MANGALORE UNIVERSITY

DEPARTMENT OF INDUSTRIAL CHEMISTRY, MANGALAGANGOTHRI – 574 199

M. Sc. DEGREE PROGRAMME IN INDUSTRIAL CHEMISTRY

(With effective from the Academic Year 2016-17)

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

PREAMBLE

Revision of syllabi for the two years' Master Degree (Choice Based Credit System- Semester Scheme) Programme in Industrial Chemistry

PG 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 to each course amounting to **90** credits for the entire programme.

There are totally **9** theory courses, One semester Industrial project in IV semester are assigned as Hard Core courses with a total credits of 54. Students have to study 3 soft core courses each in I ,II and III semester. The choice has been given for the soft core courses in the I ,II and III semesters for Industrial chemistry post graduates. All 9 practical courses will be taught as soft courses with 2 credits for each courses in I and II semester where as III semester practical courses are given 3 credits. Total Soft core credits amount to 30. Board of Studies in Industrial chemistry has carefully chosen two Open Elective courses for the students from other disciplines, one each in II and III semester, with total credits of 6. Therefore, grand total credits for the programme = **90.**

A detailed skeleton of the entire programme is being tabulated for the benefit of the aspiring post graduates. Other important aspects such as University question paper pattern, internal assessment examinations, allotment of marks and the approximate dates of the internal examinations are being tabulated with a discussion in the BOS.

Program Outcome:

The M.Sc. Industrial chemistry course has an objective to impart knowledge and hands-on experience to the students. The program includes anin-depth study on a number of areas in chemical sciences to which students are introduced at the core curriculum level, theoretical and experimental solutions to various problems and molding the students relevant to contemporary industries. The areas introduced by the department includeAgrochemicals, Pharmaceutical chemistry, and Petrochemicals. Beside the theoretical and laboratory based curriculum, students complete an advanced project in the final semester of the program at an industry.

The degree provides a solid foundation in the discipline of core chemical sciences, critical thinking and problem solving skills. During the academic program students also develop excellent written and oral communication skills, learn to work as a team and project management.

Program Specific Outcome:

The specific 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.

Two-year Master's Degree Programme
(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	18	---	--	Industrial Project (H)	-----	18
	Total	**54**	**30**	**6**			**90**

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**	2	70+30=100
ICS 405: Paper and Textile technology	S				
ICP406 : Inorganic Chemistry Practicals-I	S	4	**2**	4	70+30=100
ICP 407 : Organic Chemistry Practicals-I	S	4	**2**	4	70+30=100
ICP 408 : Physical Chemistry Practicals-I	S	4	**2**	4	70+30=100
			21		**700**
II SEMESTER					
ICH451 : Analytical Chemistry	H	4	**4**	3	70+30=100
ICH452 : Organic Chemistry-II	H	4	**4**	3	70+30=100
ICH453:Energy Systems, Colloids and Petrochemicals	H	4	**4**	3	70+30=100
ICS 454 : Chemical Engineering Technology	S	3	**3**	2	70+30=100
ICS 455: Soft materials and Nanotechnology	S				
ICP 456 : Inorganic Chemistry Practicals -II	S	4	**2**	4	70+30=100
ICP 457 : Organic Chemistry Practicals -II	S	4	**2**	4	70+30=100
ICP 458 : Physical Chemistry Practicals -II	S	4	**2**	4	70+30=100
ICE 459 : Industrial Safety, Environmental and Electrochemical Sciences	OE	3	3	2	70+30=100
			24		**800**
III SEMESTER					
ICH 501 : Spectroscopic Techniques	H	4	4		70+30=100
ICH 502 : Catalysis and Polymers	H	4	4	3	70+30=100
ICH 503: Synthetic, Heterocyclic and Medicinal Chemistry	H	4	4	3	70+30=100
ICS 504: Cheminformatics and Drug Design	S	3	3	**2**	70+30=100
ICS 505: Chemical analysis in Agro, Food and Pharmaceutical Industries	S				
ICP 506 : Inorganic Chemistry Practicals-III	S	6	3	5	70+30=100
ICP 507 : Organic Chemistry Practicals-III	S	6	3	5	70+30=100
ICP 508 : Physical Chemistry Practicals-III	S	6	3	5	70+30=100
ICE 509: Agriculture And Health care Chemicals	OE		3	2	70+30=100
			27		**800**
IV SEMESTER **Project Work (4 Months)** ICH 551 : Project Report ICH 552 : Viva-voce	H		**18**		400+200 100
					Total= 700
			90		**Grand Total=3000**

BASIS FOR INTERNAL ASSESSMENT

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

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

➢ Internal assessment in II Semester shall be awarded as: 20 marks for Test and 10 marks for seminar.

➢ Internal assessment in III Semester shall be awarded as: 20 marks for Test and 10 marks for industrial visit report.

➢ Practical internal assessment marks shall be based on test (25) and record (5) for I semester. For II and III semesters IA shall be based on practical test (15 marks), Viva (10 marks) and record (5marks). 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 objective type 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 from Part B.

PRACTICALS EXAMINATION PATTERN

In the I semester 70 marks shall be awarded based on the experiment. But in the 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.

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 jointly allotted by internal (Department) and Industry (external) guides. The progress of the project work of a student can be evaluated by the internal guide by officially visiting respective industry during project tenure. Viva-Voce examination is to be conducted as per the University regulations.

I SEMESTER

ICH401: INORGANIC CHEMISTRY

Course Outcomes:

Students gain knowledge and skills related to the course is as follows.

- Fundamental knowledge in alkaline earth metal complexes and their biological significance.
- Halogen and noble gas chemistry.
- Organometallic chemistry and metallurgy used in industries as catalyst, to extract nuclear fuels and related applications.
- Molecular symmetry and group theory to understand structure and spectroscopy.

UNIT I: **14 hrs**

Alkali and alkaline earth metal complexes of crown ethers, cryptands and calixarenes and their biological significance. Halogens and Noble gas chemistry–interhalogens, psuedohalogens, polyhalide ions, oxyhalogen species, xenon oxides and fluorides. Oxyacids of N, P and S. Graphitic compounds, carbides, pure silicon, silica and silicates, zeolites. P-N, P-O and P-S compounds including cyclophosphazines, Sulphur-nitrogen and boron-nitrogen compounds

UNIT II: **14 hrs**

Methods of reduction of oxide ores, chemical and electrolytic reductions, reduction potentials, Latimer, Frost diagrams and Ellingham diagram effect of complexation on potential. Theory and applications of pyrometallurgy (Copper, Nickel, Gold and Titanium), hydrometallurgy (Uranium and nuclear fuels, Electrometallurgy (Nickel and lead). Powder metallurgy-Principles and applications.

UNIT III:

14 hrs

Organometallics: Historical development, classification and nomenclature, bond energies and stability. 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 IV: Molecular Symmetry and Group Theory: **14 hrs**

Molecular Symmetry- 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 Raman active lines.

References

1. Carter Robert I: Molecular Symmetry And Group Theory, John Wiley,2005
2. Agarwala U C Et Al., Molecular Symmetry In Chemistry Via Group Theory, Ane Books, 2013.
3. V. Ramakrishnan And M.S. Gopinanthan: 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, New York,1993.
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8. Inorganic Chemistry of Biological Processes, 2nd edn., M.N.Hughes, Wiley, 1988.
9. Bioinorganic Chemistry, I.Bertini. H.B.Gray, S.J.Lippard and J.S.Valentine, Viva Books,1998
10. Bodsworth C: Metallurgy and metallurgical engineering series,CBS,1988
11. Johnson, Carl G :Metallurgy , The times of india,1956.
12. Chemistry of the Elements, N.N.Greenwood & A. Earnshaw, Butterman-Helnmann, 2005.
13. Principles of Extractive Metallurgy, H. S. Ray and A. Ghosh.
14. Extraction of Nonferrous Metals, H. S. Ray, R. Shridhar and K. P. Abraham.
15. Gilchrist, J. D, Extraction metallurgy, Pergamon, 1989.
16. Advanced Inorganic Chemistry, F.A.Cotton and G.Wilkinson, Wiley, 1991.
17. Organometallic Chemistry, R.C.Mehrotra and A.Singh, New Age International, 1999.
18. Chatwal, Gurdeep R, Organometallic Chemistry,Himalaya, 1992.
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20. Astruc Didier, Organometallic Chemistry and catalysis,Spinger, 2007.
21. Vogel's Textbook of Quantitative Chemical analysis, 5th edn, G.H.Jeffery, J. Bassett, J.
22. Mendham and R.C.Denney, ELBS, 1989
23. Wilkinson, Geooffrey E D.,Comprehensive organometallic chemistry,Pergamon,1982.

ICH 402: ORGANIC CHEMISTRY-I

Course Outcomes:

- Nature of reaction intermediates and the factors affecting reaction conditions such as nature of solvent, isotope effects and salt effects.
- Reaction types and their kinetics, thermodynamic and effect of thermodynamic parameters on reaction with kinetic aspects.
- Application of fundamentals on aliphatic nucleophilic and electrophilic substitution by studying their mechanism with named reactions.
- Aromatic nucleophilic substitution, addition and elimination mechanisms with respect to stereochemistry.
- Student learns about the fundamental and applications of chirotechnology.

UNIT I: **14 hrs**

Acids and Bases: Introduction to acids and bases, Bronsted-lowry and acid-bases concept, organic acids and bases, pKa and pH, effect of solvent on acid and base strength, effect of structure of organic compound on acid and base strength. Running scale of acidity, general and specific acid base catalysis. Reactivity in relation to molecular structure and conformation. Steric effects. F strain. Ortho effect. Bond angle strain. The Hammett equation and its applications. Taft equation. Linear free energy relationships. Solvent polarity and parameters. Y, Z and E parameters and their applications. Primary and secondary kinetic isotope effects. Salt effects and special salt effects in SN reactions. **Reaction intermediates:** Generation, structure, stability, reactivity & detection of classical & non-classical carbocations, carbanions, free radicals, carbenes, nitrenes & arynes. N, S & P ylides & enamines.

UNIT II: Organic Reactions and Mechanism (Part-I) **14 hrs**

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, stereochemical evidences, cross-over experiments, kinetic evidences & kinetic isotopic effects. The Hammond postulate. Principle of microscopic reversibility. Marcus theory. Phase transfer catalysis and its applications

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 acylic and bicyclic systems (Non- classic carbocations) Substitution at allylic, trigonal and Vinylic carbons, hydrolysis of esters, Meyer's aldehydes, ketones and carboxylic acids, alkylation with triakyl boranes.

Aliphatic Electrophilic substitutions: SE1 SE2 and SEi mechanisms hydrogen exchange, migration of double bonds, halogenation of aldehydes, ketones, acids, acylhalides sulphoxides and sulphones, aliphatic diazonium coupling, nitrosation at Carbon and nitroogen diazo transfer reaction carbene and nitrene insertion, formation of sulphur yield, metalation with organometallic compounds and with metals. Decarboxylation of aliphatic acids. Haloform reaction and Haller-Baner reaction.

UNIT III: Organic Reactions and Mechanism(Part-II) **14 hrs**

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 ofreactivity in the attacking radical effect of solvent on reactivity halogenation 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, sandmayer reaction, kolbe reaction and Hunsdiecker reaction.

Addition Elimination Mechanisms: (a) Addition to carbon multiple bonds- Addition reactions involving electrophiles, necleophiles and free radicals, cyclic mechanisms, orientation and stereochemistry, hydrogenation ofdouble and triple bonds, hydroboration, Birch reduction. Michael reaction, addition of oxygen and N,.04; (b) Addition to carbon- hetero atom multiple bonds: Mannich reaction AH reductions of Carbonyl compounds acids, esters, nitrites, addtion of Grignard reagents, 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: Chirotechnology **14 hrs**

Concept of chirality, optical isomerism, D,L-; R,S- designations, geometrical isomerism and E,Z designations, Stereoselective and stereospecific reactions, Racemisation, mechanism of racemisation, 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. Use of α-amino acids in the synthesis of benzodiazepines, carbohydrates in the synthesis of swainosonine (D-mannose) and tomolal (mannitol). Synthesis and applications of oxazaborolidines, IPC_2BH, (S)-BINAP-DIAMINE and (R)-BINAL-H. Use of (R,R)- DIPAMP, (S,S)-CHIRAPHOS, (R,R)-DIOP, SAMP, RAMP, , S-PBMgCl, (+) and (-)-DET.

References:

1. Robert B. Grossman :The Art of Writing Reasonable Organic Reaction Mechanisms Second 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 4th Edn.–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 Text book of Organic Chemistry-Tewari, Vishnoi and Mehrotra (Vikas, New Delhi)1998.
13. A Text book of Organic Chemistry-3rd Edn.-R.K. Bansal, (New Age, New Delhi) 1997.
14. Organic Chemistry-3rd Edn- 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.

ICH 403: PHYSICAL CHEMISTRY

Course Outcomes:

- Basic principle of quantum mechanics, thermodynamics.
- Basics and applications of chemical kinetics.
- Studies on corrosion, causes, types and protection aspects.
- Metal finishing process, types and applications.
- Application of electrochemistry in chloro alkali industries, electrosynthesis and electrochemical engineering.

UNIT I: **14 hrs**

Quantum mechanics: Basic principles of quantum mechanics: Postulates; operator algebra; exactly-solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling. Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications. Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle. Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated π-electron systems

UNIT II: **14 hrs**

Thermodynamics: Terminology, Laws of thermodynamics. Heat changes in chemical reaction-Born-Haber cycle, bond energy, Kirchoff`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 change 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 (qualitative aspects only). Explosive reaction (H_2-O_2,).

UNIT III: **14 hrs**

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: **14 hrs**

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

Electrosynthesis: Fundamentals of electroorganic & electroinorganic synthesis, Kolbe's synthesis,

electroreduction and oxidation of hydrocarbons, electroreduction of nitrocompounds, synthesis of adiponitrile. Electroinorganic 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.

Electrochemistry of Environment: Global warming, role of electrochemistry in the transport system, fixing of CO_2, sewage disposal and treatment of waste.

References:

1. Quantum Chemistry, Ira N. Levine, 5th Edn., Prentice Hall of India Pvt. Ltd., 2006
2. Quantum Chemistry, A. B. Sannigrahi, 2nd Edn., Arunabha Sen Books and Allied Pvt. Ltd., 2010
3. Quantum Chemistry, S. Devanarayanan, Scitech Publishers (India) Pvt. Ltd., 2013
4. Quantum Chemistry, Donald A McQuanie, Viva Books Pvt. Ltd., 2013
5. Thermodynamics for Chemists, S Glasstone, East-west Editon, New Delhi, 2003.
6. Chemical Thermodynamics-Basic Theory and Methods, 4th Edn., Klotz, Rosenbeg, Benjamin, 1986
7. Chemical Kinetics-Hareesh Mehra, Alfa publishing, New Delhi, 2006.
8. Principles & Applications of Electrochemistry, D R Crow, 3rd Edn., Chapman & Hall,1987.
9. Chemical Kinetics, K J Laidler, Harper & Raw.
10. Industrail electrochemistry by Peltcher
11. Modern Electrochemistry, Vol I, IIA & IIB(1998) J.O.M. Bockries and A.K.N.Reddy
12. Engineering Chemistry by Jain and Jain

ICS 404: ENVIRONMENT, HEALTH AND SAFETY MEASURES

Course Outcomes:

1. Fundamentals, analysis and control methods of air and water pollution
2. Quality control and quality assurance aspects used in industry and the laws regarding QA and QC along with chemical warfare convention.
3. Learns about good lab practices.

UNIT I: **10 hrs**

Air Pollution, Analysis & Control Methods: Qualitative study of **e**nvironmental segments, air pollutants, prevention & control, Green house gases & acid rain. Carbon monoxide, industrial sources & tranportation sources. SO_x-sources, control techniques-scrubbing, limestone injection process. Ozone hole & CFC's.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: **10 hrs**

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

UNIT III: **12hrs**

Quality Control and Quality Assurance: 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. ISO 17025.

Chemical Warfare Convention: Definitions and schedules. Toxic chemicals, remote control systems, tear gas, chemical weapons, ocean dumping of chemical weapons.

UNIT -IV: **10hrs**

Good Laboratory Practices: Safety equipments, personal protective equipments, 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, leaking compressed gas cylinders, fires, medical emergency accident reporting.Safety rulesof laboratory acquaintance of experimental set up and instruments, intellectual property and intellectual property rights. Data management, importance of safety and security of data.

References

1. Environmental Chemistry, A.K. Dey, Wiley Eastern.
2. Environmental Chemistry, S.K.Banerji, Prentice Hall India, 1993.
3. Chemistry of Water Treatment, S.D. Faust and O.M. Aly, Butterworths,1983.
4. Environmental chemistry, Ahluwalia V K, Anne Books India, 2008.
5. Chemistry for Environmental Engineering, Sawyer and McCarty, McGraw Hill, 1978.
6. Environmental Chemistry, I.Williams, John Wiley, 2001
7. Statistical Quality Control, 2nd Edn., Manohar Mahajan Dampat Rai and Sons, 1995.
8. Quality management:a process improvement approach,Fryman Mark A, Cengage learning, 2002.
9. Quality Control, Paranthaman D, Tata, McGraw Hill,1987.
10. Gupta R. N. Chemical warfare and casuality management 2011
11. Vyas M. N. Safety and hazards management in chemical industries 2013.Atlantic publication.
12. Dikshith T.S.S Safety evaluation of environmental chemicals. New Age International, 1996.
13. Chemical Safety Matters-IUPAC-IPCS, Cambridge Univ. Press, 1992

ICS 405: PAPER AND TEXTILE TECHNOLOGY

Course Outcomes:

1. Fundamentals of Paper and textile technology.
2. Pulp and paper science with pulp manufacturing.
3. Coating and recycling of paper and textile.

UNIT I **12 hrs**

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 & chemical pulping. Kraft pulping. **Papermaking:** Beating and Refining of pulp.

UNIT II **10hrs**

Textile Technology: Brief history on origin of textiles. Introduction to textile fibers and basic requirements of textile fibers. Manufacture of eco-friendly regenerated fibre. 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 in cotton.

UNIT III **10 hrs**

Introduction to blending techniques and its types. Blends of Polyester/cotton and polyester/viscose. Introduction to synthetic fibres. 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.

UNIT IV **10 hrs**

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.

References

1. Bleaching of Pulp, R. P. Singh, TAPPI Press.
2. 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.
3. Hand Book for Pulping and Papermaking, Christopher J. Biermann
4. Environmental Friendly Technologies for the Pulp and Paper Industries, Young and Akhtar TAPPI Press.
5. Hand Book for Pulp and Paper Technologists, Gary A. Smook
6. Formation of synthetic fibres, Walczalk.K. Gordon & Sci. London
7. Manual of Cotton Spinning, Coulson. A.F.W. (Ed.), Vol. I to IV,
8. Textile Institute Pub., Manchester, 1989.
9. Spun Yarn Technology, Osteby, Butterworths, London, 1987.
10. Physical Testing of Textiles, B.P. Soville, Wood Head,1999.
11. Principles of Textile Testing, Booth J. E., Butterworth, Wendon III Edition.
12. Technology of Textile Processing, Technology of Dyeing, Shenai, V.A. 4th Edn., Sewak Publications, Bombay,1988

ICP 406: INORGANIC CHEMISTRY PRACTICALS-I

Course Outcomes:

Practical training in volumetric and gravimetric analysis and statistical analysis of data.

1. Analysis of Haematite-insoluble residue by gravimetry & Iron by volumetry using Ce^{4+}.
2. Analysis of Dolomite-insoluble residue by gravimetry & Ca, Mg by complexometry.
3. Pyrolusite-Insoluble residue by gravimetry and Manganese content by oxalate method.
4. Estimation of percentage of copper in brass
5. Estimation of ferrous iron by dichrometry
6. Preparation of pure sample of ferrous ammonium sulphate (Mohr's salt) [$FeSO_4.(NH_4)_2SO_4.6H_2O$]
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. 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.
15. Any other interesting experiments

Reference

Vogel's Text Book of Quantitative Chemical Analysis (5th Ed), G.H.Jeffrey, J. Bassette, J.Mendham and R.C.Denny, Longman, 1999.

ICP 407: ORGANIC CHEMISTRY PRACTICALS-I

Course Outcomes:

- Students attain knowledge in single and two stage organic preparation, purification, analytical and TLC.

Single and Two stage organic preparations, purification and characterization: Preparations of 1,2,3,4–tetrahydrocarbazole, 7–hydroxy-4-methyl-coumarin, aspirin, adipic acid, Para red and Methyl red Preparations of p-bromo & p-nitroaniline from acetanilide, Ethyl resorcinol from Resorcinol, ε-Caprolactam from cyclohexanone, p-Amionobenzoic acid from p-Nitrotoludine, s-Tribromobenzene from aniline, Benzylic acid from Benzoin, p- Chlorotoluine from p-Toludine, 2,4-Dinitrophenylhydrazine from Chlorobenzene, m- Nitrobenzoic acid from methyl benzoate, 2,4-Dinitrophenol from Chlorobenzene, o- Aminobenzoic acid from Phthalic anhydride, hydantoin from benzyl, p-Aminoazobenzene from Aniline, thiazoles from acetophenones, pyrimidines from aldehydes/ketones and thiourea, , eosin from resorcinol & phthalic anhydride, Indigo from anthranilic acid, methyl orange from aniline, 5-hydroxy-1,3-benzothiole from hydroquinone,Benzimidazole from urea.

Any other interesting experiments

References

1. Experimental Organic Chemistry–Vol. I & II–P. R. Singh et al,TMH New Delhi, 1981
2. Laboratory Manual in Organic Chemistry–Dey & Sitaraman, Allied , New Delhi,1992.
3. Vogel's Text Book of Practical Organic Chemistry including Qualitative Organic Analysis- B. S. Furniss et al., Longman-ELBS, London, 1989.
4. Organic analytical chemistry, Theory and Practice-Jag Mohan, Narosa, 2003.
5. Practical organic chemistry by F.G. Mann & B.C. Saunders, 4th Edition, Longman,1970.
6. Laboratory Manual of Organic Chemistry - Raj K Bansal, 2nd Edition, Wiley, 1990.
7. Systematic Lab Experiments in organic chemistry-Arun Sethi, New Age International, 2006.
8. Advanced Practical organic chemistry-Jag Mohan, Himalaya Publishing House, 1992.

ICP 408: PHYSICAL CHEMISTRY PRACTICALS-I

Course Outcomes:

- Students learn following technique under physical chemistry.
  Determining physical constants using refractometry, adsorption experiment and viscometry, Study on kinetics of hydrolysis, catalytic effect and calculation of thermodynamic parameters.

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& 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 catalysed 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 of t-Butylchloride.
14. Reaction between hydrogen peroxide and HI.
15. Determination of solubility of lead iodide at different T & hence molar heat of solution.
16. Determination of heat of solution of a sparingly soluble solute.
17. Any other interesting experiments

References

1. Findlay's Practical Physical Chemistry, B. P. Levitt, Longman, London.
2. Experiments in Physical Chemistry, James and Prichard.
3. Experimental Physical Chemistry, Daniels et al.
6. Experimental Physical Chemistry, Das & Behera, Tata McGraw Hill, New Delhi, 1983.
7. Advanced Practical Physical Chemistry, Yadav, 1989.
8. Experiments in Physical Chemistry, J.C.Ghosh, Bharathi Bhavan, 1974.

II SEMESTER

ICH 451: ANALYTICAL CHEMISTRY

Course Outcomes:

- Students get to learn how measure errors occur during estimations
- Chromatographic techniques namely, gas chromatography, liquid chromatography, ion exchange chromatography, TLC and paper chromatography.
- Electroanalytical techniques with advance instrumental technique such as surface probe microscopy, thermal analysis and X-ray diffraction analysis.

UNIT I **14 hrs**

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 hrs**

Chromatographic Techniques: Principles, classifications and theory of chromatographic separations.

Gas Chromatography: Principles, columns, detectors-TCD, FID, ECD and column efficiency, capacity factors, resolution. Practical aspects of GC-Hypernated techniques. **Liquid Chromatography** HPLC: Principles, equipment, columns, detectors, choice of column, materials GC, GCMS and LCMS.

Ion exchange chromatography: Structures of resins, selectivity, capacity of resins, ion exchange equilibria, applications-removal of interfering ions, concentration and recovery of traces, anion and cation separations and application for the separation of lanthanides and actinides. Techniques of column chromatography and size exclusion chromatography.

Thin layer chromatography, efficiency of TL plates, selection of stationary and mobile phases. Qualitative and quantitative analysis

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 R_f values. Advantages and applications.

UNIT III **14 hrs**

Electroanalytical Techniques

Introduction, theory, principle, methodology, instrumentation and application of the following tecniques: 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, limitations and precautions.

UNIT IV Advanced instrumental techniques: **14 hrs**

Spectrophotometry, Atomic spectroscopy

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

Thermal Analysis- TG, DTA and DSC- Principles and applications.

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

References:

1. Inorganic Chemistry, 3rd edn., G.L. Miessler and D.A. Tarr, Pearson Education inc.
2. Inorganic Chemistry, 4th edn., J.E Huheey, R.L.Keiter and A.L.Keiter, Addison Wesley,1993.
3. G.D. Christian, Analytical Chemistry, John Wiley, 1986.
4. Krupadanan G L David et al., Universities press, 2001.
5. R.A. Day and A.L. Underwood: Quantitative Analysis, (Prentice Hall, India), 1998.
6. H.H. Wlliard, L.L. Merrit and J.J. Dean, Instrumental methods of analysis, 1988.
7. B.K. Sharma, Instrumental methods of chemical analysis, Goel publishing House, 2000.
8. Skoog, Holler and Nieman: Principles of Instrumental Analysis, Harcourt Acta, 2001.
9. Brown D R, Chromatogarphy, Ivy Publishing House,2001.
10. B.K. Sharma, Chromatogarphy, Krishna Prakashan media, 1997.
11. Bier, Milan E D, Electrophoresis: Theory methods and applications, Academic 1967.
12. A K Tareen and Kutty, Crystallpgraphy, University Press, 2002.
13. F.C. Ladd Mark & Palmer, R.A.: Structure Determination by X-ray Crystallography, 2003.
14. S. K. Chatterjee , X-Ray Diffraction theory and application, ISTE, 2007.
15. S. M Cannon, Comprehensive Inorganic Chemistry, , Newyork, 1972.
16. J.H. Kennady, Analytical Chemistry: Principles , Cengage Learning India Pvt.Ltd.
17. Dhanaraj, G., Byrappa, K., Prasad, V., Dudley, M. (Editors): Springer Handbook of Crystal Growth. © 2010.
18. A.G. Jackson: Handbook of Crystallography For Electron Microscopists and Others
19. Library of Congress Cataloging-in-Publication Data Jackson, A. G. (Allen G.) ISBN- 13: 978-1-4612-7776-7 1, 1991.

ICH 452: ADVANCED ORGANIC CHEMISTRY

Course Outcomes:

- Students learn about how to use different reagents in organic synthesis and their industrial applications.
- Organic named reactions and rearrangements.
- Natural product chemistry with isolation, characterisation and synthesis.
- Chemistry of lipids, oils and fats.
- Learn about green chemistry basics, types and advantages.

UNIT I:

Reagents in Organic Synthesis **14 hrs**

Uses of 1,3-dithiane, organoboranes, Trimethyl silyl iodide, Tri-n-butyl tin hydride, Selenium dioxide, Wilkinson catalyst, Ozone, Periodic acid, Osmium tetroxide, Perbenzoic acid, Lead tetra acetate, Lithium aluminium hydride, Sodium borohydride, Organolithium, organomagnesium and Organo zinc compounds in organic synthesis and functional group transformations.Synthetic applications of Crown ethers, β-cyclodextrins, PTC, ionic liquids, Baker's yeast, NBS, LDA, $NABH_4$, $LiAlH_4$, $LiBH_4$, DIEA, BuLi, diborane, 9-BBN, t- butoxycarbonylchloride, DCC, Gilman's reagent, lithium dimethyl cuprate, tri-n- butyltinhydride, 1,3-dithiane, trimethyl silyl chloride, $Pb(OAc)_4$, ceric ammonium nitrate, DABCO, DMAP, DBU, Oxone®, DDQ, DEAD and Lindlar catalyst in organic synthesis.

Selenium dioxide, DIBAL, $KMNO_4$, OsO_4, Pd/C, AIBN, Bu_3SnH, MnO_2, Diazomethane, DMAP, $NaIO_4$, Organolithium, organomagnesium and Organo zinc compounds in organic synthesis and functional group transformations.

UNIT II: **14 hrs**

Organic Name Reactions and Rearrangements

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

UNIT III **14 hrs**

Natural product chemistry

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. Biosynthesis of terpenes from mevalonic acid and sterols from squalene.

Structure elucidation of ocimene monoterpene, classification of pigments, structure elucidation of β – carotene. Structural differences between a triterpene and a sterol. Synthesis of quercetin, synthesis of testosterone, androsterone, estrone and progesterone. Determination of carbon skeleton of alkaloids (Hofmann, Emde and Von Braun degradation methods). Structural elucidation of ephedrine, nicotine, atropine, hygrine.

Chemistry Lipids: Introduction, Classification and biological functions, phospholipids. **Oils and fats:** Introduction and properties, synthesis of mono, di and mixed glycerides. **Fatty acids:** Introduction, classification, analysis of oils and fats, synthesis of oleic acid

UNIT IV **14 hrs**

Green Chemistry:

Definition and principles, planning a green synthesis in a chemical laboratory, Green preparation- Aqueous phase reactions, solid state (solventless) reactions, photochemical reactions, Phase transfer catalyst catalysed reactions, enzymatic transformations & reactions in ionic liquids.

Sonochemistry: Introduction, instrumentation, the phenomenon of cavitation, types of sonochemical reaction, Sonochemical esterification, substitution, addition, oxidation, reduction and coupling reactions.

Microwave induced organic synthesis: Introduction, reaction vessel and reaction medium, concept, specific effect, atom efficiency, % atom utilisation, 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 enaminoketones.

Twelve principles of green chemistry. Green chemical strategies for sustainable development- Reaction mass balance, atom economy evaluation for chemical reaction efficiency, green solvents, reaction media- Synthesis under water, solventless, fluorous and ionic liquid media. Synthesis using scavenger resins, catalysis and biocatalysis. Green computation. Green processes-. Microwave synthesis- fundamentals of microwave synthesis- Two Principal Mechanisms for Interaction With Matter- The Microwave Effect with examples - Single-Mode and Multimode Microwave cavities. Microwave technology- Techniques and applications in MORE chemistry. Sonochemical synthesis. Applications of sonication in the synthests of organic compounds.

References:

1. Robert B. Grossman :The Art of Writing Reasonable Organic Reaction Mechanisms
2. Second Edition, © 2003, Springer-Verlag New York, Inc. 1999.
3. Daniel E. Levy:Arrow Pushing in Organic Chemistry An Easy Approach to Understanding Reaction Mechanisms John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
4. Audrey Miller, Philippa H. Solomon: Writing Reaction Mechanisms in Organic Chemistry, Elsevier Science & Technology Books, ISBN: 0124967124, 1999
5. Organic Chemistry-P.Y.Bruice (Pearson Education Pvt. Ltd., New Delhi),2002.
6. Advanced Organic Chemistry-Reactions, mechanisms & structure-J.March (Wiley, NY)2000.
7. Organic Chemistry-Vol. -1,2 &3- Mukherji, Singh and Kapoor. (Wiley Eastern,) 1994.
8. A guide book of mechanisms in Organic Chemistry-P.Sykes (Orient- Longman) 1985.
9. Organic Chemistry-R.T. Morrison and R.N. Boyd (Prentice Hall, New Delhi) 1994.
10. Organic Chemistry 4th Edn.–S.H. Pine et al (McGraw-Hill, London) 1987.
11. Advanced Organic Chemistry- R.A. Carey and R.J. Sundberg (Plenum, New York)1990.
12. Modern Concepts of Advanced Organic Chemistry-R.P. Narein (Vikas, Delhi) 1997.
13. A Text book of Organic Chemistry-Tewari, Vishnoi and Mehrotra (Vikas, New Delhi)1998.
14. A Text book of Organic Chemistry-3rd Edn.-R.K. Bansal, (New Age, New Delhi) 1997.
15. Organic Chemistry-3rd Edn- F.A. Carey (Tata McGraw Hill, New Delhi) 1996.
16. K. Mislow: Introduction to Stereochemistry, Published by W.A.BENJAMIN, 1965, Bookbarn International (Bristol, SOM, United Kingdom).
17. Stereochemistry, Conformation and Mechanism-P.S.Kalsi (Wiley Eastern,New Delhi)1993.
18. Stereochemistry of Carbon Compounds-E.L.Eliel (Tata McGraw Hill, New. Delhi) 1994.

ICH 453: ENERGY SYSTEMS, COLLOIDS AND PETROCHEMICALS

Course Outcomes:

- Students learn about types of renewable and non renewable sources of energy.
- Electrochemical energy systems pertaining to classical and modern batteries and also fuel cells
- Application of photoelectrochemistry and photoelectytic catalysis in waste removal and solar cell applications.
- Principle and application of colloidal chemistry in electrophoresis.
- Adsorption phenomenon and its application.
- Petroleum and petrochemicals: history, composition and reformation with finishing process namely hydro treatment.

UNIT I: **14 hrs**

Energy Systems

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-Laclanche dry cell (Zn and Mg), Alkaline MnO_2 batteries. Secondary batteries-Introduction, lead acid battery, Alkaline storage battery. 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: **14 hrs**

Non conventional energy systems: 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. Applications of photochemistry-photoelectrocatalysis, photoreduction of CO_2 and photoelectrochemical waste removal. Hydrogen storage by metal and metal-alloys.

Wind energy-Atmospheric circulations, factors influencing wind and Betz limit. Formation of biomass, photosynthesis; Biomass resources. Chemical constituents and physicochemical characteristics of biomass; Biomass conversion processes; Biofuel, Petrocrops.

Ocean energy resources, Principles of ocean thermal energy conversion systems. Geothermal energy: Origin, types of geothermal energy sites.

UNIT III: **14 hrs**

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 industrial applications.

UNIT IV: **14 hrs**

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, alternative fuels.

References

1. Engineering chemistry, Gadag R V, I K international, 2010.
2. Chemical and Electrochemical Energy Systems, Narayan R & B Viswanathan, University Press,1998.
3. Energy Storage for Power Systems, Ter-Gazarian A., Peter Peregrinus, London, 1994.
4. Modern Electrochemistry, Vol 2A and B, JOM Bockris & AKN Reddy, Springer, NY, 1998.
5. Biochemical & Photosynthetic Aspects of Energy Production, Anthony San Pietro, Academic Press, N Y, 1980.
6. Bio Energy for Rural Energisation, R.C. Maheswari, Concepts Publication, 1997.
7. Wind Energy Systems, G L Johnson, Prentice Hall Inc, New Jersey, 1985.
8. Modern Petroleum Refining Process, 2nd Edn., Rao, IBH.
9. Introduction to Petrochemicals, Maiti, IBH.
10. Synthetic Organic Chemistry, G R Chatwal, Himalaya Publishing House.
11. A Text Book of Engineering Chemistry, M M Uppal, Khanna Publishers, 1986.
12. Modern Petroleum Chemistry-An overview, Kochu Baby, Manjuram & Kannatheri Publication, Kochi.
13. Colloids Chemistry, A.K.Sharma, Goel publishing House, Meerut, 1991.

ICS 454: CHEMICAL ENGINEERING TECHNOLOGY

Course Outcomes:

1. Students learn about unit operations pertaining to evaporation, distillation and crystallisation.
2. Unit processes and flow sheet for manufacturing of chemicals through sulphonation, nitration, alkylation and acylation; catalytic hydrogenation, oxidation and esterification.

Unit Operations

UNIT I: **10 hrs**

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

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

UNIT II: **12 hrs**

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

Gas absorption: Definition, examples, comparison of absorption and distillation, solution criteria for gas absorption, mechanically agitated vessels.Characteristics of tower packing, types of packing, merits of plate & packed tower.

Flow chemistry: concepts and applications

Unit Processes

UNIT III: **10 hrs**

Unit process and flow sheet. **Nitration:** Nitrating agents, kinetics and mechanism of nitration of aromatic compounds, nitration of paraffinic hydrocarbons, nitrate esters, N- nitrocompounds, 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 & acylation at Carbon, Oxygen and Nitrogen, Friedel- Craft reaction, applications of active methylene compounds like diethyl melonate and ethyl acetoacetate. Industrial processes

UNIT IV: **10 hrs**

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:** Oxidising agents with typical applications of each, liquid phase oxidation with oxidising compounds. **Esterification:** Kinetics and mechanism, esterification of carboxylic acid derivatives, esters by addition to unsaturated systems, industrial esterifications, ethyl acetate, methyl methacrylate, cellulose acetate and nitroglycerin.

References

1. Chemical Technology, F A Henglein, Pergamon.
2. Chemical Engineering, Vol. I, II & III, J M Coulson
3. The Chemical Process Industries, R N Shrove, MGH.
4. Introduction to Chemical Engineering, W L Badger & J T Bandchero, MGH.
5. Chemical Process Principles, Vol I & II, O A Hougen, K M Watson & R A Ragetz, John Wiley.
6. Unit Operation-II, K A Gavhane, Nirali Prakashan, Pune.
7. Unit Processes in Organic Synthesis, P H Groggins, MGH.
8. Chemical Technology, F A Henglein, Pergamon.
9. Engineering chemistry, Gadag R V, I K international, 2010.
10. Comprehensive industrial chemistry, More Prakash G, Pragathi prakashan, 2010.

ICS 455: SOFT MATERIALS AND NANOTECHNOLOGY

Course Outcomes:

- Students learn about fundamental of liquid crystal and their application in LCD technology.
- Thin films processes and applications.
- Conducting organic and super conductors.
- Nano technology and its applications.
- Nano composites and their application in drug delivery systems.

UNIT I: **12 hrs**

Liquid Crystals: Mesomorphic behaviour, thermotropic liquid crystals, positional order, bond orientation, order nematic & smectic mesophases, nematic transition & clearing temperature-homotropic, planer & schlieren textures, twisted nematic, chiral nematic, molecular arrangement in smectic A & Smectic B phases, optical properties of liquid crystals, Dielectric susceptibility & dielectic constants, Lyotropic phases & their description or ordering in liquid crystals.

UNIT II **10 hrs**

Soft Materials: Thin Films and Langmuir-Blodgett Films, Preparation techniques, vaporation/sputtering, chemical process, MOCVD, sol-gel etc. growth technique, photolithography, properties and applications of thin and L-B films.
Organic Solids and Fullerenes: Conducting organics, organic superconductors, magnetism in organic materials. Fullerenes: doped fullerenes as superconductors.

UNIT III: **10 hrs**

Nanotechnology and its applications: Introduction to nanoscience and technology, terminology and history, optical and semiconducting properties of nanoparticles, metallic nanoparticles, top-down and top-up fabrication, solution based and vapour phase synthesis, synthesis of frameworks, supports and substrates, physical and chemical vapour deposition, artificially layered materials, quantum wells, self-assembled nanostructers, supramolecular chemistry and morphosynthesis, dimensional control; carbon nanotubes, mesoporous meterials and metal organic frameworks.

UNIT IV: **10 hrs**

Nanocomposites Introduction to Nanocomposites, Composite material, Mechanical properties of Nano composite material: stress - strain relationship, toughness, strength, plasticity. Synthetic methods for various nanocomposite materials: mechanical alloying, thermal spray synthesis etc. Nano composites for hard coatings; DLC coatings; Polymer nanocomposites; Thin film nanocomposites; Applcations of nanocomposites in drug delivery.

References

1. Material science and Engineering, W D Callister, Wiley.
2. Solid State Chemistry, A R west.
3. Modern Prospective in Solid State Chemistry,C N R Rao and J Gopalakrishnan.
4. Principles of Polymer Science, Bahadur P and N.V Shastry, Narosa, New Delhi, 2000.
5. Polymer Science and Engineering, D.J.Williams, Prentice Hall Inc, New Jersy, 1971.
6. Theory and Basics of Polymer Science, F.W. Billmeyer, John Wiley & Sons, NY,1984
7. P.M. Ajayan, L.S. Schadler and P.V. Braun, Nanocomposite Science & Technology - WileyVCH GmbH Co.
8. Chatopadhyaya.K.K, and Banerjee A.N, Introduction to Nanoscience and Nanotechnology
9. C.N.R. Rao, A. Muller and A.K. Cheetham, The Chemistry of nanomaterials: Synthesis, Properties and Applications, Vol-I.

ICP 456: INORGANIC CHEMISTRY PRACTICALS-II

Course Outcomes:

- Instrumental techniques used in inorganic practical such as colorimetry, flame photometry and analysis of ore and minerals.

1. Colorimetric determination of Ti (IV) and Zr (IV)
2. Simultaneous colorimetric determination of two metal ions – Mn and Cr.
3. Flame photometric determination of Na, K, Li and Ca individually and in mixtures.
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-Tiron system,
8. Cement analysis: i) SiO_2-Gravimetrically ii) Calcium, Volumetrically iii) Iron, Volumetrically iv) Magnesium, Complexometrically iv) Aluminium, Gravimetrically.
9. Determination of available chlorine in bleaching powder and residual chlorine in water samples.
10. Determination of Iron present in sulpha- drugs; colorimetrically.
11. Determination the percentage of phosphorus present in terms of P_2O_5 from a fertilizer sample volumetrically.
12. Any other experiment of interest-Determination of oxygen by Oslet method, Determination of elements by AAS method-demonstration only.
13. Any other interesting experiment.

References

1. Physicochemical Experiments, J. Rose.
2. Vogel's Text Book of Quantitative Chemical Analysis(5th Ed), G.H.Jeffrey, J.Bassette, J.Mendham and R.C.Denny, Longman, 1999.

ICP 457: ORGANIC CHEMISTRY PRACTICALS-II

Course Outcomes:

- Quantitative determination of small molecules, biomolecules and functional groups.

Quantitative determination of sugars, amino acids, phenols, carboxylic acids, amides, esters, aldehydes, ketones, urea by various methods. Determinations of acid and ester and acid and amide in mixtures of two.

Determination of functional groups like hydroxyl, vic-hydroxyl, enol, amino, amide, unsaturation and nitro groups by various methods.

Any other interesting experiment.

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.

ICP 458: PHYSICAL CHEMISTRY PRACTICALS-II

Course Outcomes:

Experiments to determine concentration of analyte by using electrochemical method like conductometry and potentiometry.

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

1. Determination of hydrolysis constants (aniline hydrochlride 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 ionisation 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 conductances and dissociation constants of weak acids.
8. Any other experiments of interest

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

9. Determination of pK values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.
10. Determination of acidic & basic dissociation constants and isoelectric point of an amino acid.
11. Determination of the potential of an electrochemical cell and mean ionic activity coefficient.
12. Determination of activity coefficient of an electrolyte at different molalities.
13. Determination of pH of buffer solutions with a pH meter & evaluation of pK_a of acids
14. Determination of thermodynamics of a cell reaction
15. Determination of pKa values of mono, di and tri-acid base.
16. Determination of solubility of insoluble silver halide and the standard electrode potential using quinhydrone electrode
17. Determination of degree of hydrolysis of CH_3COONa and NH_4Cl.
18. Determination of hydrolysis constant of aniline hydrochloride.
19. Verification of Nernst equation for Ag^+, $Cu^{2+}$and Zn^{2+} species.
20. Determination of transport number of ions by emf method (Ag^+, Cd^{2+}, NO_3^{1-},SO_4^{2-})
21. pH titration of (a) HCl versus NaOH, (b) $CuSO_4$ versus NaOH and (c) HOAC versus NaOH and (d) lead nitrate versus potassium chromate.
22. Potentiometric titration of halides in mixtures (Cl^-, Br^- and I^-) with silver nitrate.
23. Potentiometric determination of dissociation constants of weak acids.
24. Any other experiment of interest.

References

1. Findlay's Practical Physical Chemistry, B. P. Levitt, Longman, London.
2. Experiments in Physical Chemistry,James and Prichard.
3. Experimental Physical Chemistry, Daniels et al.
6. Experimental Physical Chemistry, Das & Behera, Tata McGraw Hill, New Delhi, 1983.
7. Advanced Practical Physical Chemistry, Yadav, 1989.
8. Experiments in Physical Chemistry, J.C.Ghosh, Bharathi Bhavan, 1974.

ICE 459: INDUSTRIAL SAFETY, ENVIRONMENTAL AND ELECTROCHEMICAL SCIENCES

Course Outcomes:

- It is an open elective course student learns safety aspects in industry, chemical warfare convention.
- QA and QC, environment problems such as air and water pollution.
- Corrosion causes and inhibition

Unit I: **10 hrs**

Safety: Flammable material handling and fire fighting equipments, control measures for toxic chemicals, industrial hygiene, safety in laboratories & plant, safety in the transportation & storage of chemicals. OHSAS 18000.

Chemical Warfare Convention: Definitions and schedules. Toxic chemicals, remote control systems, tear gas, chemical weapons, ocean dumping of chemical weapons.

Unit II: **12 hrs**

Quality Control and Assurance: 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. ISO 17025.

Unit III: **10 hrs**

Air Pollution: Qualitative study of **e**nvironmental segments, air pollutants, prevention & control, Green house gases & acid rain. Ozone hole & CFC's.Photochemical smog, PAN and Bhopal Gas tragedy.

Water, Waste Water Treatment and Analysis: Hydrologic cycle, sources, criteria & standards of water quality- safe drinking water. Public health significance & measurement of colour, turbidity, total solids, acidity, fluoride, alkalinity, hardness, chloride, residual chlorine, sulphate, fluoride and phosphate in natural & polluted water. Significance of DO, BOD & COD. Water purification for drinking & industrial purposes, disinfection techniques, demineralization, desalination processes & reverse osmosis.

Energy systems: Chemical energy sources and limitations. Electrochemical energy sources. Principle and importance of primary(dry cell), secondary (Lead-acid battery) and fuel cells (H_2-O_2). Basics of solar energy system. Safety implications. Energy from wind, ocean, geothermal and biomass.

Unit IV: **10hrs**

Corrosion: Fundamentals of corrosion. Corrosion related damage, Types of corrosion. Methods of prevention & control (organic & inorganic coating, inhibitors, cathodic & anodic protection, material selection & design improvement). Corrosion problems in practice, passivity.

Metal Finishing & Processing: Metal finishing & technological importance, fundamentals of electrodeposition, electroplating process (copper and Nickel). Principles & applications of electroless plating.

Paints: Classification of paints, types, Constituents of paints. Requirements of a good paint. Emulsion paints. Paint removers.

Electrochemistry of Environment: Global warming, role of electrochemistry in the transport system, fixing of CO_2, sewage disposal and treatment of waste

References

1. A Text Book of Fertilizers, Ranjan Kumar Basak.
2. Agronomy - Theory & Digest, Bidhan Chandra, Krishi Vishwavidyalaya, Mohanpur.
3. Fertilizers, Organic Manures & Biofertilizers–A Product Quality Guide for Major & Micronutrients, HLS Tandon, Fertilizer Development and Consultation Organisation, New Delhi.
4. Handbook on Fertilizer Technology, Bham Swaminathan & Manish Goswami, The Fertilizer, Association of India, New Delhi.
5. Perfumary Technology,B. Billot and F. V. Wells
6. Perfumes,Soaps, Detergents and Cosmetics, S.C.Bhatia, CBS publishers.
7. Introduction to Food chemistry, Suresh Gopalani,Cyber Tech publishers, 2012.
8. Food propagation, Origin propagation analysis, S.N. Mahindru,APH publishers, 2004.
9. Chemistry of Insecticides and fungicides, U S Ramulu
10. Pest management principles and practices, Rajesh ravi,2007.
11. Biochemical toxicology of Insecticides, R.D. O. Brien, Izuru Yamamoto.

III SEMESTER

ICH 501: SPECTROSCOPIC TECHNIQUES

Course Outcomes:

1. Molecular spectroscopy technique namely vibrational and Raman spectroscopy.
2. Applications of UV, IR, NMR and mass spectroscopy in structure determination of organic molecule.
3. Application of spectroscopy by solving composite problems.

UNIT I **14 hrs**

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, zero point 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 (Ex-CO_2 & H_2O). **Vibration-rotation spectra** of diatomic and polyatomic molecules, selection rules, PQR branches.

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

UNIT II **14 hrs**

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. Emperical rules to calculate $\lambda_{max.}$ Application of UV spectroscopy in the structural study of organic molecules.

UNIT III **14 hrs**

Nuclear Magnetic Resonance Spectroscopy: Magnetic properties of nuclei, theory and measurement techniques, NMR spectrometer, solvents used, 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.

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.

UNIT IV **14 hrs**

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, nitrocompounds 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.

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 Longman 1973
4. Fundamentals of Molecular Spectroscopy IV ed., C.N.Banwell & E.M.McCash Tata McGrraw-Hill Publishing Company Ltd.,1994.
5. Organic Analytical Chemistry Theory andPractice, Jag Mohan, Narosa Publishing House2003
6. Spectrophotometric Identification of Organic Compounds 6th Ed., John Wiley &Sons,Inc, Newyork,2004.

ICH 502: INDUSTRIAL CATALYSIS AND POLYMERS

Course Outcomes:

1. Students learn about preparation of catalyst and their behaviour with reference to their performance criteria.
2. Organometallic compounds used as catalysts in industry for various processes for manufacture of small molecules and polymers.
3. Studies on polymer basic concept and processing technique and uses of polymer in biological field are learnt.

UNIT I: **14 hrs**

Preparation of catalyst and their behaviour, Selection, preparation and evaluation of catalysts-test reaction, promoters, carriers and stabilisers, Role of supports, preparation & structure of supports, silica, alumina, silica-alumina, zeolites, carbon catalyst manufacture, catalyst size and shape, pre-treatments, deactivation process, sintering, poisoning and catalyst fouling,Nano cataysts. **Definition of performance criteria of catalysts:** Activity, selectivity, temperature response, catalyst life. Surface active agents, classification of surface active agents, micellisation, hydrophobic interactions, critical micellar concentration (CMC), factors affecting the CMC of surfactants.

UNIT II: **14 hrs**

Catalysis by Organometallic Compounds:
Transition metal hydrides: Synthetic routes, structure and reactivity, synthetic applications. (Cu, Pd, Ni, Fe, Co, Ti complex); **Catalysis by organometallic compounds:** 16- and 18- electron rules, Coordinative unsaturation, oxidative addition and reductive elimination and insertion reactions, olefin hydrogenation, Wacker process, Zeigler-Natta process, olefin metathesis, Monsanto process for the synthesis of acetic acid, heterogenisation of homogeneous catalysts using polymer supports.

UNIT III:
Polymers **14 hrs**

Basic concepts and techniques in polymer chemistry. General structures & classifications of polymers. Techniques of polymerization and molecular weight determination. Structural factors, properties and uses of commercial and engineering polymers. Thermoplastics, thermosets and elestomers. Polymer processing techniques, additives for improvement of polymer properties, spinning of industrial polymers, wet and dry. Melt spinning.

UNIT IV: **14 hrs**

Polymer blend and composites-preparation, properties and uses. Introduction to nano composites. 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: 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, environmental issues of waste management.
Composites: Introduction, classification, preparation procedures, special properties and their applications.

References

1. Material science and Engineering, W D Callister, Wiley.
2. Solid State Chemistry, A R west.
3. Modern Prospective in Solid State Chemistry,C N R Rao and J Gopalakrishnan.
4. Principles of Polymer Science, Bahadur P and N.V Shastry, Narosa, New Delhi, 2000.
5. Polymer Science and Engineering, D.J.Williams, Prentice Hall Inc, New Jersy, 1971.
6. Theory and Basics of Polymer Science, F.W. Billmeyer, John Wiley & Sons, NY,1984.
7. Industrail electrochemistry by Peltcher
8. Modern Electrochemistry, Vol I, IIA & IIB(1998) J.O.M. Bockries and A.K.N.Reddy
9. Engineering Chemistry by Jain and Jain.

ICH 503: SYNTHETIC, HETEROCYCLIC AND MEDICINAL CHEMISTRY

Course Outcomes:

- Planning and execution of multistep synthesis with retro synthetic approach.
- Photochemical reaction with pericyclic reaction, cycloaddition, sigmatropic reactions.
- Heterocyclic and medicinal chemistry used for drug discovery process
- Classification, synthesis and mode of action, some of drugs which are in practice.

UNIT I: Planning and Execution of Multistep Synthesis **14 hrs**

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-methoxyacetophenone, 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: **14 Hours**

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, formation and cyclisation of Dipolar molecules.

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, nitrile oxide and sydnones

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 hrs**

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 hrs**

Introduction, Drug discovery- Historical examples, Natural products. Classification and nomenclature of drugs, 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, induced fit theory. 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).

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. Stereochemistry- Conformation and Mechanism, P.S.Kalsi, Wiley Eastern, New Delhi, 1993.
12. Medicinal Chemistry, Ashuthosh Kar, Fourth edition, New Age International Pvt Ltd.
13. Pericyclic reactions, S. M. Mukherji (The McMillan Bangalore), 1979.
14. Foye's Priciples of Medicinal Chemistry, 4th ed., Lipponcut Williams & Wilkins 2005.
15. V.K. Ahluwalia and Mahu Chopra, Medicinal chemistry.
16. Graham L Patrick, An introduction to medicinal chemistry, Oxford.
17. Ashutosh Kar, Medicinal chemistry.
18. D. Voet and J.G. Voet, Biochemistry, Wiley.

ICS 504: CHEMINFORMATICS AND DRUG DESIGN

Course Outcomes:

- Cheminformatic techniques are learned to search chemical structure in chemical data base.
- Training in computational techniques which are used for drug design and prediction properties

Unit I **10 hrs**

Introduction to Cheminformatics: Introduction to cheminformatics, History and Evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular Modeling and Structure Elucidation **Representation of Molecules and Chemical Reactions:** Nomenclature; Different types of Notations; SMILES coding; Matrix Representations; Structure of Molfiles and Sdfiles; Libraries and toolkits; Different electronic effects; Reaction classification.

Unit II **10 hrs**

Searching Chemical Structure: Full structure search; sub structure search; basic ideas; similarity search; Three dimensional search methods; Basics of Computation of Physical and Chemical Data and structure descriptors; Data visualization.

Unit III **10 hrs**

Computer Assisted Virtual screening design: Structure Based Virtual Screening- Protein Ligand Docking, Scoring Functions for Protein Ligand docking, Practical aspects of structure based Virtual Screening; Prediction of ADMET Properties, 2 D and 3D data searching, Chemical databases, Role of computers in Chemical Research.

Unit IV **12 hrs**

Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modeling Toxicity; Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design, Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand-Based and Structure Based Drug design; Application of Cheminformatics in Drug Design.

Reference Books

1. Andrew R. Leach, Valerie J. Gillet, Cluwer , Introduction to Cheminformatics, Academic Publisher, Netherlands, 2003.
2. Lisa B. English (Editor), Combinatorial Library Methods and Protocols, Humana Press Inc,Volume:201, 2002.
3. Frank Jensen, Introduction to Computational Chemistry, Wiley Publisher, Second Edition,2006.
4. Johann Gasteiger (Editor), Thomas Engel (Editor), Chemoinformatics: A Textbook, Wiley Publisher ISBN: 978-3-527-30681-7, 2003.
5. Rajarshi Guha (Editor), Andreas Bender (Editor), Computational Approaches in Cheminformatics and Bioinformatics Wiley-Blackwell, 2012.
6. Fan Li, Developing Chemical Information Systems: An Object-Oriented Approach Using enterprise JAVA, John Wiley & Sons, 2006,ISBN,0470068787, 978047006878

ICS 505: CHEMICAL ANALYSIS IN AGRO, FOOD AND PHARMACEUTICAL INDUSTRIES

Course Outcomes:

Students gain knowledge about the analysis of soil and fuel, determination calorific values of fuels, drug, food analysis and clinical chemistry.

Unit I **10 Hrs**

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 **10 Hrs**

Clinical Chemistry: Composition of blood collection, andpreparation of samples, clinical analysis – serum electrolytes, blood glucose, bloodurea nitrogen, uric acid, albumin, globulin, barbiturates, acidic and alkaline phosphates,Immunoassay , principals of radiimmunoassy and applications. The blood- gas analysis –trace elements in the body.

Unit III **10 Hrs**

Drug analysis: Narcotics and dangerous drugs, classification of drugs, screening by gas m thin layer chromatography and spectrophotometric analysis.

Introduction to Fluorescence, instrumentation and its application in Biological, Medical and Drug Development.

Unit IV **12Hrs**

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, HPLC, gas chromatography for organo – phosphates, thin layer chromatography for identification ofchlorinated pesticides in food products

Reference Books

1. Fundamentals of analytical chemistry by D. A. Skoog , D. M. West and F. J. Honer, W. B. Saunders.
2. Chromic phenomenon , The Technological application of color chemistry Peter,Bamfield

ICP 506: INORGANIC CHEMISTRY PRACTICALS-III

Course Outcomes:

Students get hands on experience on

- Advance techniques in gravimetric and volumetric analysis.
- Experiments based on environmental chemistry.

1. Analysis of brass–Cu gravimetrically using ∝-Benzoinoxime & Zn complexometrically.
2. Analysis Cu-Ni alloy.
3. Analysis of Stainless Steel-Insoluble residue by gravimetry, Ni gravimetrically using DMG,
4. Fe volumetrically using Ce(IV) & Cr(III) volumetrically by persulphate oxidation.
5. Flame photometric determination of Na, K mixtures.
6. Chemical Separation Techniques

a. Cu(II) + Fe(II)-Cu gravimetrically as CuSCN and Fe using Ce(IV).
b. Cu(II) + Ni(II)-Cu gravimetrically as CuSCN and Ni using EDTA.
c. Fe(III) + Ca(II)-Fe gravimetrically as Fe_2O_3 and Ca using EDTA.
d. Cr(III) + Fe(III)-Using EDTA by Kinetic masking method.

7. Analysis of chalcopyrites, magnetite and ilmenite.
8. Ion-exchange chromatography: Separation & determination of Mg^{2+}/Zn^{2+}, $Zn^{2+}/Cd^{2+}Cl/Br^{-}$
9. Determination of COD of a water sample
10. Determination of dissolved oxygen (DO) by Winkler's method
11. Determination of nitrate & nitrite in water samples and sea water.
12. Analysis of heavy metals in waste water, seawater (Pb, Hg etc. By spectrophotometry)
13. Determination of available NPK in soil and Fertilizer analysis.
14. Nephelometric determination of sulphate/phosphate.
15. Determination of alkalinity of water samples
16. Determination of fluoride in drinking water by spectrophotometry and ion selective electrode
17. Determination of phosphates in detergents
18. Spectrophotometric determination of sulphur and phosphorus present in soil.
19. Any other experiment of interest: Oil analysis using IR.

References

1. A Text book of Quantitative Inorganic Analysis, A.I. Vogel, ELBS, 1978.
2. Standard Method for the Examination of Water and Waste Water, APHA, AWWA and WPCF, Washington DC,1989.
3. Quantitative Chemical Analysis, I. M. Kolthof and E.P. Sandell, McMillan, 1980.
4. Environmental Chemistry, I.Williams, Wiley, 2001
5. Comprehensive Analytical Chemistry, Lobinski and Marczenko, Vol.30, Elsevier, 1996.

ICP 507: ORGANIC CHEMISTRY PRACTICALS-III

Course Outcomes:

Students get laboratory training in Extraction, characterization of natural products and characterization of natural product and green synthesis.

Isolation of natural products like Caffeine, Recinoleic acid, Azelic acid, Piperine, Hespiridine, Cysteine, Casein, Lycopene and enzymes like Lipase and Sucrase. Extraction of Groundnut oil, Coconut oil and eucalyptus oil. Determination of acid, saponification and iodine values of oils and

fats. Isolation of Carotenes, purification by paper, Column and TLC. Charecterization of natural products by oxidation studies & derivatization of natural products(oxidation of hydrocarbons to carboxylic acid, phenols to aryloxy acetic acid and dtermination of their equivalent weights. A few green synthesis.

Separation of components from mixture of organic compounds by fractional crystallization, fractional distillation and adsorption, Elucidation of structure of organic compounds using UV, IR,NMR and Mass spectra. Locating an organic compound by reference to literature (Chemical Abstract).

Any other experiment of interest: Estimation of protein from feed samples, Estimation of cellullolse using cellulose, Qualitative analysis for trace minerals found in feed, Quantification of rancidity and peroxide values in oils, Estimation of urease activity in the feed ingredient, Proximate analysis and calculation of metabolizable energy, Chemical analysis of milk, Identification of mycotoxins found in feed ingredients

References

1. Elementary Practical Organic Chemistry-Quantitative Organic Analysis, Vol. III, A.I. Vogel.
2. Vogel's Text Book of Practical Organic Chemistry, Furniss et al., ELBS, London, 1978.
3. Experimental Organic Chemistry, Vol. I & II, P.R.Singh, Tata McGraw-Hill, 1981.
4. Practical Organic Chemistry, IV Edn., Dey &.Sitaraman, Allied, New Delhi, 1992.
5. Laboratory Experiments in Organic Chemistry, Adam, Johnson & Wicon, McMillan, 1979.
6. Experimental Organic Chemistry, H.D.Durst & G.E.Goke, McGraw-Hill, 1980
7. More Spectroscopic Problems in Organic Chemistry, A.J. Baker et al., Heyden, 1975.
8. Spectral Problems in Organic Chemistry, Davis & Wells, Chapman & Hall, 1984.
9. Monograph on Green Chemistry Laboratory Experiments, Green Chemistry Task Force Committee, DST
10. Organic Analytical Chemistry-Theory and Practice, Jag Mohan, Narosa, 2003.
11. Lehninger Principles of Biochemistry, David. L Nelson and Michael M Cox.
12. Dairy chemistry and animal nutrition, V.K. Chhozllani.
13. Principles of Animal nutrition and Feed technology, Part I and II, D.V Reddy.
14. Feeds and Principles of Animal Nutrition, G. C. Banerjee.

ICP 508: PHYSICAL CHEMISTRY PRACTICALS-III

Course Outcomes:

- Analysis of polymers, study on phase diagram.
- Thermochemical experiment with spectrophotometer.

Any twelve experiments are to be carried out

Thermodynamic Experiments (Any 6 Experiments to be carried out)

1. Determination of molecular weight and size parameters of polymers by viscometry.
2. Determination of sequences in polyvinyl alcohol by viscometry.
3. Study of association of benzoic acid in benzene.
4. Determination of partial molar volumes of a) Salts – water and b) alcohol – water (methanol & ethanol) systems by density method.

5. Determination of specific heat of liquids and solutions by calorimetry.
6. Study of phase diagram of a ternary aqueous system of potassium chloride and water.
7. Study of phase diagram of a ternary system of benzene – acetic acid – water or DMSO-water – benzene or ethanol – benzene – water etc.
8. Determination of heat of solution of KNO_3 in water, integral heat of dilution of H_2SO_4 and heat of ionization of acetic acid and ammonium hydroxide calorimetrically.
9. Determination of heat of neutralisation of two acids and hence their relative strength.
10. Determination of conc. of $KMnO_4$ and $K_2Cr_2O_7$ by spectrophotometer.
11. Determination of pKa values of indicators.

Voltammetry & Polarography Experiments (Any 6 Experiments to be carried out)

1. Determination of the half-wave potential of Cd(II), Cu(II) & Zn(II) ions in 0.1M solutions.
2. Determination of metal ions individually and in mixtures.
3. Determination of the formula and the stability constant of a lead oxalate.
4. Study of the polarogram of supporting electrolyte with and without dissolved oxygen.
5. Determination of Huckel β value of aromatic hydrocarbon reduction at dropping mercury electrode.
6. Verification of Ilkovic equation.
7. Determination of i) stability constant of a metal complex (lead oxalate or copper glycinate) and ii) concentration of metal ions polarographically.
8. Amperometric titrations.
9. Study of potential-pH diagrams.
10. Determination of thermodynamic parameters of a cell reaction by EMF method.
11. Electroplating of i) Nickel, ii) Chromium, iii) Aluminium and iv) copper on a copper plate.
12. a) Verification of Tafel equation of hydrogen evolution reaction. b) Determination of rate of corrosion by weight loss method.
13. a) Identification of deposits by chemical spot tests. b) Determination of electrochemical equivalent of copper.
14. Coulometric Experiments
15. Any other experiment of interest.

References

1. Findlay's Practical Physical Chemistry, B. P. Levitt, Longman, London.
2. Experiments in Physical Chemistry, James and Prichard.
3. Experimental Physical Chemistry, Daniels et al.
4. Experimental Physical Chemistry, Das & Behera, Tata McGraw Hill, New Delhi, 1983.
5. Advanced Practical Physical Chemistry, Yadav, 1989.
6. Experiments in Physical Chemistry, J.C.

ICE509: AGRICULTURE & HEALTH CARE CHEMICALS

Course Outcome

- To study classification of fertilizers, their synthesis and applications.
- To learn about characteristics of insecticides, preparations and their uses in agriculture.
- To know various methods of preparations of healthcare chemicals like soaps and detergents, perfumes.
- To learn the techniques of quality assessment and controlling measures.

UNIT I: **12 hrs**

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, Fertilizer mixtures-Physical Mixtures, Granulated Mixtures.

UNIT II **10 hrs**

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

UNIT III **10 hrs**

Perfumery: Introduction, Compounds used in perfumery and their classification, methods of preparation and importance of phenyl ethanol, Yara yara, Ionone musk ketone, musk ambrette, musk xylene, phenyl acetic acid and its esters, benzyl acetate, synthetic musks and jasmine.
Essential oils: Source, constituents, isolation & uses.

UNIT IV **10 hrs**

Oils, soaps and Detergents: Refining of edible oils, manufacturing of soaps, detergents-classification-anionic, cationic, non-ionic and amphoteric detergents, detergent builders and additives, liquid soaps. Manufacturing of fatty acids and glycerol, greases from fatty acids, turkey red oil
Food Analysis: Moisture, ash, crude protein, crude fiber, fat, carbohydrate, calcium, potassium, sodium and phosphates, food adultration-common adulteration in food, contamination of food stuffs, microscopic examination of food for adulterants, pesticide analysis in food products.

References

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2. Quality management:a process improvement approach,Fryman Mark A, Cengage learning, 2002.
3. Quality Control, Paranthaman D, Tata, McGraw Hill,1987.
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5. Vyas M. N. Safety and hazards management in chemical industries 2013.Atlantic publication.
6. Dikshith T.S.S Safety evaluation of environmental chemicals. New Age International, 1996.
7. Chemical Safety Matters-IUPAC-IPCS, Cambridge univ. Press, 1992.
8. Environmental Chemistry, A.K. Dey, Wiley Eastern.
9. Environmental Chemistry, S.K.Banerji, Prentice Hall India, 1993.
10. Chemistry of Water Treatment, S.D. Faust and O.M. Aly, Butterworths,1983.
11. Environmental chemistry, Ahluwalia V K, Anne Books India, 2008.
12. Chemistry for Environmental Engineering, Sawyer and McCarty, McGraw Hill, 1978.
13. Environmental Chemistry, I.Williams, John Wiley, 2001
14. Engineering Chemistry by Jain and Jain.
15. Industrail electrochemistry by Peltcher
16. Modern Electrochemistry, Vol I, IIA & IIB(1998) J.O.M. Bockries and A.K.N.Reddy
17. Chemical Engineers Hand Book, 8th Edn., Robert H. Perry, Mc Graw Hill, 1995.
18. Principles of Industrial Chemistry, C. A. Clausen and G. Matts.

SEMESTER IV

INDUSTRIAL PROJECT

ICP 551: Project report

Course Outcomes:

- Student undergoes training at chemical industries for 4 months internship and prepare dissertation on the work carried out

ICP 552: Viva –Voce

Course Outcomes:

- Oral examination based on project report.