; Revised ed. Edition,2002.

7. Carbohydrate Chemistry and applications of carbohydrates, K. M. Lokanatha Rai.
8. Carbohydrate Chemistry: Volume 40, Editors: Amelia Pilar Rauter, Thisbe Lindhorst, Yves Queneau RSC Publishing,2014
9. A Textbook of Organic Chemistry-Tewari, Vishnoi and Mehrotra (Vikas, New Delhi) 1998.
10. A Text book of Organic Chemistry-3rdEdn.-R.K. Bansal, (New Age, New Delhi)1997.
11. Organic Chemistry-3rdEdn- F.A. Carey (Tata McGraw Hill, New Delhi)1996.
12. T. Tsuji, Transition Metal Reagents and Catalysts: Innovations in Organic Synthesis, John Wiley & Sons, 2000.
13. S. D. Burke, R. L. Danheiser, Handbook of Reagents for Organic Synthesis, John Wiley & Sons, 1999.
14. L. Kuerti and B. Czako, Strategic Applications of named Reactions in Organic Synthesis, Elsevier Academic Press, 2005
15. N. R. Krishnaswamy, Chemistry of Natural Products; A Unified Approach, Universities Press, 1999.
16. T. Eicher, S. Hauptmann, The Chemistry of Heterocycles, 2nd ed., Wiley, 2003.
17. Heterocyclic chemistry Vol. 1-3, R.R. Gupta, M.Kumar and V. Gupta, Springer Verlag.
18. An Introduction to the Heterocyclic Compounds, R.M. Acheson, Jonn Wiley.
19. Principles of Modern Heterocyclic Chemistry, L.A. Paquett.
20. Chemistry of Natural Products P.S. Kalsi, Kalyani Publishers
21. Chemistry of Organic Natural Products, O.P. Agarwal, Vols., 1 & 2, Goel Pub
Natural Products Chemistry K.B.G. Torssell, John Wiley, 1983.

Course Outcomes:

Thinking and learning level of the student, upon successful completion of the course, the students will be able to

CO1: acquire knowledge of different organic reactions and the reagents utilized as tools in the practice of organic synthesis -**Apply**

CO2: examine the reagents and parameters required for the synthesis of designated target molecules - **Analyse**

CO3: understand and implement a range of concepts related to various organic named reactions and rearrangements in the synthesis of desired molecules - **Understand**

CO4**: p**rovide examples of the various types of reactions and rearrangement processes' mechanistic pathways -Analyze

CO5: understand the classification of natural products, its isolation and biological importance. - **Understand**

CO6: understand the biological and industrial applications of carbohydrates - **Understand**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH 452	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓		✓		✓	✓
CO 2	✓						✓	
CO 3		✓	✓		✓		✓	
CO 4		✓					✓	✓
CO 5			✓	✓	✓	✓		
CO 6	✓		✓	✓		✓	✓	✓

Course Name: ENERGY SYSTEMS, COLLOIDS, AND PETROCHEMICALS.
Course Code: ICH-453
Course Type: Hard Core
Contact Hours/Week: 4L **Course Credit: 04**
Course Objectives

- To introduce conventional energy sources and their mechanics
- To understand the role of non-conventional systems in sustainable development
- To analyze the stability, coagulation, and practical applications of colloidal system
- To understand the thermodynamics and efficiency of various energy systems
- To study the principle behind solar, wind, tidal, and geothermal energy
- To understand the processes involved in the petrochemical industry

Course Content

UNIT I: Energy Systems **14 hr.**

Chemical energy sources and their limitations (natural gas, coal, nuclear fussion, nuclear fission and Hydro power). Electrochemical energy systems-Introduction, classification, battery characteristics. Primary batteries- Alkaline MnO_2 batteries. Secondary batteries-Introduction, lead acid battery, Alkaline storage batteries. Lithium batteries-The primary & secondary lithium batteries. Lithium based conducting polymer battery. Fuel cells-Introduction, efficiency, classification and types, H_2-O_2 fuel cell, methanol fuel cell, solid polymer electrolyte fuel cell biofuel cell.

UNIT II: Non-conventional energy systems **14 hr.**

Solar energy cells-Introduction, semiconductor electrodes, semiconductor-electrolyte interface, parameter controlling efficiency, stability of semiconductor electrodes, **Photoelectrochemical and photogalvanic cells**. Production of Hydrogen, hydrogen energy. Hydrogen storage by metal and metal-alloys. Applications of photochemistry-photoelectrocatalysis, photoreduction of CO_2 and photoelectrochemical waste removal.

Formation of biomass, photosynthesis; Biomass resources. Chemical constituents and physicochemical characteristics of biomass; Biomass conversion processes; Biofuel, Petrocrops.

Wind energy-Atmospheric circulations, factors influencing wind and Betz limit. Ocean energy resources, Principles of ocean thermal energy conversion systems. Geothermal energy: Origin, types of geothermal energy sites.

UNIT III: **14 hr**

Colloidal Chemistry: Introduction, Method of determining particle size. Donnan membrane, equilibrium and potentials, Importance and applications of colloidal chemistry. Theory, properties and applications of gels and emulsion. Migration of an ion in an electric field, factors affecting electrophoretic mobility. Types of electrophoresis-free electrophoresis, zone electrophoresis-paper and cellulose acetate electrophoresis, gel electrophoresis.

Adsorption: Introduction, types, Adsorption isotherms-Langmuir and BET(no derivation), Gibbs adsorption isotherm, applications of adsorption- surface area determination. Kinetics of gaseous reaction on solid surface-uni and bimolecular surface reactions (qualitative study), Catalysis: Types and industrialapplications.

UNIT IV: **14 hr**

Petroleum and Petrochemicals: History of Petroleum-Origin, recovery and transportation, Composition of crude oils-Paraffins, Naphthenes, Aromatics, Sulphur compounds, Nitrogen compounds, Metallic constituents, Distillation-Pretreatment, atmospheric distillation, Vacuum distillation, Cracking-Thermal cracking, visbreaking, coking, catalytic cracking, hydrocracking, Reforming-Catalytic reforming.

Hydrotreatment and Sulphur Recovery: Finishing processes-Caustic washing, Merox process, Hydrofing, methods for improving storage stability, filter, Molecular sieves Petroleum Products-LPG, LNG, Motor gasoline or Petrol, Diesel, Kerosene, Naphtha, Aviation turbine fuel, Heavy fuel oil, Bitumen, Lubricating oil, Greases, Petroleum waxes, Petroleum fractions for petrochemicals. Naphtha and Para xylene. General properties of petroleum products and alternative fuels.

Books and References:

1. Engineering chemistry, Gadag R V, I K international, 2010.
2. Chemical and Electrochemical Energy Systems, Narayan R & B Viswanathan, UniversityPress,1998.
3. Modern Electrochemistry, Vol 2A and B, JOM Bockris& AKN Reddy, Springer, NY,1998.
4. Biochemical & Photosynthetic Aspects of Energy Production, Anthony San Pietro, Academic Press, N Y,1980.
5. Bio Energy for Rural Energisation, R.C. Maheswari, Concepts Publication,1997.
6. Modern Petroleum Refining Process, 2nd Edn., Rao,IBH.
7. Introduction to Petrochemicals, Maiti,IBH.
8. A Text Book of Engineering Chemistry, M M Uppal, Khanna Publishers,1986.
9. Modern Petroleum Chemistry-An overview, Kochu Baby, Manjuram&Kannatheri
10. Colloids Chemistry, A.K.Sharma, Goel publishing House, Meerut,1991.
11. Sequeira, A. Jr. Petroleum Processing Handbook. J.J. McKetta (Editor). Marcel Dekker Inc., New York. p. 634.1992.
12. Walmsley, A.G. In Modern Petroleum Technology. G.D. Hobson and W. Pohl (Editors). Applied Science Publishers Inc., Barking, Essex, England. Chapter 17.1973.

Course Outcomes: Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Students can analyse the working of thermal power plants and internal combustion engines- **Analyse**

CO 2: Students can explain the basic working principle of solar panels, wind turbines, and biogas systems- **Analyse**

CO 3: Students will understand the significance of colloids in industrial and biological systems- **Understand**

CO 4: Electrochemical energy systems pertaining to classical and modern batteries and also fuel cells- **Apply**

CO 5: Students will appreciate the importance of petroleum-based products in the chemical industry and evaluate their environmental concerns- **Evaluate**

CO 6: Understand the synthesis and applications of primary petrochemicals like ethylene, propylene, benzene etc.-**Understand**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH 453	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓		✓		✓			✓
CO 2	✓		✓		✓			
CO 3	✓		✓		✓			✓

CO 4	✓		✓			✓		
CO 5		✓	✓					✓
CO 6			✓		✓			✓

Course Name: CHEMICAL ENGINEERING TECHNOLOGY
Course Code: ICS-454
Course Type: Soft Core
Contact Hours/Week: 4L **Course Credit: 04**

Course Objectives:

- To outline the comprehensive framework of unit operations and unit processes employed in the chemical industries
- To understand the fundamental design and principles of operating instruments utilized in chemical industries
- To know the recent trends of unit operation and process involving flow chemistry technology
- To understand the manufacturing process of nitration, esterification, sulfonation, halogenation reactions used in the chemical industries

Course Content

UNIT I: Unit Operations **10 hr.**

Evaporation: Types of evaporators, jacketed, horizontal and vertical tube evaporators, forced circulation evaporations, multiple effect evaporators.

Distillation: Boiling and distillation, vapor-liquid equilibria, Rault's law & Henry's law, relative volatility, azeotropic mixtures, flash distillation, steam distillation, vacuum distillation, fractional distillation.

UNIT II: Crystallization and Flow chemistry **12 hr.**

Crystallization: Theory & mechanisms of growth of crystal, nucleation, saturation (Mier's theory), super saturation, types of crystallization, classification of crystallizers (agitated tank, Swenson Walkers, Krystal, Oslo, continuous vacuum crystallizers), caking of crystals, effect of impurities.

Gas absorption: Definition, examples, solution criteria for gas absorption, Characteristics, types, merits and demerits of plate and tower packing. Comparison of absorption and distillation,

Flow chemistry: concepts and applications.

Flow chemistry: Introduction, Batch v/s Flow chemistry, General working principle, Types of reactors, Advantages and disadvantages, synthetic applications

UNIT III: Unit Processes **10 hr.**

Unit process and flow sheet. **Nitration:** Nitrating agents, kinetics and mechanism of nitration of aromatic compounds, nitration of paraffinic hydrocarbons, nitrate esters, N- nitro compounds, and typical industrial manufacturing process. **Sulfonation:** Sulfonating agents, kinetics and mechanism, desulfonation, work-up procedures. Industrial equipment and technique, Batch and continuous processes, manufacturing processes for detergents, dye intermediates, turkey red oil.

Alkylation and acylation: Alkylation and acylation at Carbon, Oxygen and Nitrogen, Friedel- Craft reaction, applications of active methylene compounds like diethyl melonate and ethyl acetoacetate. Industrial processes

UNIT IV: Catalytic hydrogenation and hydrogenolysis: **10 hr.**

Catalytic hydrogenation and hydrogenolysis: Different types of catalysts, Industrial hydrogenation processes. **Halogenation:** Kinetics & mechanism of halogenation reaction, survey methods, catalytic chlorination, manufacturing processes for chlorobenzene, BHC, chlorinated methanes, vinyl chloride. **Oxidation:** Oxidizing agents with typical applications of each, liquid phase oxidation with oxidizing compounds. **Esterification:** Kinetics and mechanism, esterification of carboxylic acid derivatives, esters by addition to unsaturated systems, industrial esterification, ethyl acetate, methyl methacrylate, cellulose acetate and nitroglycerin.

Books and References.

1. F A Henglein, Chemical Technology,Fiesrt English edition, Pergamon,1969.
2. J M Coulson, Chemical Engineering, Vol. I, II & III, Pergamon,1964.
3. R N Shreve, The Chemical Process Industries, McGraw Hill Professional, 1984.
4. W L Badger, J T Bandchero, Introduction to Chemical Engineering, McGraw Hill Professional, 1955.
5. A Hougen, K M Watson, R A Ragetz, Chemical Process Principles, Vol I & II, John Wiley and sons,1959.
6. John J McKetta Jr, Unit operations handbooks, Volume 1, CRC Press,1992.
7. Wareen L. McCabe,Jullan C. Smith, Peter Harrlott, Unit operations of chemical engineering, McGraw Hill Professional, 1956.
8. P H Groggins, Unit Processes in Organic Synthesis, McGraw Hill Professional, 5th Edition,1995.
9. Engineering chemistry, Gadag R V, I K international, 2010.
10. Comprehensive industrial chemistry, More Prakash G, Pragathiprakashan, 2010.

Course Outcomes:

Thinking and learning level of the student, upon successful completion of the course, the students will be able to

CO 1: acquire knowledge regarding unit process and unit operations related to evaporation, distillation, and crystallization methods employed in the chemical industries. **Understanding**

CO 2: have the opportunity to understand the design of instruments at the plant level to produce the necessary products, as well as to learn about the implementation of safety precautions in the chemical industry. **Apply**

CO 3: have the opportunity handling of hazardous reactions such as nitration, sulfonation, and halogenation reactions at big scale at plant level in the chemical industries. **Apply**

CO 4: acquire knowledge of principle, working and applications of flow chemistry **Knowledge**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 454	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓			
CO 3					✓		✓	✓
CO 4	✓	✓				✓		✓

Course Name: CHEMICAL ANALYSIS IN AGRO AND FOOD INDUSTRIES
Course Code: ICS-455
Course Type: Soft Core
Contact Hours/Week: 4L **Course Credit: 04**

Course objectives:

- To study the analysis of fuel and soil
- To learn different types offertilizers
- To study different types of insecticides,herbicides,fungicides,repellents
- To learn the adulterants of food and its purification

Course Content

UNIT I **10 hr.**

Analysis of soil: Moister, pH, total nitrogen, phosphorous, silica, lime, Magnesia, Manganese, sulfur and alkali salts.

Fuel analysis: Solid, liquid and Gas , ultimate and proximate analysis heating values , grading of cool , liquid fuels , flasks points , aniline point , octane number and carbon residue , gaseous fuels – producer gas and water gas – calorific value.

UNIT II **12hr.**

Fertilisers: Introduction, Essential plant Nutrients, Classification of Essential Nutrients, Primary Nutrients, Secondary Nutrients, Micronutrients, Macronutrients, Classification of Fertilizers- Straight Fertilizers, Compound/Complex Fertilizers, Fertilizer Mixtures, Feed Stock/ Raw materials- Nitrogenous Fertilizers, Phosphatic Fertilizers, Potassic Fertilizers, Manufacture and general properties of Fertilizer products- Intermediates- Ammonia, Nitric Acid, Sulphuric Acid, Phosphoric Acid, Nitrogenous Fertilizers- Ammonium Sulphate, Ammonium Nitrate, Calcium Ammonium Nitrate, Calcium Nitrate, Ammonium Chloride, Urea, Phosphatic Fertilizers, Ground Rock Phosphate, Single Superphosphate, Triple Superphosphate, Potassic Fertilizers- Potassium Chloride (Muriate of Potash), Potassium Sulphate (Sulphate of Potash), Potassium Nitrate, Complex Fertilizers- Ammonium Phosphate Sulphate, Ammonium Phosphates, Mono Ammonium Phosphate (MAP), Di-Ammonium Phosphate (DAP), Nitrophosphates, Urea Ammonium Phosphates, NPK Complex Fertilizers

UNIT III **10 hr**

Insecticides: Introduction, classification, Organochlorine insecticides-BHC, DDT, endosulfan, sevin, Insect pheromones, general introduction and applications in integrated pestmanagement.

Repellents: Survey & synthesis of the repellents-N,N-diethyltoluamide, 2-ethyl-1,3- hexanediol,.

Fungicides: Introduction, Inorganic & organic fungicides, Systemic fungicides-types & examples.

Herbicides: Introduction, study of sulfonyl ureas, Mechanism of action and toxicities of insecticides, fungicides and herbicides.

UnitIV10 hr

Food analysis: Moister, ash, crude protein, fat, crud fiber, carbohydrate, calcium,potassium, sodium, and phosphates, food adulteration – common adulteration in food,contamination of food stuffs, microscopic examination of foods for adulterants,Pesticide analysis in food products-Extraction and purification of sample, thin layer chromatography detection for organo phosphorous insecticide residues, thin layer chromatography for identification of Organo-chlorine pesticides in food products

Books and Reference

1. Food contaminants- Origin,propagation and analysis by S.N.Mahindru,2004
2. Food chemistry by Alex V Ramani, Tamil Nadu,2009
3. Methods on Physico-chemical analysis of fruits by Dr.B.C.Mazumdar and Dr.K.Mazumder,2003

4. A textbook of Fertilizers by Ranjan Kumar Basak,2007
5. Chemistry of Herbicides by Sree Ramulu, U S,1982

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: To study the analysis of fuel and soil - **Analyse**

CO 2: To Analyse food samples to determine nutritional content, food additives, contaminants, and preservatives using classical and instrumental methods **- Analyse**

CO 3: To understand different types of insecticides, herbicides,fungicides,repellents - **Understand**

CO 4: To evaluate the adulterants of food and its purification- **Evaluate**

CO 5: Students gain knowledge about the analysis of soil and food, determination calorific values of fuels, food analysis and clinical chemistry. Students learn about different types of fertilizers,insecticides,fungicides,herbicides – **Knowledge**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 455	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1			✓	✓	✓		✓	
CO 2			✓		✓	✓	✓	
CO 3	✓				✓		✓	
CO 4		✓	✓	✓	✓		✓	
CO 5			✓		✓	✓	✓	

Course Name: Techniques in quantitative analysis.
Course Code: ICP-456
Course Type: Chemistry practical
Contact Hours/Week: 4 L **Course Credit: 02**

Course objectives:

- To develop proficiency in classical quantitative analytical techniques
- To impart the basic analytical and technical skills to work effectively in different fields of chemistry
- To perform accurate quantitative measurements with an understanding of the theory and use of contemporary chemical instrumentation, interpret experimental results, perform calculations on these results and draw reasonable, accurate conclusion
- To gain hands on experience in volumetric and gravimetric analysis with statistical analysis of data

Course Content

1. Colorimetric determination of Ti (IV) and Zr (IV)
2. Simultaneous colorimetric determination of two metal ions – Mn andCr.
3. Flame photometric determination of Na, K, Li and Ca individually and inmixtures.
4. Solvent extraction of Ni(II)
5. Estimation of iron in cement by colorimetically
6. Determination of composition of complexes:a) Job's method: Fe-1, 10- Phenanthroline

complex b) Mole ratio method: Zr-Alizarin red S complex, c) Slope ratio method: Cu ethylenediamine complex, d) Limiting logarithmic method: Uranyl sulphosalicyclic acid complex.

7. Determination of stability constants-Turner Anderson method: Fe-Tironsystem,
8. Cement analysis: i) SiO_2-Gravimetrically ii) Calcium,Volumetrically
    a. iii) Iron, Volumetrically iv) Magnesium, Complexometrically iv) Aluminium, Gravimetrically.
9. Determination of available chlorine in bleaching powder and residual chlorine in watersamples.
10. Determination of Iron present in sulpha- drugs;colorimetrically.
11. Analysis of chalcopyrites, magnetite and ilmenite.
12. Ion-exchange chromatography: Separation & determination of Mg^{2+}/Zn^{2+}, Zn^{2+}/Cd^{2+}& Cl^-/Br^-
13. Determination of COD of a watersample and dissolved oxygen (DO) by Winkler'smethod
14. Determination of nitrate & nitrite in water samples and seawater.
15. Analysis of heavy metals in waste water, sea water (Pb, Hg etc.by spectrophotometry).
16. Determination of available NPK in soil and fertilizer.
17. Nephelometric determination ofsulphate/phosphate.
18. Determination of alkalinity of watersamples.
19. Determination of fluoride in drinking water by spectrophotometry and ion selective electrode.
20. Determination of phosphates in detergents

Books and References

1. Vogel's Text Book of Quantitative Chemical Analysis (5^{th} Ed), G.H.Jeffrey, J.Bassette, J. Mendham and R.C.Denny, Longman, 1999.
2. Sarvesh Kumar Dubey Asha Arora :A Practical Book on Soil Plant Water and Fertilizer Analysis,S.R.Scientific Publication.2010
3. Gupta PK, Soil, Plant, Water And Fertilizer Analysis (2nd Ed.), 2017

Course outcome

CO 1: Apply principles of flame photometry and spectrophotometry to quantitatively determine metal ions (e.g., Na^+ , K^+ , Ca^{2+}) and colored species in given samples with precision and accuracy**Apply**
CO2: Demonstrate proficiency in the operation of analytical instruments, including flame photometers and UV-Vis spectrophotometers, and interpret corresponding spectra/data.**Analyze**
CO3: Analyze the chemical composition of bleaching powder through classical and instrumental methods, identifying available chlorine and other active components.**Analyze**
CO4 Correlate theoretical concepts with experimental observations, reinforcing understanding of atomic emission and molecular absorption phenomena in inorganic chemical analysis.**Understanding**
CO5: Develop technical reporting and data interpretation skills, including calibration curve generation, sample preparation, and error analysis-**Analyze**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 456	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓					
CO 2			✓	✓	✓			
CO 3	✓	✓		✓	✓			✓

CO 4			✓					
CO 5	✓	✓		✓	✓	✓		✓

Course Name: ESTIMATIONS AND EXTRACTIONS IN ORGANIC CHEMISTRY
Course Code: ICP-457
Course Type: Chemistry practical
Contact Hours/Week: 4H **Course Credit: 02**

Course Objectives

- To equip students with knowledge and skills for the quantitative determination of various organic compounds, including sugars, amino acids, phenols, carboxylic acids, amides, esters, aldehydes, ketones, and urea using classical and instrumental techniques.
- To teach methods to determine components of binary mixtures, particularly combinations of acids with esters or amides.
- To enable identification and estimation of functional groups such as hydroxyl, vicinal diols, enols, amino, amide, nitro, and unsaturation using suitable qualitative and quantitative methods.
- To provide hands-on experience in the extraction of natural products like caffeine, piperine, nicotine, and hesperidin using conventional and Soxhlet extraction techniques.
- To encourage careful observation, proper documentation, critical analysis of data, and safe laboratory practices.

Course Content
Estimations
Quantitative determination of sugars, amino acids, phenols, carboxylic acids, amides, esters, aldehydes, ketones, urea by various methods. Determinations of acid and ester; acid and amide in a mixture % of Keto-enol in diketo compounds
Determination of functional groups like hydroxyl, vic-hydroxyl, enol, amino, amide, unsaturation and nitro groups by various methods.

Extractions:

- Isolation of caffeine from Milk
- Isolation of caffeine from tea leaves
- Isolation of Piperine from black pepper
- Isolation of Nicotine from Tobacco
- Isolation of Hesperidin from Orange Peel Using Soxhlet Extractor

References:

1. Elementary Practical Organic Chemistry,Vol. II, Quantitative Organic Analysis-A.I.Vogel
2. Experimetal Organic Chemistry, Vol. I &II, P.R.Singh, Tata McGraw-Hill,1981.
3. Practical Organic Chemistry- IV Ed- Dey &.Sitaraman, Allied, New Delhi,1992.
4. Laboratory Experiments in Organic Chemistry-Adam, Johnson &Wicon, McMillan,1979.
5. Experimental Organic Chemistry,.H.D.Durst&G.E.Goke, McGraw-Hill,1980
6. More Spectroscopic Problems in Organic Chemistry-A.J. Baker et al.,Heyden,1975.
7. Spectral Problems in Organic Chemistry,Davis& Wells, Chapman &Hall,1984.
8. Elementary Practical organic chemistry, Part 2: Quantitative organic analysis by Arthur I. Vogel, 2nd Edition, CBS Publishers and distributors,1987.
9. Organic analytical chemistry, Theory and Practice-Jag Mohan, Narosa,2003.

10. Laboratory Manual of Organic Chemistry - Raj K Bansal, 2nd Edition, Wiley,1990.
11. Systematic Lab Experiments in Organic Chemistry-Arun Sethi, New age International, 2006.

Course Outcomes:

After successful completion of this course, students will be able to:

CO1: Quantitatively analyze organic compounds including sugars, amino acids, phenols, carboxylic acids, and nitrogen-containing compounds using appropriate titrimetric and colorimetric methods.

CO2: Accurately determine combinations in organic mixtures, such as acid-ester and acid-amide systems, by applying selective chemical separation and estimation techniques.

CO3: Identify and estimate the presence of key functional groups (hydroxyl, vic-hydroxyl, enol, amino, nitro, etc.) using classical qualitative methods supported by confirmatory tests.

CO4: Perform extractions of natural products like caffeine (from milk or tea), piperine, nicotine, and hesperidin using both solvent extraction and Soxhlet apparatus with a strong understanding of the underlying principles.

CO5: Apply laboratory best practices, maintain detailed records, and interpret experimental data with scientific reasoning and awareness of safety protocols.

CO6: Integrate theoretical concepts with practical application, preparing them for advanced work in organic chemistry, natural product chemistry, and analytical chemistry.

Course Articulation Matrix: Mapping of Course outcome (Cos) and (POs)

Course/Paper Title: ICP 457	**Program Outcomes (POs)**							
Course outcome		**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO1		✓	✓					
CO2	✓	✓	✓					
CO3		✓	✓	✓	✓			
CO4	✓	✓	✓	✓	✓	✓	✓	
CO5		✓	✓	✓				✓
CO6		✓	✓	✓				✓

Course Name: ELECTROANALYTICAL TECHNIQUES
Course Code: ICP-458
Course Type: Chemistry practical
Contact Hours/Week: 4H **Course Credit: 02**

Course Objectives

- To introduce the theoretical foundations of electrochemical processes, including electrode potentials, redox reactions, and mass transport.
- To provide comprehensive knowledge of key electroanalytical techniques such as potentiometry, conductometry, coulometry, and voltammetry.
- To develop students' abilities to operate electroanalytical instruments, interpret data, and troubleshoot experiments
- To illustrate the use of electroanalytical methods for the quantitative and qualitative analysis of chemical species in various matrices.

- To encourage analytical thinking in experimental design and interpretation of electrochemical measurements.

Electrochemistry:

A. Conductometry (At least 5 experiments to be carried out)

1. Determination of hydrolysis constants (aniline hydrochloride etc.).
2. Titration of a mixture of acetic acid, monochloro and trichloacetic acids with NaOH.
3. Determination of concentrations/amounts of sulphuric acid, acetic acid and copper sulphate using sodium hydroxide.
4. Measurements of the conductance of a weak acid, HOAC and of the strong electrolytes NaOAc, HCl and NaCl and to calculate the ionization constant of the acid.
5. Analysis of the mixture of HCl and NH_4Cl.
6. Determination of activity coefficient of Zinc ions in 0.002M $ZnSO_4$.
7. Determination of equivalent conductance's and dissociation constants of weak acids.

B. Potentiometry (At least 7 experiments are to be carried out)

8. Determination of pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.
9. Determination of acidic & basic dissociation constants and isoelectric point of an amino acid.
10. Determination of the potential of an electrochemical cell and mean ionic activity coefficient.
11. Determination of activity coefficient of an electrolyte at different molalities.
12. Determination of pH of buffer solutions with a pH meter & evaluation of pK_a ofacids
13. Determination of thermodynamics of a cell reaction
14. Determination of pKa values of mono, di and tri-acidbase.
15. Determination of solubility of insoluble silver halide and the standard electrode potential using quinhydroneelectrode
16. Determination of degree of hydrolysis of CH_3COONa andNH_4Cl.
17. Determination of hydrolysis constant of anilinehydrochloride.
18. Verification of Nernst equation for Ag^+, $Cu^{2+}$and Zn^{2+}species.
19. Determination of transport number of ions by emf method (Ag^+, Cd^{2+}, NO_3^{1-},SO_4^{2-})
20. pH titration of (a) HCl versus NaOH, (b) $CuSO_4$ versus NaOH and (c) HOAC versus NaOH and (d) lead nitrate versus potassium chromate.
21. Potentiometric titration of halides in mixtures(Cl^-,$Br^-$and I^-)with silver nitrate.
22. Potentiometric determination of dissociation constants of weak acids.

References

1. B. P. Levitt, Longman, Findlay's Practical Physical Chemistry, J Wiley, London,1954.
2. Experimental Physical Chemistry, Das & Behera, Tata McGraw Hill, New Delhi,1983.
3. J.B. Yadav, 16th edition of Advanced Practical Physical Chemistry, Goel publishers,1989.
4. Experiments in Physical Chemistry, J.C. Ghosh, Bharathi Bhavan,1974.
5. D.A.Skoog and D.M.West, Fundamentals of Analytical Chemistry, IV Edition, Old Reinhord & Winston, Publication, 1982.
6. B.K. Sharma, Instrumental methods of Chemical analysis, Goel Publishing House, 24th Edition, 2005

7. Gurdeep R. Chatwal, Sham K. Anand, Instrumental Methods of Chemical Analysis, Himalaya Publication, 1979.
8. Experimental Physical Chemistry, V.D, Athawale, Parul Mathur, New Age International Pvt.Ltd. 2001.

Course Outcomes:

After successful completion of this course, students will be able to:

- **CO1**: Explain the principles of electrochemical cells, electrode potentials, and redox reactions involved in electroanalytical methods.
- **CO2**: Apply potentiometric methods using ion-selective electrodes and reference electrodes for accurate determination of ionic species.
- **CO3**: Utilize conductometric techniques for analysis of electrolytic solutions and titrations involving ionic reactions.
- **CO4**: Perform coulometric experiments to determine analyte concentrations based on charge passed during electrolysis.
- **CO5**: Analyze complex mixtures using voltammetric techniques (e.g., cyclic, differential pulse, and stripping voltammetry), understanding current-potential relationships.
- **CO6**: Operate and calibrate electroanalytical instruments, record data accurately, and interpret results for both academic and industrial applications.
- **CO7**: Design and optimize electroanalytical procedures for specific chemical and biochemical applications.

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICP 458	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO1	✓	✓	✓					
CO2			✓	✓	✓			
CO3	✓	✓		✓	✓			✓
CO4			✓					✓
CO5	✓	✓		✓	✓	✓		✓
CO6	✓	✓		✓	✓	✓		✓
CO7	✓	✓		✓	✓	✓		✓

Course Name: Chemistry of household chemicals and cosmetics
Course Code : ICE-460
Course Type : Open elective
Contact Hours/Week: 3L **Course Credit: 03**

Course Objectives:

- To introduce the chemical nature, formulation, and functional principles of common household chemicals and personal care products
- To understand the physicochemical properties, mode of action, and safety profiles of

ingredients used in cosmetics and household products

- To familiarize students with labeling, regulatory standards, and quality control practices in the chemical formulation industry
- To develop awareness about the environmental and health impacts of synthetic chemicals in daily-use products
- To encourage exploration of greener, safer, and bio-based alternatives in consumer chemical products

Course Content

UNIT I **15Hr.**

Household chemicals: History of household Industry, Basic Theory of Household Chemicals, and Raw material required for household product, Product manufacture in household industry. Role of household product in day to day life. Cleaning agents: Introduction, synthesis and applications of Natural cleaning agents, cleaning action, Floor cleaner, Toilet Cleaner, Bathroom Cleaner, Kitchen Cleaner.

UNIT II **15Hr.**

Technology of Soap: Chemistry of soap; Raw material for soap industry and their selection; hard fats yielding and oil yielding soaps; Chemical reactions of soaps; Hard and Soft soaps; Plant and process employed in soap manufacture; Liquid hand wash and liquid dish wash. Preparation of sanitary acid , Preparation of liquid soap, Preparation of white phenyl, Solid soap manufactureDetergents and surfactants Washing action of detergents; Types of detergents; Introduction of surfactants; Types of surfactants.

Unit III **15Hr.**

Introduction, history, classifications and sources of cosmetics and perfume.Psychological benefits, fragrance and mood, aromatic substances, types of aromatic substances, chemical constituents of aromatic substances, odours of substances from vegetable, animal and artificial origin.
Additives(thickeners,foam stabilizers, pearlescent agents, conditioning agents, etc.) Oil components; Waxes, Silicone Chemistry oils; Cream bases; Emulsifiers; Humectants; AcrosolPropcllants. Production of essential oils with special reference to the following, Eugenol, Geraniol, Jasmone, Civetone. Preparation of herbal face creams using natural resources.

Books and References

1. Majur Chandrashekar Shetty, Small scale industries and house hold industries in developing economy. Asia Publishing House, 1963.
2. Prasad Giri Raj: Modern Technology Of Perfumes, FlavoursAnd Essential Oils (2nd Edition), NIIR Board, 2004.
3. B.K.Sharma: Industrial chemistry by GOEL Publishing House, 2000
4. Poucher's Perfumes, Cosmetics and Soaps, Publisher: Springer Netherlands
Ed by H. Butler 2000.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO1: Identify and describe the key chemical components in household cleaners, detergents, and personal care products-**Understand**

CO2: Explain the chemical principles behind cleansing, emulsification, disinfection, preservation, and fragrance release in household and cosmetic products-**Understand**

CO3: Analyze formulation strategies used in detergents, shampoos, toothpastes, deodorants, and skin care products-**Analyze**

CO4: Evaluate the toxicity, skin compatibility, and environmental persistence of common synthetic

and natural cosmetic ingredients –**Evaluate**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICE 510	Program Outcomes (POs)							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓		✓	✓		
CO 2	✓	✓	✓		✓	✓		✓
CO 3	✓	✓	✓					✓
CO 4	✓	✓	✓		✓		✓	✓

III SEMESTER

Course Name: SPECTROSCOPIC TECHNIQUES
Course Code: ICH-501
Course Type: Hard Core
Contact Hours/Week: 4L **Course Credit: 04**
Course Objectives:

- An exploration of molecular spectroscopy methods, specifically vibration and Raman spectroscopy
- To understand the principles and applications of UV, IR, HNMR, and mass spectroscopy in the structure analysis of organic molecules
- To acquire knowledge in structure elucidation through the resolution of composite spectral challenges

Course Content

UNIT I: Introduction to spectroscopic techniques **14 hr.**

Introduction to spectroscopic techniques, intensity of spectral lines, natural line width and line broadening. Rotational, vibrational and electronic energy levels and selection rules. **Microwave Spectroscopy:** The rotation and classification of molecules, rotation spectra of diatomic and polyatomic molecules. Rigid and non-rigid rotator models. Determination of bond lengths, isotope effect on rotation spectra. Stark effect, nuclear and electron spin interaction. Microwave Spectrometer.

Vibrational Spectroscopy: Vibration spectra of diatomic molecules - linear harmonic oscillator, vibrational energies, zeropoint energy, force constants & bond strengths; anharmonicity of molecular vibrations- Morse PE diagram, selection rules, fundamental, overtones and hot bands. Vibrations of polyatomic molecules- normal modes of vibrations & nature of molecular vibrations (Eg.$CO_2$and H_2O).**Vibration-rotation spectra** of diatomic and polyatomic molecules, selection rules, PQRbranches.

Raman spectroscopy: Introduction, theory and applications of Raman spectra, mutual exclusion principles and its applications.

UNIT II: **14 hr.**

Application of infrared spectroscopy in the structural study-identity by fingerprinting and identification of functional groups. Characteristic vibrational frequencies of common functional groups (alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines). Study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides and acids). Factors affecting band positions and intensities-hydrogen bonding, phase and solvent.

UV/Electronic Spectroscopy: Basic principles, Beer-Lambert law, molar absorptivity, energy levels, types of electronic transitions. Franck - Condon principles, ground and excited electronic states of

diatomic molecules. Chromophores, auxochromes, electronic spectra of polyatomic molecules. Emission spectra, spectra of transition metal complexes, charge transfer spectra. Instrumentation and application. Factors affecting the positions of UV bands. Electronic transitions and empirical correlations of predicting λ_{max} of organic compounds. Woodward–Fieser rules. UV absorption of aromatic compounds - effect of substituents and solvent effects. Empirical rules to calculate $\lambda_{max.}$ Application of UV spectroscopy in the structural study of organic molecules.

UNIT III: 14 hr.

Nuclear Magnetic Resonance Spectroscopy: Magnetic properties of nuclei, theory and measurement techniques, chemical shift and its measurements, factors affecting chemical shift. Integration of NMR signals, spin-spin coupling, coupling constant. Shielding and deshielding. Chemical shift assignment of major functional groups, Classification (AX, AMX, ABX), spin decoupling; effects of chemical exchange, fluxional molecules, Hindered rotation through NMR spectrum, Karplus relationships (Karplus curve), double resonance techniques, solvent effects and Nuclear Overhauser Effect, lanthanide shift reagents.

NMR of nuclei other than proton: ^{13}C chemical shift & factors affecting it, Coupling constants. Decoupling-Noise decoupling & broad band decoupling. Off-resonance proton decoupling-some representative examples. 2D NMR techniques. ^{19} F NMR spectroscopy

UNITIV: 14 hr.

Mass Spectrometry: Basic principles, interpretation of mass spectra, molecular ions, meta- stable ions and isotope ions, ion abundance. Fragmentation processes-representation of fragmentation, basic fragmentation types and rules. McLafferty rearrangement. Fragmentations (fragmentation of organic compounds with respect to their structure determination) associated with functional groups- alkanes, alkenes, cycloalkanes, aromatic hydrocarbons, halides, alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, esters, amides, acid chlorides, nitro compounds and amines, retro Diels-Alder fragmentation and nitrogen rule.

Composite problems involving the applications of UV, IR, ^{1}H and ^{13}C NMR and mass spectroscopic techniques.

Books and References

1. Organic spectroscopy, William Kemp, 3rd Edn., Palgrave,1991.
2. Organic spectroscopy: Principles and applications, Jagmohan, 2nd Edn., Narosa,2007.
3. I.L.Finar Organic Chemistry Vol I 6th edition ELBS Longman1973
4. Fundamentals of Molecular Spectroscopy IV ed., C.N.Banwell & E.M.McCash Tata McGrraw-Hill Publishing CompanyLtd.,1994.
5. Organic Analytical Chemistry Theory and Practice, Jag Mohan, Narosa Publishing House, 2003.
6. Spectrophotometric Identification of Organic Compounds, R.M.Silverstein, F.X. Webster, 6th Ed., John Wiley &Sons, Inc, Newyork,2004.
7. N. J. Turro, Modern Molecular Photochemistry, University Science Books, 1996.
8. N. J. Turro, J. C. Scaiano, V. Ramamurthy, Modern Molecular Photochemistry of Organic Molecules, 1st ed., University Science Books, 2010.
9. T.W. Greene, P. G. M. Wuts, Protecting Groups in Organic Synthesis, 2nd ed., John Wiley, 1991.
10. Atta-Ur-Rahman, M. I. Choudhary, Solving Problems with NMR Specroscopy, Academic Press, New York, 1996.
11. D. F. Taber, Organic Spectroscopic Structure Determination, A Problem Based Learning Approach, Oxford University Press, 2009.
12. D. H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, Tata McGraw Hill, 1988.
13. E. B. Wilson, Jr., J. C. Decius, P. C. Cross, Molecular Vibrations: The Theory of Infrared and Raman Spectra, Dover Publications, 1980.

14. H. Gunther, NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry, 3rd ed., Wiley- VCH, 2013.

Course Outcomes:
Thinking and learning level of the student upon successful completion of the course, the students will be able to
CO 1: Acquire knowledge in basic understanding of interaction of energy with matter and its resulting consequences -**Understanding**
CO 2:The course will equip with a comprehensive understanding of molecular spectroscopy techniques, specifically vibrational and Raman spectroscopy -**Analyze**
CO 3: Identify structures of unknown organic compounds based on the data from UV-Vis, IR, Mass Spectrometry ^{1}HNMR and ^{13}CNMR spectroscopy- **Apply**
CO 4: Utilize hyphenated techniques and spectral library matching to identify the structures of unidentified organic compounds - **Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICP 501	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓		✓	✓		
CO 2	✓	✓	✓		✓		✓	✓
CO 3		✓	✓	✓	✓		✓	
CO 4	✓	✓	✓	✓	✓		✓	✓
CO 5	✓	✓	✓	✓	✓	✓	✓	✓
CO 6	✓	✓	✓		✓		✓	
CO 7	✓	✓	✓	✓	✓	✓	✓	✓

Course Name: INDUSTRIAL CATALYSIS AND GREEN CHEMISTRY
Course Code: ICH-502
Course Type: Hard Core
Contact Hours/Week: 4L **Course Credit: 04**

Course Objectives

- To study in detail about the types and applications of catalysts
- To learn about the applications of solid catalyst in industry
- Understanding the role of organometallic compounds as catalysts
- To learn about nano catalysts and their applications
- To study photo catalyst and their applications
- To understand green chemistry techniques

Course Content

UNIT I: Industrial catalysis **14 hr.**
Heterogeneous catalysis: Preparation of solid catalyst-Precipitation method, Impregnation, Physical

mixing, Evaluation-test reactions and characterization (physical and chemical analysis) of prepared catalyst, Performance criteria of catalysts-Activity, selectivity, temperature response, catalyst size and shape, pretreatment, catalyst life, criteria for selection of catalyst.
Catalytic promoters, stabilizers, catalytic supporter- role of supporter, preparation and structure of supports- Silica, alumina, Zeolite, supported catalyst, Deactivation of catalyst – sintering, poisoning-selective poisoning and non- selective poisoning, fouling, effect of coke formation on catalyst, Electro catalyst- Features and applications, Industrial applications of catalysis, Surface active agents, classification of surface active agents, micellization, hydrophobic interactions, critical micellar concentration (CMC), factors affecting the CMC of surfactants.

UNIT II: Catalysis by Organometallic Compounds 14 hr.

Transition metal hydrides: Synthetic routes, structure and reactivity, synthetic applications. (Pd, Ni, Fe, Co, Ti complex); Coordinative unsaturation, oxidative addition and reductive elimination and insertion reactions, olefin hydrogenation, Wilkinson's Catalyst, Wacker process, Zeigler-Natta process, olefin metathesis, Monsanto process for the synthesis of acetic acid, heterogenization of homogeneous catalysts using polymer supports.

UNIT III:Catalysis by Nano catalysts 14 hr.

Synthesis of Nanoporous Catalysts Microporous materials: Zeolites- Zeotypes – Overall steps in zeolite crystallization, Zeolite synthesis via dry gel route, Zeolite Y- determination of surface acidity-shape-selectivity; Mesoporous aluminosilicates: Synthesis of Mesoporous Silica- MCM-41, SBA-15; Aluminophosphates; Mesoporous Carbon- Sulfated Zirconia- Ag/SiO_2 composite nano catalysts. Nano photocatalysis and Catalysis of Gold nanocrystals Introduction to photocatalysis: Principle- Band energy engineering- Degradation of dye, Hydrogen generation- Organic synthesis.

UNIT IV: Green Chemistry 14 hr.

Planning a green synthesis in a chemical laboratory, green preparation-Aqueous phase reactions, solid state (solvent less) reactions, photochemical reactions, Phase transfer catalyst-catalyzed reactions, enzymatic transformations and reactions in ionic liquids. Synthesis using scavenger resins, catalysis and biocatalysis.
Sonochemistry: Introduction, instrumentation, the phenomenon of cavitation, types of Sono chemical reaction, Sono chemical esterification, substitution, addition, oxidation, reduction and coupling reactions. Microwave induced organic synthesis: Introduction, reaction vessel and reaction medium, concept, specific effect, atom efficiency, % atom utilization, advantages and limitations, alkylation of active methylene compounds, N-alkylation, condensation of active methylene compounds with aldehydes, Diels-Alder reaction, Leuckardt reductive amination of ketones, ortho ester Claisen rearrangement and synthesis of enamino ketones.

Books and References

1. Heterogeneous Catalysis, D.K. Chakrabarty and B. Viswanathan, New Age International (P) Limited, 2008
2. Nanoporous Materials: Synthesis and Applications, Edited by Qiang Xu, CRC Press, 2013
3. Catalysis: Principles and Applications, Edited by B. Viswanathan, S. Sivasanker, A.V. Ramaswamy, Narosa Publishing House, 2011
4. Introduction to catalysis and Industrial catalytic process by Robert J. Farruto, 2016.
5. Photocatalysis, Edited by Masao Kaneko, Ichiro Okura, Springer, 2003.
6. New and Future Developments in Catalysis, Edited by Steven L. Suib, Elsevier, 2013.
7. Catalysis by Gold, Geoffrey C. Bond, Catherine Louis, David T. Thompson, Imperial College Press, 2006.
8. Green Chemistry edited by Bela Torok Timothy Dransfield , Elsevieer,2017.
9. New Trends in Green Chemistry,V.K.Ahluvalia ,1st ed, Springer Nature, 2019.
10. Green Chemistry, Theory and Practice, Paul T. Anastas and John C. Warner, Oxford

University Press, 1998, New York, USA.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Explain the principles and mechanisms of heterogeneous catalysis and its industrial and environmental applications- **Understand**

CO 2: Evaluate green chemistry principles and apply them to design environmentally friendly and sustainable chemical processes- **Evaluate**

CO 3:Analyze the role of organometallic compounds in homogeneous and heterogeneous **catalysis**, including reaction mechanisms and selectivity- **Analyse**

CO 4: Demonstrate the application of sonochemistry in catalysis, synthesis, and energy-efficient processes. **Apply**

CO 5: Interpret the role of nanomaterials in catalysis and assess their advantages over conventional catalysts in terms of surface area, selectivity, and reusability-**Analyze**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH 502	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓		✓		✓			
CO 2	✓	✓	✓					✓
CO 3	✓	✓	✓		✓			✓
CO 4			✓				✓	✓
CO 5	✓	✓	✓	✓	✓			

Course Name: SYNTHETIC, HETEROCYCLIC AND MEDICINAL CHEMISTRY
Course Code: ICH-503
Course Type: Hard Core
Contact Hours/Week: 4L **Course Credit: 04**

Course Objectives:

This course will provide students with an in-depth understanding of the retrosynthetic analysis technique for designing synthetic pathways, particularly for intricate organic compounds

This course aims to assist students in comprehending the fundamental concepts and applications of pericyclic reactions

To study the synthesis, reactivity, and industrial applications of heterocyclic compounds

To study the principles of drug design, the mechanisms by which various drugs operate, and their significance in biological contexts

Course Content

UNIT I: Planning and Execution of Multistep Synthesis **14 hr.**

Basic principles and technologies used in disconnection approach, synthons and synthetic equivalents, Interconversion of functional groups, one group C-X and two group C-X disconnections. Protecting groups-Principles of protection of hydroxyl, amino, carboxylic and carbonyl groups. Use of C-C one group and C-C two group disconnections in the synthesis of 1,2; 1,3; 1,4; 1,5 and 1,6-difunctionalised compounds. Retrosynthetic analysis of alcohols, carbonyl compounds, cyclic and acyclic alkanes, benzocaine, p-methoxy acetophenone, acetocyanohydrin, 2-methyl-6-methoxy-indole-3-acetic acid, 6-methylquinoline and. Illustrative synthesis of Juvabione, Longifolene, Prelog-Djerassi lactone,

Solid phase synthesis of polypeptides.

UNIT-II: Pericyclic chemistry **14 hr.**

Pericyclic Reactions: Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3- butadiene, 1,3,5-hexatriene and allyl systems. Classifications of Pericyclic reactions. Woodward-Hoffmann correlation diagram and FMO approach.

Electrocyclic Reactions: Introduction, Con-rotatory and dis-rotatory Process, 4n and 4n+2 systems. Reactions of cations and anions.

Cycloaddition reaction: Suprafacial and Antrafacial addition, 2+2 and 4+2 systems, 1,3- dipolar cycloaddition reactions and their applications in the synthesis of five membered heterocycles.

Sigmatropic reactions: Suprafacial and Antrafacial shift of H, [1,3] and [3,3]-sigmatropic shifts. Claisen, Cope, Oxy-Cope and Aza-Cope rearrangements.

UNIT III: Heterocyclic Compounds **14 hr.**

Hantzsch-Widman system for naming monocyclic, fused and bridged heterocycles. Chemistry of derivatives of pyrazole, imidazole, oxazole, thiazole, benzofuran, indole, benzothiophene, pyridine, quinoline. Inter conversion of coumarin to benzofuran, pyrrole to pyridine, Pyrimidine to pyrazole, indole/isatin to quinoline, furans to pyrrole. Uses of furan, pyrrole, thiophene in the synthesis of non-heterocycles.

UNIT IV: Medicinal Chemistry **14 hr.**

Concept of lead compounds, analogues and prodrug, Factors governing drug design ADME, drug design through molecular disjunction and conjunction. Drug receptor interactions- Forces involved in drug receptor interactions Theories of drug action-occupancy, rate, and induced fit theory. Concept of fragment-based drug discovery. Structurally specific and non-specific drugs, Classification, synthesis and mode of action of following classes of drugs-Antipyretic analgesics (Cinchophen), General anaesthetics (Thiopental sodium), Local anaesthetics (benzocaine), cardiovascular drugs (diazoxide), antimalarials (chloroquine phosphate), antineoplastic agents (methotrexate and fluorouracil), antiviral drugs (methisazone).

Books and References

1. Organic Synthesis-Special Techniques, V.K.Ahluwalia and R. Aggarwal, Narosa, New Delhi, 2001.
2. Organic Synthesis, R.E.Ireland, Prentice Hall India,1969.
3. Advanced Organic Chemistry, IV Edn., Part A &B, F.J.Carrey&R.J.Sundberg, Kluwer, 2001.
4. Organic Synthesis- A Disconnection Approach,Stuart
5. Art in Organic Synthesis, Anand, Bindra&Ranganath, Wiley, New Delhi,1970.
6. Modern Methods of Organic Synthesis, N. Carruthers, Cambridge University,1996.
7. Organic Reaction Mechanisms, V.K.Ahluwalia&R.K.Parashar, Narosa,2006
8. Heterocyclic Chemistry, J. Joule & G. Smith, Van-Nostrand, ELBS,1978.
9. Comprehensive Heterocyclic Chemistry, Vol.I-VI Edn., Katritzky& Rees, Pergamon,1984.
10. Heterocyclic Chemistry, Raj K. Bansal, New Age International,1999.
11. Medicinal Chemistry, Ashuthosh Kar, Fourth edition, New Age International PvtLtd.
12. Pericyclic reactions, S. M. Mukherji (The McMillan Bangalore),1979.
13. V.K. Ahluwalia and Mahu Chopra, Medicinal Chemistry.
14. Graham L Patrick, An introduction to medicinal chemistry, Oxford.
15. Ashutosh Kar, Medicinal Chemistry.
16. Frank Jensen, Introduction to Computational Chemistry, Wiley Publisher, Second Edition,2006.
17. Pericyclic Reactions, S. M. Mukherji, Macmillan, India.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the

students will be able to

CO 1: Develop a synthetic route for transforming simple organic molecules in to more complex structures using a retrosynthetic strategy Apply

CO 2: The student will gain an understanding of the essential principles and applications of pericyclic reactions Understanding

CO 3: The student will gain an understanding of the synthesis, chemical reactivity, and biological significance of different heterocyclic compounds Understanding

CO 4: To examine the fundamentals of drug design, the mechanisms through which different drugs function, and their importance in biological settings. Apply

CO 5: Recognize pericyclic reactions, including an understanding of thermal and photochemical processes **Analyze**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH 503	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓		✓		✓			
CO 2	✓	✓	✓					✓
CO 3	✓	✓	✓		✓			✓
CO 4			✓				✓	✓
CO 5	✓	✓	✓	✓	✓			

Course Name: COMPUTER AIDED DRUG DESIGN

Course Code: ICS-505

Course Type: Soft Core

Contact Hours/Week:4L **Course Credit: 04**

Course Objectives:

The subject is designed to impart knowledge on the current state of the art techniques involved in computer assisted drug design

Upon completion of this course the student should be able to

Role of CADD in drug discovery

Different CADD techniques and their applications

Various strategies to design and develop new drug like molecules

Working with molecular modeling softwares to design new drug molecules

The *in silico* virtual screening protocols

Course Content

UNIT I **12hr.**

Introduction to Computer Aided Drug Design (CADD) History, different technique sand applications Quantitative Structure Activity Relationships: Basics History and development of QSAR: Physicochemical parameters and methods to calculate physicochemical parameters: Hammett equation and electronic parameters (sigma), lipophilicity effects and parameters (log P, pi-substituent constant), steric effects (Taft steric and MR parameters) Experimental and theoretical approaches for the determination of these physicochemical parameters Quantitative Structure Activity Relationships Deriving 2D-QSAR equations 3D-QSARapproaches and contour map analysis Statistical methods used in QSAR analysis and importance of statistical parameters

UNIT II **12 hr.**

Molecular Modeling and Docking: A) Molecular and Quantum Mechanics in drug design, B) Energy

Minimization Methods: comparison between global minimum conformation and bioactive conformation, C) Molecular docking and drug receptor interactions: Rigid docking, flexible docking and extra-precision docking. Agents acting on enzymes such as DHFR, HMG-CoA reductase and HIV protease, choline esterase (AchE and BchE) Molecular Properties and Drug Design: a) Prediction and analysis of ADMET properties of new molecules and its importance in drug design, b) De novo drug design: Receptor/enzyme-interaction and its analysis, Receptor/enzyme cavity size prediction, predicting the functional components of cavities, Fragment based drug design, c) Homology modeling and generation of 3D-structure of protein

UNIT III **10hr.**

Pharmacophore Mapping and Virtual Screening Concept of pharmacophore, pharmacophore mapping, identification of Pharmacophore features and Pharmacophore modeling; Conformational search used in pharmacophore mapping In Silico Drug Design and Virtual Screening Techniques Similarity based methods and Pharmacophore based screening, structure based In-silico virtual screening protocols 12

Books and References

1. Computational and structural approaches to drug discovery, Robert M.Stroudand, JanetF. Moore, RCS Publishers.
2. Introduction to Quantitative Drug Design by Y.C. Martin, CRC Press, Taylor&Francis group.
3. Drug Design by Ariens Volume 1 to 10, Academic Press, 1975, Elsevier Publishers.
4. Principles of Drug Design by Smith and Williams, CRC Press, Taylor & Francis.
5. The Organic Chemistry of the Drug Design and Drug action by Richard B. Silverman, Elsevier Publishers.
6. Medicinal Chemistry by Burger, Wiley Publishing Co
7. An Introduction to Medicinal Chemistry –Graham L. Patrick, Oxford University Press.
8. Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, Ippincott Williams & Wilkins.
Comprehensive Medicinal Chemistry – Corwin and Hansch, Pergamon Publishers.
Computational and structural approaches to drug design edited by Robert M Stroudand Janet. F Moore
Rajarshi Guha(Editor), Andreas Bender (Editor),ComputationalApproaches in Cheminformatics and Bioinformatics Wiley-Blackwell, 2012.
Fan Li, Developing Chemical Information Systems: An Object-Oriented Approach Using enterprise JAVA, John Wiley & Sons, 2006, ISBN:0470068787,978047006878.
Johann Gasteiger (Editor), Thomas Engel (Editor), Chemoinformatics: A Textbook, Wiley Publisher ISBN: 978-3-527-30681-7, 2003.

Course outcome:

CO 1: Apply molecular modelling software to design and optimize potential drug molecules-**Apply**
CO 2: Analyze drug-target interactions using molecular docking, scoring functions, and visualization tools-**Analyze**
CO 3: Evaluate pharmacokinetic properties (ADMET) and drug-likeness usingcheminformatics tools and Lipinski's rule-**Evaluate**
CO4: Integrate computational techniques and databases (e.g., PubChem, PDB, Drug Bank) in the drug discovery pipeline-**Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 505	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

CO 1	✓		✓		✓			
CO 2	✓	✓	✓					✓
CO 3	✓	✓	✓		✓			✓
CO 4			✓				✓	✓
CO 5	✓	✓	✓	✓	✓			

Course Name: Polymers and Display materials
Course Code: ICS 506
Course Type: Soft Core
Contact Hours/Week: 3L **Course Credit: 03**
Course Objectives:

- To learn polymer chemistry and properties and synthetic methods
- To know the versatility of polymer materials in their applications
- To study some polymers used in industry
- To provide the knowledge of basic concepts of liquid crystals and its applications in display technology
- To learn OLED phenomenon and applications
- To learn the aspects thin film preparations

Course Content

UNIT I: Polymers 15 hr.

Polymers: Introduction-Basic concepts and classification of polymers, Molecular weight and its distribution, Polymerization techniques- bulk, solution, suspension, emulsion, poly-condensation, solid and gas phase polymerization. Determination of molecular weight: Osmometry, viscometry**.** Viscosity vs. molecular weight and mechanical property vs. molecular weight relationships, Chain structure and configuration, Synthesis, properties, structural features and applications of some important commercial polymers (PS, PVC, PMMA, PET, Nylon-6, Nylon-6,6), Engineering polymers (Kevlar, Nomex, ABS, PC, Teflon). Polymer processing techniques, additives for improvement of polymer properties, spinning of industrial polymers, wet, dry melt spinning and electrospinning.

UNIT-II: Polymer blend and composites 15hr.

Polymer blend and composites-preparation and uses. Characterization techniques of polymer blend and composites using FT-IR, PXRD, TGA, DSC, FE-SEM, EDX, XPS. Polymers as separation devices-principles and applications of reverse osmosis, ultra and nano filtration and electrodialysis, Uses in food industry and biotechnology. Medical applications of polymers: Introduction to nano composites Concepts and design of oral, transdermal and targeted drug delivery systems-micro, macro and nano sized systems. Biodegradable polymers- Sources of plastic waste, waste management techniques.

UNIT III: Liquid crystals and thin films 15hr.

Liquid Crystals: Definition,Liquid crystal phases,Thermotropic liquid crystals, Nematic phase, Smectic phases, Chiral phases, Cholesterics, Lyotropic liquid crystals –Hexagonal columnar phase, Micellar cubic phase. Theoretical treatment of liquid crystals- Parameter to describe a liquid crystal, optical properties of liquid crystals, LCD.

Organic LED materials: Introduction, phenomena, fabrication and applications. PLED and QLED.

Fabrication of Thin Films: Thin Films and Langmuir-Blodgett Films, Preparation techniques, vaporization/sputtering, chemical process, MOCVD, sol-gel etc. growth technique, photolithography, properties and applications of thin and L-B films.

Books and References.

1. Material science and Engineering, W D Callister,Wiley 7th ed., 2007.
2. Liquid Crystals, Second Ed., John Wiley & Sons, Inc.,2007.
3. Solid State Chemistry, A R West, Wiley 1987.
4. Modern aspect of Solid-State Chemistry, C N R Rao, 1st ed., 1970.
5. Principles of Polymer Science, Bahadur P and N.V Shastry, Narosa, New Delhi,2000.
6. Polymer Science and Engineering, D.J.Williams, Prentice Hall Inc, New Jersy,1971.
7. Theory and Basics of Polymer Science, F.W. Billmeyer, John Wiley &Sons,NY,1984
8. Engineering Polymer Sourcebook, Seymour RB, Mc Graw Hill,
9. Introduction to Physical Polymer Science L. H. Sperling, Wiley- Interscience

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Understanding the versatility of polymers their uses in diverse fields and also understands the chemistry of polymers- **Understand**

CO 2: Determine a structure and composition of polymer composites - **Apply**

CO 3: Students learn about fundamental of liquid crystal and their application in LCD technology- **Apply**

CO 4: learn about thin films processes and applications- **Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICS 506	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓		✓	✓	✓		✓	✓
CO 2	✓	✓	✓	✓	✓	✓		✓
CO 3	✓	✓	✓		✓			✓
CO 4		✓	✓	✓		✓	✓	✓

Course Name: SYNTHESIS OF COMPLEXES, CATALYSTS AND ESTIMATION OF ALLOYS

Course Code: ICP 506

Course Type: Soft Core

Contact Hours/Week: 6H **Course Credit: 03**

Course Objectives

- To gain the basic analytical and technical skills to work effectively in different fields of chemistry
- To demonstrate the ability to synthesize and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation

- To learn advance techniques in gravimetric and volumetric analysis
- To synthesize complexes and nano catalysts

1. Analysis of brass–Cu gravimetrically using α-Benzoinoxime and Zn complexometrically.
2. Analysis Cu-Nialloy.
3. Analysis of Stainless Steel-Insoluble residue by gravimetry, Ni gravimetrically using DMG complex.
4. Fe volumetrically using Ce(IV) &Cr(III) volumetrically by persulphateoxidation.
5. Flame photometric determination of Na, Kmixtures.
6. Chemical SeparationTechniques
7. Cu(II) + Fe(II)-Cu gravimetrically as CuSCN and Fe usingCe(IV).
8. Cu(II) + Ni(II)-Cu gravimetrically as CuSCN and Ni using EDTA.
9. Fe(III) + Ca(II)-Fe gravimetrically as Fe_2O_3 and Ca using EDTA.
10. Cr(III) + Fe(III)-Using EDTA by Kinetic maskingmethod.
11. Synthesis and characterization of potassium trioxalato chromate (III) trihydrate
12. Solid phase synthesis of transbisglycinatocopper(II)
13. Preparation of tris acetyl-acetoacetanatoiron(II)
14. Preparation of bis-dichlorotriphenyl phosphine nickel (II)
15. Synthesis of hexamine cobalt (II) chloride
16. Preparation of Silver nanoparticles
17. Preparation of ZnO nanoparticls

Books and References

1. G.H.Jeffrey, J.Bassette, J.Mendham and R.C.Denny, Vogel's TextBook of QuantitativeChemical Analysis, 5thEdition, Longman, 1999.
2. Vogel, "Textbook of Qualitative Inorganic Analysis", 3 Edition, ELBS. 1976.
3. D.A.Skoog and D.M.West, Fundamentals of Analytical Chemistry, IV Edition, Old Reinhord and Winston, Publication, 1982.
4. B.K. Sharma, Instrumental methods of Chemical analysis, Goel Publishing House, 24th Edition, 2005
5. Gurdeep R. Chatwal, Sham K. Anand, Instrumental Methods of Chemical Analysis, Himalaya Publication, 1979.
6. Industrial Applications of Homogeneous Catalysis, Editors: Mortreux, A., Petit, F. (Eds.) Springer,1988
7. Louis S. Hegedus, Björn C. G. Söderberg, Transition Metals in the Synthesis of Complex Organic Molecules, Björn C. G. Söderberg, Springer1994.
8. Nikolay Gerasimchuk, Sergiy Tyukhtenko, Inorganic Synthesis: A Manual for Laboratory Experiments Cambridge Scholars Publishing, 2021.
9. Colquhoun, H M, Holton, J, Thompson, D J, and Twigg, M V. New pathways for organic synthesis. Practical applications of transition metals. United States: N. p., 1984.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Understanding the versatility of polymers their uses in diverse fields and also understands the chemistry of polymers- **Understand**

CO 2: Determine a structure and composition of polymer composites - **Apply**

CO 3: Students learn about fundamental of liquid crystal and their application in LCD technology- **Apply**

CO 4: learn about thin films processes and applications- **Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICP 506	Program Outcomes (POs)							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓		✓	✓	✓		✓	✓
CO 2	✓	✓	✓	✓	✓	✓		✓
CO 3	✓	✓	✓		✓			✓
CO 4		✓	✓	✓		✓	✓	✓

Course Name: SYSTEMATIC QUALITATIVE ANALYSIS AND IDENTIFICATION OF ORGANIC COMPOUND
Course Code:ICP-507
Course Type: Practical
Contact Hours/Week: 6H **Course Credit: 03**
Course Objectives

- To provide fundamental understanding regarding the separation of organic binary mixtures
- To classify the nature of the mixture such as solid-solid, solid-liquid, liquid-liquid etc
- To educate various purification methods including distillation
- To identify components along with their functional group test and melting/boiling points
- To verify the structure while preparing the corresponding derivative
- To gain practical experience in identifying functional groups and preparing derivatives
- T gain knowledge regarding the separation methods for acids, bases, phenols, and neutral compounds
- To comprehend the identification of organic compounds through the spectroscopic techniques such as FT-IR, Mass, ^{1}H NMR, ^{13} CNMR

Course Content
1. Systematic qualitative analysis of an organic mixture containing two compounds (Identification, method of separation and the functional group (s) present in each of them and preparation of one solid derivative for the conformation of each of the functional group (s).
2. Structural elucidation of organic compounds by spectroscopic techniques.

Books and References

1. Comprehensive practical organic chemistry: Qualitative analysis by VK Ahluwalia, Sunita Dhingara
2. More Spectroscopic Problems in Organic Chemistry-A.J. Baker et al., Hayden,1975.
3. Spectral Problems in Organic Chemistry, Davis& Wells, Chapman and Hall,1984.
4. Elementary Practical organic chemistry, Part 2: Quantitative organic analysis by
5. Arthur I. Vogel, 2nd Edition, CBS Publishers and distributors,1987.
6. Practical organic chemistry, Mann and Saunders
7. A hand book of qualitative and quantitative analysis by H. T. Clarke

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Acquire knowledge reading the separation and estimation of binary mixtures -**Apply**

CO 2: Additionally, they are capable of identifying functional groups and determining the structures of organic compounds through spectroscopic techniques. -**Understand**

CO 3: Understand basics of separation of organic tertiarymixtures **-Understand**

CO 4: Identify and chemical nature of mixture, and Separate of each component from mixture- **Analyze**

CO 5: Identify each component through their functional group test, elemental analysis and M.P/BP.- **Analyze**

CO 6: Purify the compounds using different techniques including distillation, crystallization etc, and record physical constants for individual compounds- **Analyze**

CO 7: Appreciate good laboratory practices- **Apply**

Course/Paper Title: ICP 506	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓		✓	✓	✓		✓	✓
CO 2	✓	✓	✓	✓	✓	✓		✓
CO 3	✓	✓	✓		✓			✓
CO 4		✓	✓	✓		✓	✓	✓
CO 5		✓	✓	✓		✓	✓	✓
CO 6		✓	✓	✓		✓	✓	✓
CO 7		✓	✓	✓		✓	✓	✓

Course Name: SYNTHESIS, CHARACTERIZATION AND APPLICATIONS OF POLYMERS AND COMPOSITES

Course Code : ICP-508

Course Type: Practical

Contact Hours/Week:6h **Course Credit: 03**

Course Objectives

- To synthesize and characterize polymers and composites/nanocomposites
- To determine physical properties of polymers
- To study dye adsorption kinetics, isotherm and thermodynamics of polymers
- To evaluate water retention capacity of polymer
- To synthesize polymer nanofibers through electrospinning process and evaluate to their drug and pesticide release capacities

Course Content

Any twelve experiments to be carried out

1. Synthesis and characterization of polystyrene
2. Condensation polymerization of Nylon 6 6

3. Preparation of polysaccharide stabilized silver nanoparticles and their characterization
4. Synthesis and characterization of ZnO nanoparticle incorporated polysaccharides/polymers
5. Separation and purification of polymer quantitatively
6. Estimation of viscosity average molecular weight of polymers
7. Determination of glass transition temperature of a polymer by dilatometry
8. Determination of molecular weight of polymer by end group analysis
9. Preparation and characterization of phenol-formaldehyde resin
10. Kinetics of dye adsorption capacity of polymers
11. Dye adsorption isotherm studies of polymers
12. Thermodynamic studies of dye adsorption by polymers
13. Electro spun nanofibers of polysaccharides/polymers
14. Drug release capacities of composites of polysaccharides
15. Water absorption capacities of polymer gels and composites
16. Drug release studies of polymer nanocomposites
17. Comparison of thermal properties of polymers
18. Morphological analysis of polymers/nanocomposites Experiments with Origin, kinetDS and chemsketch softwares

Books and References

1. Advanced Practical Physical Chemistry by J. B. Yadav, 5th edition, 1989.
2. Experimental Methods in Polymer Science by Toyoichi Tanaka, 2000, Elsevier.
3. Polymer Synthesis and Characterization: A Laboratory Manual by S. R. Sandler, W. Karo, J. Bonesteel, and E. M. Pierce, Academic Press, New York,1998.
4. Polymer Chemistry by S. Koltzenburg, M. Maskos and O. Nuyken, Springer, 2017.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO1: To prepare polymers, hydrogels, and composites- **Prepare**

CO2: To understand the principles of controlled and sustained drug release mechanism using polymer composite hydrogels-**Understand**

CO3: Analyze dye adsorption on hydrogels for water purification - **Analyze**

CO4: Apply concept of thermodynamics and kinetic parameters of chemical reactions for adsorption and drug delivery- **Apply**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICP 508	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓	✓	✓	✓		
CO 2	✓	✓	✓		✓		✓	✓
CO 3	✓	✓	✓	✓	✓		✓	✓
CO 4	✓	✓	✓	✓	✓		✓	✓

Course Name: Pesticides and their environmental impact assessment
Course Code: ICE-510
Course Type: Open Elective
Contact Hours/Week:3L **Course Credit: 03**
Course Objectives

- To introduce the types, structures, and chemical nature of common pesticides and their modes of action
- To understand the synthesis, application, and degradation pathways of pesticides in the environment
- To evaluate the impact of pesticides on soil, water, air, and non-target organisms
- To familiarize students with national and international regulations regarding pesticide usage
- To train students in techniques of Environmental Impact Assessment (EIA) specific to agrochemicals. To encourage the adoption of greener, sustainable pest management strategies

UNIT I **15 hr.**

Pesticides: Introduction and classification.
Insecticides: Introduction, classification, Organochlorine insecticides-BHC, DDT, sevin, endosulfan, Insect pheromones, general introduction and applications in integrated pest management.
Repellents: Survey and synthesis of the repellents-N, N-diethyltoluamide, 2-ethyl-1,3- hexanediol.
Fungicides: Introduction, Inorganic and organic fungicides, Systemic fungicides-types andexamples.
Herbicides: Introduction, study of sulfonyl ureas, Mechanism of action and toxicities of insecticides, fungicides and herbicides.

UNIT II **15 hr.**

Residues of Agrochemicals: a) Pesticides Residues in the Atmosphere: Pesticides into the atmosphere, their fate and transport of vapors, precipitation, effect of residues on human life, b) Pesticides residues in Water system: Nature and origin of pollution of aquatic systems, Point and Non-Point pollution. Dynamicsof pesticides in aquatic environment.

UNIT-III **15hr.**

Pesticides residues in the Soil: Absorption, Retention, Transport and Degradation of pesticides in the soil, Effect on microorganisms and Consequent effect on the soil condition, Fertility, Interaction in the soil, Effect of pesticide residues on the quality of human life. Model ecosystem, In general and consequent effect on human life. The Cases of & affected societies (endosulfan tagedy) and starving populations facing problems of health and nutrition, Traditional wisdom and Food security.

Books and References

1. Dikshith T.S.S. Safety evaluation of environmental chemicals. New Age International,1996.
2. Chemical Safety Matters-IUPAC-IPCS, Cambridge univ. Press,1992.
3. Environmental Chemistry, A.K. Dey, WileyEastern.
4. Environmental Chemistry, S.K.Banerji, Prentice Hall India, 1993.
5. Chemistry of Water Treatment, S.D. Faust and O.M. Aly, Butterworths,1983.

6. Environmental chemistry, Ahluwalia V K, Anne Books India,2008.
7. Chemistry for Environmental Engineering, Sawyer and McCarty, McGraw Hill,1978.
8. Environmental Chemistry, I. Williams, John Wiley,2001
9. Engineering Chemistry by Jain andJain.
10. Pesticide Synthesis Handbook : Thomas A. Unger, Prochrom Industrias Quimicas S/A Elsevier, 1996.
11. Metabolic pathways of agrochemicals. Part 1 [Herbicides and plant growth regulators] : Ed-in-chief T Roberts, Royal Society of Chemistry, Cambridge, 1998.
12. Metabolic pathways of Agrochemicals. Part-2 [Insecticides and Fungicides] :Terry.R.Roberts and David H. Hutson, 1999.
13. Chemistry of Insecticides and Fungicides :U.S.ShreeRamulu Oxford & IBH Pub., 2nd, 1995.
14. Principles of Pesticide Chemistry: S. K. Handa, Ed. By Agrobios (India), 2008.
15. Handbook of Systemic Fungicides Vol- I :S.C.Vyas, Published by Mcgraw Hill, 1993.
16. Analytical Methods for Pesticides, Plant growth regulators & food additives: Vol. I-XVII Ed. By Gunter Zweig.
17. The Agrochemical Handbook: Royal Society, England, Hartley, D., Kidd, H.,1984.
18. Pesticide Science and Biotechnology: R. Greenhalgh and T.R.Roberts International Union of Pure and Applied Chemistry, Blackwell Scientific Publication, 1987.
19. The Chemical Process Industries: D.N. Shreve
20. Pesticides in India- Recent facts and figure: R & D section, Yawalkar Pesticides, Nagpur (Agri-Horticulture, Nagpur).
21. Pesticide Chemistry: G. Matolcsy, M. Nádasy, V. Andriska, Elsevier Science Publishing, USA, 1988.
22. Pesticides: preparation and mode of action:Crymlyn. R., 1978.

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: Classify and describe different types of pesticides (organophosphates, carbamates, organochlorines, etc.) based on their chemical structure and function- **Understand**

CO 2: Analyze the adverse effects of pesticide residues on ecosystems, human health, and biodiversity- **Analyze**

CO 3: Apply principles of environmental chemistry to evaluate pesticide pollution through laboratory and field data-**Apply**

CO 4: Assess pesticide-related case studies using Environmental Impact Assessment (EIA) protocols and identify risk mitigation strategies- **Evaluate**

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICE510	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1		✓	✓	✓			✓	✓
CO 2	✓	✓	✓		✓			✓
CO 3		✓	✓		✓		✓	✓
CO 4						✓		
CO 5	✓		✓		✓	✓		✓

IV SEMESTER

Course Name: Project report
Course Code: ICH-551
Course Type: M.Sc. Project dissertation
Contact Hours/Week: 40 H **Course Credit: 16**

Course Objectives

- To acquire practical experience in executing various types of reactions within the chemical industry
- To acquire experience in the operation of various analytical instruments, including HPLC, GC-MS, ^{1}H NMR, ^{13} C NMR and UV-visible spectrophotometry, utilized in the chemical industry
- To acquire knowledge on the development of analytical methods for the analysis of pharmaceuticals and their intermediates
- To acquire knowledge on the management of diverse hazardous reactions and reagents. To acquire knowledge on the implementation of environmental health and safety rules and the safe handling of chemicals, as well as to adhere to various types of standard operating procedures.
- To seek jobs in chemical industries.
- To learn research methodology and to form a project report on the work carried out at the Industry during IV semester

Course Content

Students will undertake project work at several chemical firms in India for four months, supervised by an internal guide as one of the teachers from the Department of Industrial Chemistry and an external scientist or research executive, group leader of the respective chemical industries. The student has to prepare a dissertation

Course Outcomes:

Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO 1: students are capable of managing many sorts of reactions and reagents in the chemical industry- **Analyze**
CO 2: Students will understand instruments such as HPLC-GC-MS, 1H-NMR, and UV-Visible spectrophotometers employed in the chemical industry- **Understand**
CO 3: Students will devise diverse methodologies appropriate for the analysis of medicines and their intermediates-**Analyze**
CO 4: Students will become acquainted with the application of safety and health management systems utilized in chemical industries- **Understand**
CO 5: Student undergoes training at chemical industries for 4 months internship and prepare dissertation on the work carried out-**understand**
CO 6: The students will understand research methodology and how to document results and derive conclusions- **Understand**
CO 7: Students will secure placements in the chemical industry

Course/Paper Title: ICH 551	Program Outcomes (POs)							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓	✓			✓	✓
CO 2	✓	✓	✓		✓			✓
CO 3		✓	✓		✓		✓	✓
CO 4				✓	✓	✓		✓
CO 5	✓	✓	✓	✓	✓	✓	✓	✓
CO 6	✓	✓	✓	✓	✓	✓	✓	✓
CO7	✓	✓	✓	✓	✓	✓	✓	✓

Course Name: Viva–Voce examination
Course Code: ICH-552
Course Type: Evaluation of Project work (Viva-voce examination)
Contact Hours/Week: NA **Course Credit: 02**
Course Objectives:

- To evaluate the project work to be carried out in chemical industries both by internal and external supervisor
- To present the abstract of the project work carried out during IV semester for evaluation by the examiners

Course Content
A student needs to work in various types of chemical industries for the period of 4 months and after completion of the project work, a student needs to present his/ her project report in front of the internal and external guide for *prima face viva voce* examination.

Course Outcomes:
Thinking and learning level of the student upon successful completion of the course, the students will be able to

CO1: Apply theoretical knowledge of chemistry and chemical engineering principles to identify and solve real-world industrial problems- **Apply**
CO2: Demonstrate the ability to design and execute a project plan, including literature review, process development, data collection, and analysis within the context of a chemical industry setting-**Create**
CO3: Evaluate chemical manufacturing processes with regard to efficiency, safety, environmental impact, and regulatory compliance-**Evaluate**
CO4: Communicate technical findings effectively through written reports, presentations, and discussions, adhering to industrial documentation standards- **Apply**
CO5: Work effectively as part of a team and demonstrate professionalism, ethical practices, and project management skills in an industrial or industrial-simulated environment- **Apply**
CO6: Develop insights into modern chemical industry operations, including process scale-up, instrumentation, and quality control protocols-Understand

Course Articulation Matrix: Mapping of Course outcome (COs) and (POs)

Course/Paper Title: ICH552	**Program Outcomes (POs)**							
Course outcome	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
CO 1	✓	✓	✓	✓			✓	✓
CO 2	✓	✓	✓		✓			✓
CO 3		✓	✓		✓		✓	✓
CO 4						✓		
CO 5	✓	✓	✓	✓	✓	✓	✓	✓
CO 6	✓	✓	✓	✓	✓	✓	✓	✓

****