SARDAR PATEL UNIVERSITY, MANDI-175001

FACULTY OF SCIENCES

SYLLABUS

FOR

M.Sc. Industrial Chemistry

Under

SEMESTER SYSTEM

Session: 2022-23 and 2023-2024 onwards

DEPARTMENT OF INDUSTRIAL CHEMISTRY

SARDAR PATEL UNIVERSITY

MANDI, HIMACHAL PRADESH-175001

About the Programme

M.Sc. Industrial Chemistry is a full-time 2-year postgraduate program that is a fine blend of chemical engineering and chemistry. The course focuses on physical and chemical processes towards the transformation of some specific materials into chemical products. It aims at building a strong foundation in industrial chemistry.

The Curriculum scheme is intended for post graduate students pursuing a Master of Sciences in Industrial Chemistry to assist them in planning and preparing for their educational tasks throughout the course. The catalogue contains information about the curriculum for the Master of Sciences in Industrial Chemistry degree. It also offers a comprehensive list of all courses offered in the program.

Vision & Mission

Vision of Department

"To emerge as an elite department in the area of chemical sciences to inculcate scientific and innovative temperament to promote high-quality research as well as interdisciplinary domains to serve society."

Mission of Department

To develop world-class research labs and teaching-learning processes for grooming future scientists.

To provide an experiential learning model in relevance with industry and academia.

To motivate faculty and students towards quality research and publications through seminars and dissertations.

To promote socially relevant research and innovation in chemical sciences and interdisciplinary domains in collaboration with industry and national/international agencies.

PEOs/POs/PSOs

Program Educational Objectives

PEO-1: To prepare science graduates to exhibit quality of excellence, critical thinking, creativity and self-motivation for life-long learning to handle all kind of diverse situations in multidisciplinary environment.

PEO-2: To produce graduates who are globally acceptable professionals, for government, corporate, Industry and research organizations along with skills for entrepreneurial pursuits in multidisciplinary areas.

PEO-3: To groom graduates who can demonstrate technical competence in the field of Industrial Chemistry and develop solutions to the complex problems.

PEO-4: To engage graduates in professional pursuits to enhance their own achievements along with serving the society at large.

Programme Outcomes

PO 1 Apply fundamental knowledge of physical sciences along with Industrial Chemistry specializations to solve complex scientific problems.

PO 2 Identify, formulate, review research literature, and analyse complex scientific problems reaching substantiated conclusions.

PO3 Design scientific processes and solutions for complex scientific problems that meet the specified needs with appropriate considerations of public health and safety, and cultural, societal, and environmental considerations.

PO 4 Use research-based methods including design of experiments, synthesis, analysis and interpretation of data leading to logical conclusions.

PO 5 Create, select, and apply appropriate techniques, resources, and modern scientific and IT tools including prediction and modelling to complex scientific activities with an understanding of limitations.

PO 6 Understand the impact of the professional scientific solutions in the societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable developments.

Program Specific Outcomes

PSO 1: Industrial Chemistry graduates will have the knowledge of fundamental concepts of chemistry including organic, physical, inorganic, analytical and nanotechnology.

PSO 2: Industrial Chemistry graduates will be able to use modern instrumentation and classical techniques, to design experiments, along with knowledge of the standard operating procedures and safety regulations for effective handling and use of chemicals.

PSO 3: Industrial Chemistry graduates will have additional knowledge on chemical engineering processes, IPR, TQM and technology management, polymer and medicinal chemistry along with the work experience in industries also.

Major Features of Curriculum

Incudes Range of Courses to cover up the diversity of MSc Industrial Chemistry Specializations.

High Practical approach 3 months industrial training course in which students will visit the various industries to have real world working experience.

To impart high competency in the students, the curriculum offers distinct ability enhancement and value-added courses.

Apart from the technical course, the program offers a range of courses that provides the students a wide knowledge and skill set like soft skills, value added courses in industrial chemistry domain.

Detailed Scheme and Course Contents of the Syllabus for M.Sc. Industrial Chemistry Spread Over Four Semesters (I-IV) For Session 2023-24 and Onwards

Sr. No.	Course No.	Title	Course Type	Teaching hour per weak	Credit	Max. Marks (Theory + Internal Assessment)	Total Marks
	Semester-I						
1	MIC-501	Inorganic Chemistry	DSC	4	4	80+20	100
2	MIC-502	Organic Chemistry	DSC	4	4	80+20	100
3	MIC-503	Fundamental Physical Chemistry	DSC	4	4	80+20	100
4	MIC-504	Mathematics for Chemists and Applications of Computer in Chemistry	AECC	2	2	40+10	50
5	MIC-505	Environment Pollution and Monitoring Techniques	VAC	2	2	40+10	50
6	MIC-506	Inorganic Chemistry Practical	DSC	6	3	50	50
7	MIC-507	Organic Chemistry Practical	DSC	6	3	50	50
8	MIC-508	Physical Chemistry Practical	DSC	6	3	50	50
Total				**34**	**25**		**550**
	Semester-II						
1	MIC-509	Spectroscopic Techniques	DSC	4	4	80+20	100
2	MIC-510	Advanced Analytical Chemistry	DSC	4	4	80+20	100
3	MIC-511	Mechanism and Kinetics of Polymers	DSC	4	4	80+20	100
4	MIC-512	Fundamentals of Medicinal Chemistry	DSC	4	4	80+20	100
5	MIC-513	Analytical Chemistry Practical	DSC	6	3	50	50
6	MIC-514	Polymer Chemistry Practical	DSC	6	3	50	50
7	MIC-515	Medicinal Chemistry Practical	DSC	6	3	50	50
Total				**34**	**25**		**550**
	Semester-III						
1	MIC-601	Natural Products	DSC	4	4	80+20	100
2	MIC-602	Agrochemical Chemistry	DSC	4	4	80+20	100
3	MIC-603	Organic Synthesis	DSC	4	4	80+20	100
4	MIC-604	Medicinal Chemistry	DSC	4	4	80+20	100
5	MIC-605	Natural Products Practical	DSC	6	3	50	50
6	MIC-606	Agrochemical Chemistry Practical	DSC	6	3	50	50
7	MIC-607	Organic Synthesis Practical	DSC	6	3	50	50
Total				**34**	**25**		**550**
	Semester-IV						
1	MIC-608	Physical Chemistry	DSC	4	4	80+20	100
2	MIC-609	Fuel and Energy Technology	DSC	4	4	80+20	100
3	MIC-610	IPR, Quality control and assurance	AECC	3	3	40+10	50
4	MIC-611	Industrial training and Project Report	DSC	3 Months	10	250	250
5	MIC-612	Seminar	AECC	6	4	50	50
Total				**17**	**25**		**550**
Grand Total (I-IV Semester)					**100**		2200

1. The abbreviations used in the above course are as follows:
   Discipline Specific Core (Theory/Practical) = DSC
   Ability Enhancement Compulsory Courses= AECC
   Value Added Course = VAC
2. Examination time for each paper will be three hours (except Industrial Internship and seminar).
3. The examination time for practical's will be of 6 hrs in two sessions (i.e. both morning and evening).
4. Industrial Training of 3 Months is mandatory for every student in 4th semester. (Evaluation will be done of project report submitted and viva).
5. For internal assessment (IA), following criteria will be implemented with regards to the award of internal assessment:
   I. Internal assessment of 20 % marks will be added to each paper.
   II. The award of marks out of 05 for attendance would be based upon student's attendance in respective course (Theory/Practical/Seminar) and its evaluation will be done on the basis of following criteria:

Attendance %age	Weightage of Marks (out 05 Marks)
< 75%	0
75 %	1
76-80%	2
81-85%	3
86-90%	4
>90%	5

   III. The award of 15 Marks would be based on the performance of class test, and this test will consist of both subjective as well as objective type questions.
   IV. The internal assessment of 10 Marks (in AECC/VAC courses only) would be based only on the performance of class test, and this test will consist of both subjective as well as objective type questions.
6. Total Marks of all four semesters:

Semester	Credits	Marks
Semester-I	25	550
Semester-II	25	550
Semester-III	25	550
Semester-IV	25	550
Grand Total	**100**	**2200**

7. The pass percentage will be 40% for the M. Sc in Industrial Chemistry Theory/Practical/Seminar/Project Report. The detail of pass percentage will be as under:

Course	Course Type	Marks	Pass Percentage	Minimum Pass Marks Required
Theory	DSC	80	40%	32
Theory	AECC/VAC	40	40%	16
Internal Assessment	DSC	20	40%	08
Internal Assessment	AECC/VAC	10	40%	04
Practical	DSC	50	40%	20
Project report	DSC (PRC)	250	40%	100
Seminar	AECC	50	40%	20

SEMESTER-I

Semester-I
(Course MIC- 501)
Inorganic Chemistry

Course Objectives: This is an introductory inorganic chemistry course which will help in thoroughly understanding the concepts and the applications of group theory, non-aqueous solvents, hydrides,reagents, nuclear chemistry and consequently in development of the aptitude for academic and professional skills. The course covers some important aspects of the chemistry of organometallic compounds.

Course Outcomes:

CO 1: Explain the chemistry and mechanisms of transition metal fluorides in the presence of non-aqueous solvents.
CO 2: Explain the chemistry of transition metal organometallic compounds and some important reactions in organometallic chemistry and their different applications.
CO 3: Classify the various kind of hydrides with reference to boranes and understand and describe the role of some organic reagents in inorganic chemistry.
CO 4: Apply the concepts of symmetry operation, character tables, group representation to describe the geometries and chemical bonding of molecules.
CO 5: Know the basic concepts associated with nuclear chemistry and its applications.

Note: *(i)* ***TEN*** *questions will be set by the examiner selecting* ***TWO*** *from each unit. As far as possible every question will be divided into* ***Two -Three Parts****. The students shall attempt* ***FIVE*** *questions selecting* ***ONE*** *from each unit. (ii) Students can ask for Character Tables (except for C_2V and C_3V point groups) if required.*

Lectures: 60 **Credit: 4**
Syllabus **Max. Marks (Theory): 80**
(IA): 20

Unit-I Non-Aqueous Solvents:
Factors justifying the need of non-aqueous solution Chemistry and failure of water as a solvent. Solution chemistry of sulphuric acid: Physical properties, Ionic self-dehydration in H_2SO_4, high electrical conductance in spite of high viscosity, Chemistry of H_2SO_4 as an acid, as a dehydrating agent, as an oxidizing agent, as a medium to carry out acid-base neutralization reaction and as a differentiating solvent. Liquid BrF_3: Physical properties, solubilities in BrF_3, self-ionization, acid base neutralization reactions, solvolytic reactions and formation of transition metal fluorides.

Unit-2 Organometallics
Introduction, Transition metal alkyls, metal-alkneyls and metal-alkynyls and aryls- routes of synthesis, Reactions of metal-carbon bonded compounds- homolytic cleavage, reductive elimination, electrophilic cleavage, insertion, β-metal hydrogen elimination, α-abstraction or α-elimination. Transition metal to carbon multiple-bonded compounds-carbonyls, nitrosyls, metal-dinitrogen, metal alkyls, metal-carbene complexes.

Unit-3 Inorganic Hydrides and Reagents
Inorganic hydrides: Classification, preparation, bonding and their applications. Transition metal compounds with bonds to hydrogen, carbonyl hydrides and hydride anions. Classification, nomenclature, Wade's Rules, preparation, structure and bonding in boron hydrides (boranes).
Chelating Reagents: Role of following reagents in analytical chemistry
(a) Dimethylglyoxime (b) EDTA (c) 8-Hydroxyquinoline and (d) 1,10 Phenanthroline

Unit-4 Molecular Symmetry and Group Theory
Symmetry elements and operations, Group theory- Concept of a group, definition of point group. Assignment of point groups to molecules, Group multiplication tables for C_2V and C_3V point groups. Matrix representations of symmetry operations, reducible and irreducible representations. Character tables, Applications of group theory: a) to determine symmetry of molecular orbitals of BF_3, B_2H_6; b) to determine IR active and Raman active lines in molecules with C_2V, C_3V, D_4h and Td point groups.

Unit-5 Nuclear Chemistry
Nuclear Structure: Stability of nuclei, packing fraction, n/p ratio, nuclear potential, binding energy and exchange forces, shell model and liquid drop model; decay of radio nuclei, rate of decay; determination of half-life period; modes of decay: alpha, beta, gamma and orbital electron capture; Nuclear reactions, Nuclear fusion (sun's atmosphere, hydrogen bomb) and Nuclear fission (plutonium bomb), Q value.

Books Recommended:

1. J. E. Huheey, R. L. Keiter and A.L.Keiter, Inorganic Chemistry, 4th edition. Addison Wesley,
2. H. S. Ray and A. Ghosh. Principles of Extractive Metallurgy, New Age International.
3. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, Wiley, 1991.
4. R. C. Mehrotra and A. Singh, Organometallic Chemistry, New Age International, 1999.
5. F.A. Cotton: Chemical Applications of Group theory, Wiley, New York, 1993.
6. G.L. Miessler and D.A. Tarr; Inorganic Chemistry, 3rd edn. Pearson Education Inc.
7. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, Butterman-Helnmann, 2005.
8. H.Sisler, Chemistry in non-aqueous solvents, 1961.
9. T.C.Waddington, Non-aqueous solvents, 1969.
10. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis.
11. H.J. Arnikar, Essentials of nuclear chemistry, 1982.
12. B.G. Harvey, Nuclear Chemistry, 1965.

Semester-I
(Course MIC-502)
Organic Chemistry

Course Objectives: The main objective of this course is to provide basic to advance level of knowledge to the students regarding stereochemistry and reaction mechanism. To develop a basic understanding about the structure and reactivity relationship. To understand mechanistic details of different types of aliphatic nucleophilic substitution, aromatic nucleophilic substitution and addition elimination reactions.

Course Outcomes:

CO 1: Compare the kinetic and thermodynamic requirements of the reactions to establish mechanism of organic reaction.
CO 2: Analyze the mechanistic details of different types of aliphatic nucleophilic substitution reactions.
CO 3: Explore the mechanisms of aromatic nucleophilic substitution reactions.
CO 4: Apply the mechanistic details of different types of aliphatic electrophilic substitution and free radical reactions.
CO 5: Understand the idea of stereochemistry and isomerism.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Lectures: 60 **Credit: 4**

Syllabus **Max. Marks (Theory): 80**
(IA): 20

Unit-1 Reaction Mechanism

Reaction Mechanism: Structure and Reactivity: Thermodynamic and kinetic requirements, Kinetic and Thermodynamic control, Hammonds postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates.

Effect of structure on reactivity: resonance and field effects, steric effect. Quantitative treatment: Hammett equation and linear free energy relationship, Substituent and reaction constants, Taft equation. Methods of determining Reaction mechanisms.

Unit-2 Aliphatic Nucleophilic Substitution

Aliphatic Nucleophilic Substitution: Reactivity effect of substrate structure, leaving group and nucleophile. The SN_1, SN_2, mixed SN_1 and SN_2, SET mechanisms &SNi mechanism. The neighboring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements-Wagner-Meerwein, Pinacol-Pinacolone and Demjanov ring expansion and ring contraction. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Esterification of carboxylic acid, transesterification, Phase-transfer catalysis, and ultrasound, ambident nucleophile, regioselectivity.

Unit-3 Aromatic Nucleophilic Substitution

Aromatic nucleophilic substitution: A general introduction to different mechanisms of aromatic substitution SNAr, AN and aryne, Von Richter rearrangement, Sommlet, Hauser rearrangement, Smiles rearrangement. Radical substitution Mechanism: Reaction at sp^3 and sp^2carbon, 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.

Unit-4 Addition Elimination Reaction

Addition Elimination Mechanisms: (a) Addition to carbon multiple bonds-Addition reactions involving electrophiles, necleophiles and free radicals (b) Addition to carbon hetero atom multiple bonds: Mannich reaction: LAH reductions of Carbonyl compounds acids, esters, nitrites, addition of Grignard reagents, Reformatsky reaction, Tollen's reaction, witting reaction (c) Elimination reactions: Stereochemistry of eliminations in acyclic and cyclic systems, orientation in eliminations - Saytzeff and Hoffman elimination.

Unit-5 Chirotechnology

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, methods of determination of enantiomeric excess, epimerization, epimers, anomers and mutarotation, Axial Chirality (Allenes and Biphenyls), Planar chirality, Helicity, Conformational and streoisomerism of acylic and cylic systems, cyclohexane, decalins, effect of conformation on reactivity in acylic and cyclohexane systems.

Books Recommended:

1. J. March, Advanced Organic Chemistry-Reactions, mechanisms & structure, (Wiley, NY) 2000.
2. P. Sykes, A guide book of mechanisms in Organic Chemistry, (Orient- Longman) 1985.
3. R.A. Carey and R.J. Sundberg, Advanced Organic Chemistry, (Plenum, New York) 1990.
4. Tewari, Vishnoi and Mehrotra,A Text book of Organic Chemistry, (Vikas, New Delhi) 1998.
5. Audrey Miller, Philippa H. Solomon: Writing Reaction Mechanisms in Organic Chemistry, Elsevier Science & Technology Books.
6. S.H. Pine, Organic Chemistry 4th Edition (McGraw-Hill, London) 1987.
7. R.P. Narein, Modern Concepts of Advanced Organic Chemistry, (Vikas, Delhi) 1997.
8. E. L. Eliel, Stereochemistry of Carbon Compounds, Tata McGraw-Hill.

Semester-I
(Course MIC-503)
Fundamental Physical Chemistry

Course Objectives: This course is introduced to impart students with the basic knowledge of various laws of thermodynamics, and thermodynamic properties like free energy, entropy and chemical potential and knowledge of kinetics of various complex and fast reactions and surface chemistry. The course also covers some concepts of chemical equilibrium and theories and laws of electrochemistry.

Course Outcomes:

CO 1: Explain principles of laws of thermodynamics and to use of laws of Chemical Thermodynamics to derive other thermodynamic properties.
CO 2: Understand the mechanisms and kinetics of complex and fast reactions.
CO 3: Explain the various reactions occurring on surfaces.
CO 4: Understand the concept of acid and bases and ionic equilibria.
CO 5: Know about the various theories and laws of electrochemistry.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Credit: 4
Lectures: 60
Max. Marks (Theory): 80
(IA): 20

Syllabus

Unit-1 Thermodynamics

Terminology, Laws of thermodynamics, Carnot cycle, Carnot theorem, Free energy change and work function, Entropy evaluation, Criteria for reversible and irreversible processes, Thermodynamics of mixing. Theory and determination of Chemical Potential, variation of chemical potential with temperature and pressure. Enthalpy changes in chemical reaction, Kirchhoff's equation, Flame and explosion temperature, Hess's law of constant heat summation, Measuring enthalpy of combustion.

Unit-2 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: activated complex theory, parallel, consecutive and chain reactions thermal (H_2- Br2) and photochemical H_2- Cl_2) reactions, Rice Herzfeld mechanism for dissociation of ethane.

Unit-3 Surface Chemistry

Adsorption: Definition, thermodynamics of adsorption, Langmuir adsorption isotherm, Langmuir constant and Gibb's energy of adsorption, Langmuir adsorption with lateral interaction, BET adsorption isotherm, adsorption on heterogeneous surface.

Surfactants: Micelles and Emulsions: Surfactants, types of micelles, Ostwald ripening, critical micelle concentration, thermodynamics of micellization, structure of surfactants, aggregates, biological membranes, microemulsion, inverse microemulsion formation and stabilization.

Unit-4 Ionic Equilibria

Ostwald dilution law, concepts of acids and bases, hard soft acids and bases, ionization constants of acids and bases, ionization of water, ionic product of water, the pH scale, common ion effect, buffer solutions, hydrolysis of salts, acid-base indicators and titrations, the solubility product.

Unit-5 Introduction and Applications of Electrochemistry

Electrochemistry Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Types of electrodes. General concepts of brine electrolysis, modern technological developments, chlorine cell technologies, production of potassium hydroxide, Standard electrode potential. Electrochemical series. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode.

Books recommended:

1. S.Glasstone, Thermodynamics for Chemists, East-west Editon, New Delhi, 2003.
2. Hareesh Mehra, Chemical Kinetics-, Alfa publishing, New Delhi, 2006.
3. Jain and Jain, Engineering Chemistry, Danpat Rai Publishers.
4. D. R. Crow, Principles & Applications of Electrochemistry, 3rd Edn. Chapman & Hall, 1987.
5. Klotz, Rosenbeg, Chemical Thermodynamics-Basic Theory and Methods, 4th Edn. Benjamin, 1986.
6. K.J.Laidler,Chemical Kinetics, Pearson Education.
7. J.O.M. Bockries and A.K.N.Reddy,Modern Electrochemistry, Vol I, IIA & IIB (1998).
8. Peltcher, Industrial electrochemistry.

Semester-I
(Course MIC-504)
Mathematics for Chemists & Applications of Computer in Chemistry

Course Objectives: To impart the basic knowledge of mathematical and computer tools needed to solve the chemistry problems.

Course Outcomes:

CO 1: Apply basic knowledge of differential equations used in chemistry.
CO 2: Apply the general methods of integration for their application to solve chemistry problems.
CO 3: Apply basic knowledge of Matrices and Determinants to solve chemistry problems.
CO 4: Explain the functions in FORTRAN for data analysis in chemistry.
Use of functions in FORTRAN for chemistry applications.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Lectures: 30 **Credit: 2**
Syllabus **Max. Marks (Theory): 40**
(IA): 10

Mathematics for Chemists

Unit-1 Differential calculus
Differential calculus: functions of single and several variables, partial derivatives, the total derivative, maxima and minima theorem, and simple examples related to chemistry. Vectors: representation and simple properties of vectors (addition and subtraction) vector addition by method of triangles, resolution of vectors. Scalar product of vector. Concept of normalization, orthogonality and complete set of unit vectors.

Unit-2 Integral calculus
Integral calculus: general and special methods of integration, geometric interpretation of integral, evaluation of definite and some standard integrals related to chemistry. The significance of 'exponential' equations. Differential equations: simple differential equations, separable variables, homogeneous equations, exact equations, linear equations, and equations of first and second order. Application to simple chemistry problems.

Unit-3 Matrices and Determinants
Matrices and Determinants:Definition of matrix, types of matrices (row, column, null, square, diagonal). Matrix algebra: addition, subtraction, and multiplication by a number, matrix multiplication. Transpose and adjoint of matrix, elementary transformation, representation and applications to solutions of linear equations. Application to simple chemistry problems.

Applications of Computer in Chemistry

Unit-4 Chemistry and FORTRAN Programming
Chemistry and FORTRAN Programming: Introductory FORTRAN concepts, character set, constant variables, data types, subscripted variables, and FORTRAN functions. Data transfer and program execution control: Introduction, format specification for READ and WRITE statements, format commands, control commands and transfer commands.

Unit-5 Arrays and repetitive computation
Arrays and repetitive computation; Introduction, arrays arrange storage, dimension statement, do, Nested do- loop continue statement, implied do. Sub-programme (functions and sub-routines): Introduction, sub programme, functions in FORTRAN, function arguments, subroutines, save variable function vs. subroutine programme.

Books Recommended:

1. F. Daniel, Mathematical Preparation for Physical Chemistry.
2. G. Stephemen, Mathematical Methods for Science Students.
3. T.R. Barrante, Applied Mathematics for Physical Chemistry.
4. V. Rajaraman, Fortran 77 & 90.
5. K.V. Raman, Computer in Chemistry.

Semester-I
(Course MIC-505)
Environment Pollution and Monitoring Techniques

Course Objectives: The main objective of this course is to impart the basic knowledge about the air and water pollution. To create awareness among the students about their ill effects. To understand the basis techniques to monitor environmental pollution along with its treatment methodologies with basic knowledge of various pollutants.

Course Outcomes:

CO 1: Understand the fundamentals od water pollution and various pollutants responsible.
CO 2: Knowledge about the various water treatment processes.
CO 3: Understand the idea about the various physical, chemical and biological water treatment methods.
CO 4: Explain the various techniques used for sampling of air pollutants
CO 5: Know about the various analytical methods used for the analysis of common air pollutants.

Note: *(i)* ***TEN*** *questions will be set by the examiner selecting* ***TWO*** *from each unit. As far as possible every question will be divided into* ***Two -Three Parts****. The students shall attempt* ***FIVE*** *questions selecting* ***ONE*** *from each unit.*

Lectures: 30 **Credit: 2**
Syllabus **Max. Marks (Theory): 40**
(IA): 10

Unit-1 Water Pollution

Water pollution, categories of pollutants, sources of water pollution, Nature Types of water pollutants: Elemental pollutants, Heavy metals, Metalloids, Inorganic species, Algal nutrients and eutrophication, organic pollutants, radionuclides in the aquatic environment.

Unit-2 Water Treatment

Municipal water treatment, Industrial wastewater treatment, Sewage treatment, Removal of calcium, iron, and manganese from water, water disinfection, Unit operations: Screening, sedimentation and floating, filtration, mixing, equalization, Flow proportioning, Drying and Incineration, freezing, foaming, dialysis and osmosis, adsorption, gas transfer, Elutriation.; Unit processes: pH Correction, Coagulation, oxidation and reduction, aerobic and anaerobic processes.

Unit-3 Methods of Wastewater Treatment

Physical Methods. Reverse Osmosis, electrodialysis, membrane filtrate, Chemical methods: Carbonates, Hydroxides, Sulphides, Biological methods: Biodegradable materials and removal of pollutants by microorganisms, BOD and its measurement, activated sludge process.

Unit-4 Measurement and Monitoring of Air Pollution

Photochemical smog, atmospheric aerosols, Ambient air sampling: elements of sampling system, sampling systems for gaseous pollutants: sampling systems for particulate pollutants: Behaviour of Particles at Sampling Inlets, Passive sampling systems, sampler siting requirements, sampling for air toxics.

Unit-5 Air Pollutants Analysis and Measurements

Analysis and measurements of gaseous pollutants: Carbon-monoxide (CO), ozone (O_3), nitrogen-dioxide (NO_2), sulphur-dioxide (SO_2), non-methane volatile organic compounds, laboratory analysis of air pollutant samples, semi-volatile organic compounds.

Books Recommended:

1. S.E. Manahan, Environmental Chemistry, 7th edition, CRC Press LLC, 2008.
2. A.K. De, Environmental Chemistry, Wiley Eastern.
3. V K Ahluwalia, Environmental chemistry, Anne Books India, 2008.
4. R.D. Braun, Introduction to Instrumental Analysis
5. S.P. Mahajan: Pollution control in process Industries.
6. K.S. Ramlho: Introduction to waste water treatment process.
7. M.J. Hammar: Water and waste water Technology.

Semester-I
(Course MIC-506)
Inorganic Chemistry Practical

Course Objectives: The Course is introduced to impart practical knowledge of the chemical methods of analysis with basic idea of titrimetric and gravimetric techniques. It will enable the students to develop their experimental skills and creativity.

Course Outcomes:

CO 1: Know the various types of titrimetric methods of analysis and their applications.
CO 2: Demonstrate the bromatometric, cerimetric and acid base and complexometric titrations in laboratory.
CO 3: Perform experimentation and evaluate the results.
CO 4: Develop the ability to compile interpreted information in the form of lab record and to face viva-voce.

Time: 6 Hours/week **Credit: 3**

Max. Marks: 50

Syllabus

1. **Bromatometric titrations**
   - (i) Determination of antimony (III) and arsenic (III) (Direct method).
   - (ii) Determination of aluminium, cobalt and zinc (oxine method).
2. **Complexometric titrations**
   - (i) Estimation of magnesium, copper and zinc using EDTA titrations.
   - (ii) Determination of nickel in nickel salts both by direct titration and back titration with EDTA.
   - (iii) Alkalimetric titrations with EDTA
3. **Mixture Analysis**
   - (i) Cu(II) + Mg(II): Cu (gravimetrically) as CuSCN and Mg (volumetrically) using EDTA.
   - (ii) Cu(II) + Ni(II): Cu (gravimetrically) as CuSCN and Ni (volumetrically) using EDTA.
   - (iii) Cu(II) + Ni(II)+Zn: Cu (volumetrically) using hypo solution, Ni (gravimetrically) with DMG and Zn (complexometrically) using EDTA.
4. **Sample Analysis**
   - (i) Determination of hardness of water.
   - (ii) Determination of Oxygen in hydrogen peroxide.
   - (iii) Determination of Phosphoric acid in commercial phosphoric acid.
   - (iv) Determination of Boric acid in borax.
   - (v) Determination of available chlorine in bleaching powder and residual chlorine in water samples.

Books Recommended

1. Svehla, G., Sivasankar B., 2013, Vogel's Qualitative Inorganic Analysis, 7th Edition, Pearson.
2. Bassett, J., Denney, R.C., Jeffery, G.H., Mendham, J., 1978, Vogel's Textbook of QuantitativeInorganic Analysis (revised); 4th ed., Orient Longman.
3. Mendham J., R. C., Denney J. D., Barnes and Thomas M., Vogel's Textbook of Quantitative Analysis, Pearson, Ed. 2006.
4. Vogel, A I; Tatchell A R; Furnis, B S; Hannaford, A J and Smith, PWG. 1989. Vogel's Text Book of Practical Inorganic Chemistry, 5th Edition, Pubs: ELBS.
5. Marr G. and Rocket B. W., Practical Inorganic Chemistry, University Science Books, Ed. 1999.
6. Pass G. and Sutcliffe H., Practical Inorganic Chemistry, Chapman and Hall, London, Ed. 1968.

Semester-I
(Course MIC-507)
Organic Chemistry Practical

Course Objectives: The objective of this course is to provide basic knowledge of stepwise synthesis of the organic compounds and to know the practical applicability of different types of organic reactions.

Course Outcomes:

CO 1: Know the concept of stepwise synthesis of the organic compounds.
CO 2: Develop the skill of performing experiments and analysing data to evaluate results.
CO 3: Develop the ability to compile interpreted information in the form of lab record.
CO 4: Learn to face the viva-voce examinations.

Credit: 3
Max. Marks: 50

Time: 6 Hours/week

Syllabus

Synthesis of organic compounds

1. Reduction of camphor using $NaBH_4$.
2. Prepare oxime from cyclohexanone.
3. Prepare caprolactum from cyclohexanone oxime.
4. Prepare Fluorescein from Resorcinol.
5. Prepare Eosin from Fluorescein.
6. Preparation of Acetophenone phenyl hydrazine.
7. To synthesise 2-phenyl indole from Acetophenone phenyl hydrazine(two steps).
8. Preparation of Respropiophenone.
9. To synthesize 7-Hydroxy 3-methyl Flavone by Baker Venkatraman method from Respropiophenone (two steps).
10. Preparation of 7-Hydroxy-4-methylcoumarin (Umbelliferrone), Pechmann reaction.
11. Synthesis of methyl orange from aniline.
12. Synthesis of 2,4-dinitrophenylhydrazine form chlorobenzene.

Books Recommended:

1. Harwood, L.M., and Moody, C.J., Experimental Organic Chemistry, 1st edition, Blackwell Scientific Publishers, 1989.
2. Vogel, A.I., Text Book of Practical Organic Chemistry, ELBS, 5th edition, Longman Group Ltd., 1989.
3. Mann, F.G., and Saunders, B.C., Practical Organic Chemistry, 4th edition, New Impression, Orient Longman Pvt. Ltd., 1981.
4. Tewari, K.S., Vishnoi, N.K. and Mehrotra, S.N., A Textbook of Organic Chemistry, 2nd edition, Vikas Publishing House, 1976.
5. Leonard, J., Lygo, B., Advanced Practical Organic Chemistry, J. Leonard, B. Lygo, Chapmanand Hall, 1995.

Semester-I
(Course MIC-508)
Physical Chemistry Practical

Course Objectives: This course is introduced to impart knowledge and understanding of various methods used for the determination of heat of solution, adsorption and distribution coefficients, conductance and surface tension measurements with various experimental methods to analyse the kinetics of various reactions.

Course Outcomes:

CO 1: Understand the safe handling of chemicals, environmental issues, and safety measures to be followed during the labs.
CO 2: Use various methods in determining the specific heat, heat of neutralization and heat of solution of solvents and mixtures.
CO 3: Determine surface tension of various solvents and mixtures by using different experimental methods.
CO 4: Analyze the mechanisms and kinetics of various reactions by using different experimental methods.
CO 5: Know about the adsorption and distribution of solutes.

Time: 6 Hours/week **Credit: 3**
Syllabus **Max. Marks: 50**

A. Thermochemistry

1. Determination of specific heat of liquids and solutions by calorimetry.
2. To determine the heats of neutralization of two acids, e.g., HCI and CH_3COOH and hence their relative strength.
3. To determine the integral heat of solution of a salt at two concentrations and hence the integral heat of dilution.

B. Kinetics Studies

1. Determine the rate constant of hydrolysis of an ester such as methyl acetate catalysed by an acid, say 0·5M HCl. Determine also the energy of activation of the reaction.
2. Determine the velocity constant of hydrolysis of ethyl acetate by sodium hydroxide (saponification of an ester).
3. Study the kinetics of de-polymerization of diacetone alcohol catalysed by sodium hydroxide using a dilatometer.

C. Adsorption and distribution coefficient studies

1. Investigate the adsorption of oxalic acid from aqueous solutions by activatedcharcoal, and examine the validity of classical and Langmuir's adsorptionisotherms.
2. Determine the distribution coefficient of iodine between an organic liquid such as carbon tetrachloride, carbon disulphide, kerosene etc. and water at a given temperature (or room temperature).
3. Determine the equilibrium constant of the reaction $KI + I_2 \Leftrightarrow KI_3$ by distribution method.
4. Determine the formula of the complex ion formed between the cupric ion and ammonia (cuprammonium ion) by distribution method.

D. Conductometric measurements

1. Determination of cell constant, limiting molar conductance of simple electrolytes in water, verification of Ostwald, dilution law for week acetic acid.
2. Surface tension measurements: Surface tension of pure solvents, analysis of mixtures of two miscible solvents, verification of Gibb's Thomson rule of surface tension.

Books Recommended:

1. B. P. Levitt, Findlay's Practical Physical Chemistry, Longman, London.
2. James and Prichard, Experiments in Physical Chemistry.
3. Yadav, Advanced Practical Physical Chemistry, 1989.
4. J. C. Ghosh, Experiments in Physical Chemistry, Bharathi Bhavan, 1974.
5. B.D. Khosla, V.C. Garg, Adarsh Gulati, Physical Chemistry, 1975.

SEMESTER-II

Semester-II
(Course MIC-509)
Spectroscopic Techniques

Course Objectives: The main aim of the course is to provide the basic knowledge about the principles and instrumentation of spectroscopic techniques like ultra violet-visible spectroscopy, infrared spectroscopy, nuclear magnetic resonance (NMR) spectroscopy, nuclear quadrupole resonance (NQR) spectroscopy, Mossbauer and electron spin resonance (ESR) spectroscopy along with their application for the structure elucidation of organic and inorganic compounds.

Course Outcomes:

CO 1: Understand the fundamental laws of absorption, photometric titrations, molecular fluorescence spectroscopy and their applications in quantitative analysis.
CO 2: Understand the basic principle of NMR spectroscopy and to apply its role for the structure elucidation.
CO 3: Understand the basic principle of IR spectroscopy and its applications.
CO 4: Knowledge of the various concepts of Mossbauer and NQR spectroscopy.
CO 5: Understand the theory, some basic concepts and some applications of ESR spectroscopy.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Credit: 4

Lectures: 60
Max. Marks (Theory): 80
(IA): 20

Syllabus

Unit-1 UV-visible and Fluorescence Spectroscopy

UV-visible Spectroscopy: Basic principles, Beer-Lambert law, deviation from Beer-Lambert's Law. types of electronic transitions. Franck - Condon principles, ground and excited electronic states of diatomic molecules. Chromophores, auxochromes, Instrumentation and application. Factors affecting the positions of UV bands. Photometric Titrations curves, Woodward–Fisher rules. Application of UV Spectroscopy in the structural study of organic molecules.

Molecular Fluorescence Spectroscopy: Theory, relaxation processes, relationship between excitation spectra and florescence spectra, effect of concentration on florescence intensity, instrumentation.

Unit-2 NMR Spectroscopy

Magnetic properties of nuclei, theory and measurement techniques, NMR spectrometer, chemical shift and its measurements, factors affecting chemical shift, spin-spin coupling, coupling constant, Shielding and deshielding, spin decoupling; effects of chemical exchange, solvent effects and Nuclear Overhauser Effect. Experimental techniques (CW and FT). Brief introduction of C-13 NMR.

Unit-3 Infrared Spectroscopy

Theory of IR absorption, Types of IR vibrations, Observed number of modes of vibrations, Intensity of absorption bands, application of infrared spectroscopy in functional group identification. Characteristic vibrational frequencies of common functional groups (alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines, ketones, aldehydes, esters, amides and acids). Factors affecting vibrational frequencies and band shapes (Vibrational Coupling, Electrical effects: Resonance, Inductive effects, Ring strain).

Unit-4 Mössbauer and NQR Spectroscopy

Mössbauer Spectroscopy: Introduction, Principle, Conditions for Mössbauer Spectroscopy, Parameters from Mössbauer Spectra- Isomer shift, Electric Quadrupole Interactions, Magnetic Interactions, MB instrumentation, Applications of MB spectroscopy in structural determination of

a) Low spin Fe(II) and Fe(III) Complexes- Ferrocyanides, Ferricyanides, Prussian Blue.
b) Iron carbonyls. Fe(CO)5, Fe2(CO)9 and Fe3 (CO)12.

Nuclear Quadrupole Resonance Spectroscopy: Basic concepts of NQR (Nuclear electric quadrupole moment, Electric field gradient, Energy levels and NQR frequencies), Effect of magnetic field on spectra, Relationship between electric field gradient and molecular structure.

Unit-5 Electron Spin Resonance Spectroscopy

Introduction, Similarities between ESR and NMR, Behaviour of a free electron in an external Magnetic Field, Basic Principle of an Electron Spin Resonance Spectrometer, Presentation of the spectrum, Hyperfine coupling in Isotropic Systems (methyl, benzene and Naphthalene radicals). Factors affecting the magnitude of g-values. Zero field splitting and Kramer's Degeneracy, Line width in solid state ESR, Double resonance technique in E.S.R.

Books recommended:

1. D.L. Pavia,Spectroscopy, 4th Ed., Cengage,2012.
2. Y.R. Sharma, Elementary Organic Spectroscopy -Principles and Chemical Applications, S. Chand, 1992.
3. P.S. Kalsi,Spectroscopy of Organic Compounds, 6th Edition, New age International Publishers, 2008.
4. C.N. Banwell, Fundamentals of molecular Spectroscopy, 3rd ed., TMH, New Delhi,1983.
5. W. Kemp, Organic Spectroscopy, 3rd Ed., MacMillon, 1994.
6. C.R. Dyer, Applications of Absorption Spectroscopy of Organic Compounds, Prentice Hall, 1965.
7. D. Williams, and I. Fleming, "Spectroscopic Methods in Organic Chemistry", 6th Ed., McGraw Hill Education (India) Private Limited.
8. P.M. Silverstein, Spectroscopic Identification of Organic Compounds, F. X. Wbester, 7th ed., Wiley & Sons, 2005.
9. R.S. Drago, Physical methods in inorganic chemistry, 2015.

Semester-II
(Course MIC-510)
Advanced Analytical Chemistry

Course Objectives: The key objective to frame this course is to acquire a foundational understanding of various analytical techniques employed in quantification of chemical compounds. As part of this course, students will be introduced to some basic concepts of analytical chemistry along with chromatographic, optical and thermal techniques of analysis with detailed description of instrumentation, principle and applications in various fields.

Course Outcomes:

CO 1: understand the basic concepts of errors, accuracy, precision and some test of significance to analytical data along with sampling methodologies and sampling errors.
CO 2: Understand and explain the separation techniques with reference to chromatography and their applications.
CO 3: Describe the different types absorption and emission spectroscopy and removal of interferences.
CO 4: Describe thermo-analytical techniques and their applications to the analysis of Inorganic compounds.
CO 5: Apply the concept of mass spectrometry for the determination of structure of organic compounds based on fragmentation.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Lectures: 60 **Credit: 4**
Syllabus **Max. Marks (Theory): 80**
(IA): 20

Unit-1 Quantitative Analysis
Types and sources of errors, propagation of errors, detection and minimization of various types of errors. Accuracy and precision, average and standard deviation, variance, its analysis and confidence interval, tests of significance (F-test, t-test and paired t-test), criteria for the rejection of analytical data (Q-test, average deviation and standard deviation), least-square analysis. Control chart, Sampling methods, Sampling errors.

Unit-2 Solvent Extraction and Separation Techniques
Partition law and its limitations, distribution ratio, separation factor, factors influencing extraction, multiple extractions. Extraction of metal chelates. Brief idea of High-performance liquid chromatography (HPLC) and Gas Chromatography (GC): Mechanism of separation, theory and technique, instrumentation,

Unit-3 Spectroscopic Techniques of Analysis
Theory of flame photometer, intensities of spectral lines, selection of optimal working conditions, applications of flame photometry to quantitative analysis. The Theory of Atomic Absorption Spectroscopy (AAS), Origin of atomic spectra, line width effects in atomic absorption, instrumentation and its application, Atomic emission spectroscopy (AES) and the detailed description of the techniques of inductively coupled plasma AES (ICP-AES) and its instrumentation. Chemical and spectral interferences encountered in both techniques and how to overcome them.
Basic principle of electron microscopy; specimen preparation, instruments, working and applications of scanning electron microscope (SEM), transmission electron microscopy (TEM) and atomic force microscopy (AFM), contact angle measurements.

Unit-4 Thermal Techniques of Analysis
Introduction, thermogravimetric analysis (TGA), types of thermogravimetric analysis, principle, instrumentation, factors influencing thermograms and applications of thermogravimetric analysis. Differential thermal analysis (DTA), principle of working, theory and instrumentation. Simultaneous DTA-TGA curves, factors affecting DTA curves and applications. Differentia Scanning colorimetry (DSC), principle of working theory, instrumentation and applications.

Unit-5 Mass Spectrometry
Mass Spectrometry - Introduction, ion production: electron ionisation (EI), chemical ionisation (CI), Field desorption (FD) and fast atom bombardment (FAB). factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule. High-resolution mass spectrometry.

Books recommended:

1. H.H Willard, J.L. Merritt, J.A. Dean andF.A. Settle, Instrumental Methods of Analysis.
2. G.D. Christian, Analytical Chemistry, Wiley (2007) 6th ed.
3. P.T. Skoog, D.A. Holler, F.J. Crouch,S.R.Thomson, Principles of Instrumental Analysis, Learning (2007).

4. S.M. Khopkar, Basic Concepts of Analytical Chemistry, Wiley Eastern.
5. Skoog, Holder, Nieman, Principles of Instrumental Analysis Fifth edition, Thomson Books, 1998.
6. J. Haines,Thermal Methods of Analysis, Principles, Application and Problems, Blackie Academic and Professional, 1994.
7. W.W. Wendlandt, Thermal methods of analysis.
8. A. BraithwaiteandF.J. Smith, Chromatographic Methods, 5th ed. Blackie Academic and Professional, London, 1996.
9. R.L. Pescock, L.D. Shields, T. CairnsMc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.

Semester-II
(Course MIC-511)
Mechanism and Kinetics of Polymers

Course Objectives: The key objective to frame this course is to acquire the knowledge of thermodynamics and kinetics of polymer and phase equilibria and radiation chemistry of polymers. This course will also impart knowledge and understanding of commercial polymers.

Course Outcomes:

CO1: To identify and analysis of polymers.
CO1: Presenting the mechanism of different type of polymerizations.
CO2: Reviewing the kinetics of ionic polymerization.
CO3: Enumerate the copolymerization concept and reactivity ratios.
CO4: Analyse the thermodynamics of polymer solutions.

Note: *(i)* ***TEN*** *questions will be set by the examiner selecting* ***TWO*** *from each unit. As far as possible every question will be divided into* ***Two -Three Parts****. The students shall attempt* ***FIVE*** *questions selecting* ***ONE*** *from each unit.*

Lectures: 60 **Credit: 4**
Syllabus **Max. Marks (Theory): 80**
(IA): 20

Unit-1 Identification and Analysis of Polymers

Polymer Characterization: Average molecular weight concept. Number, weight and viscosity, average molecular weights, Polydispersity and molecular weight distribution, The practical significance of molecular weight. Measurement of molecular weights - End group, viscosity, light scattering, osmotic and ultra-centrifugation methods, Analysis and testing of polymers - Chemical analysis, Spectroscopic methods, Thermal Analysis, XRD and SEM.

Unit-2 Mechanisms of Polymerization

Mechanism of Addition polymerization, condensation polymerization, Ring opening polymerization, stereo selective polymerization, electrochemical polymerization. solid state polymer and kinetic chain length.

Unit-3 Ionic Chain Polymerization

Cationic polymerization: - Initiation- protonic acids, Lewis acids, other initiators, Propagation, Termination- chain transfer to monomer, spontaneous termination, combination with counter ion, chain transfer to polymer, other transfer and termination reactions, kinetics

Anionic polymerization: - Initiation- nucleophilic initiators, electron transfer, Propagation, Termination- polymerization without termination, termination by impurities and deliberately added transfer agents, spontaneous termination, Kinetics. Comparison between cationic, anionic & radical polymerization.

Unit-4 Copolymerization and commercial polymers

Importance of chain copolymerization, Types of copolymers, Copolymer composition, Methods of determination of reactivity ratios, Reactivity ratio and copolymerization behaviour, Applications of polyethylene, polyvinyl chloride, polyamides, polyesters, polyurethanes, phenolic and epoxy resins and Silicone polymers, Applications of starch, gelatin, pectin and chitosan in polymer industry, Biodegradable polymers (lactic and glycolic acid).

Unit-5 Stereochemistry and thermodynamics of polymers

Criteria of polymer solubility, solubility parameter, solution viscosity, Flory - Huggins theory, Entropy of mixing, enthalpy of mixing, Types of stereoisomerism in polymers, Monosubstituted ethylenes (Site of steric isomerism, Tacticity), Disubstituted ethylenes (1,1-disubstituted ethylenes, 1,2- disubstituted ethylenes), Stereoregular polymers: Significance of stereo-regularity (isotactic, syndiotactic, and atactic polypropenes), Cis- and trans-1,4-poly-1,3- dienes, Cellulose and amylose.

Books Recommended

1. Principles of polymer chemistry – P.J. Flory.-Encyclopedias- 672 pages.1995
2. Macromolecules in solution – H.merawetz. interscience. N.Y.1965
3. Principles of polymerization – G. Odian.-John Wiley & sons, Inc 2004.
4. Polymer colloids, A comprehensive Introduction: Rober M. Fitch –Springer 1971 (Academic Press)

Semester-II
(Course MIC-512)
Fundamentals of Medicinal Chemistry

Course Objectives: The main objective of the course is to provide basic knowledge of medicinal chemistry. To know about the procedure followed in drug design. To understand the concepts of drug receptors and various theories of drug activity. To familiarize with pharmacokinetics (ADME) and important pharmacokinetic parameters. To understand pharmacodynamics and significance of drug metabolism in medicinal chemistry.

Course Outcomes:

CO 1: Understand the docking mechanism of molecules along with the role of computers in clinical research.
CO 2: Use of computers for structure elucidation, prediction of spectral properties, synthetic strategies and virtual screening.
CO 3: Understand the concept of development of new drugs, procedures for drug design, and structure activity relationship.
CO 4: Apply the knowledge of pharmacokinetics in drug development process.
CO 5: Apply the knowledge of pharmacodynamics in drug design and metabolism.

***Note:** (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Lectures: 60 **Credit: 4**
Syllabus **Max. Marks (Theory): 80**
(IA): 20

Unit-1 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-2 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.

Unit-3 Drug Design, Drug-Target Interactions

Development of new drugs, procedures followed in drug design, concept of lead Compound and lead modification, Screening of NPs (Isolation and purification, structural determination), concepts of prodrugs and soft drugs, structure-activity relationship (SAR) factors affecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism, spatial, consideration. Quantitative Structure Activity Relationship (QSAR) with special reference to antimalarials, antibiotics, anticholenergics and CNS active drugs. Concepts of drugs receptors. Elementary treatment of drug receptors. Elementry treatment of drug receptor interactions. Concepts of LD50 and ED50, Ec50, MIC, Natural product as a lead. Isolation &characterization of natural lead.

Unit-4 Pharmacokinetics

Pharmacokinetics: Introduction to drug absorption, Disposition, Elimination using pharmacokinetics, Important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in drug development process.

Unit-5 Pharmacodynamics

Pharmacodynamics: Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, membrane active drugs, drug metabolism, xenobiotics, biotransformation, Significance of drug metabolism in medicinal chemistry.

Books recommended:

1. Wilson and Gisvold's, Text Book of organic Medicinal &Pharmaceutical Chemistry, (2004)
2. Thomas, G. Fundamentals of medicinal chemistry. John Wiley & Sons.2004.
3. Burger's, Medicinal Chemistry & Drug Discovery, Vol-1(Chapter-9 & Ch-14),Ed.M.E.Wolff, John Wiley, 1995
4. Goodman and Gilman's, pharmacological Basis of Therapeutics, McGraw-Hill, 1996.
5. Silverman, R.B., The Organic Chemistry of Drug Design and Drug Action, Academic Press, 2014
6. Lednicer, D., Strategies for Organic Drug Synthesis and Design, John Wiely, 2009.
7. GrahamL. Patrik, An introduction to Medicinal Chemistry-, Oxford University Press, 3rd edition, 2005.
8. Berry, I.R.,& Nash, R.A., Pharmaceutical Process Validation, Academic Press, London, 3rd Edition, 2003.

Semester-II
(Course MIC-513)
Analytical Chemistry Practical

Course Objectives: The Course is introduced to impart practical knowledge of the instrumental methods of analysis based on spectrophotometry, potentiometry, pH metry, conductometry, chromatography and cyclic voltammetry. It will enable the students to develop their experimental skills and creativity.

Course Outcomes:

CO 1: Apply the fundamentals of conductometric, potentiometric and pH metric titrations for analysis of given sample solutions.

CO 2: Apply the fundamentals of spectrophotometric, voltammetric and chromatographic techniques for quality control.

CO 3: Perform experimentation and evaluate the results.

CO 4: Develop the ability to compile interpreted information in the form of lab record and to face viva-voce.

CO 5: Learn data handling and analysis and also to develop problem solving ability.

Time: 6 Hours/week **Credit: 3**

Syllabus **Max. Marks: 50**

A. Spectrophotometry

1. Investigate several characteristics of a commercial spectrophotometer and compare different cuvette materials.
2. Verification of Beer's law for $KMnO_4$, $K_2Cr_2O_7$ solutions and determination of the conc. of $KMnO_4$, $K_2Cr_2O_7$.
3. Colorimetric determination of Iron (II) with o-phenanthroline method.
4. Determination of iron content using photometric titration.
5. Determination of traces of manganese (in steel samples) calorimetrically by oxidation to permanganic acid with potassium periodate.
6. Simultaneous determination of chromium (as $Cr_2O_7^{2-}$) and manganese (as MnO_4^-) in mixture.
7. Simultaneous determination of Fe(II) and Fe(III).
8. Determination of chlorophyll in olive oil by UV-Visible and Fluorescence Spectroscopy.
9. To study the excitation and emission spectra for the fluorescent dye fluorescein and study the effect of concentration and instrumental bandwidth on the fluorescent signal.

B. Potentiometric Titrations.

1. **Neutralization reactions:**
   a) Sodium hydroxide-hydrolchloric acid.
   b) Sodium hydroxide-Boric acid.
   c) Acetic acid and hydrochloric acid-sodium hydroxide.
2. **Oxidation-Reduction Reactions.**
   a) Ferrous-dichromate.
   b) Ferrous-Ceric.
   c) Iodine-Thiosulphate.
3. **Precipitation Reactions:**
   a) Silver nitrate-sodium halides.
   b) Chloride-Iodide mixture.

C. Conductometric Titrations:

1. Differential behaviour of acetic acid to determine the relative acid strength of various acids.
2. Strong acid-strong base titration in acetic acid.
3. Determination of strength of pyridine using perchloric acid in acetic acid.
4. Determination of strength of potassium acetate in acetic acid using perchloric acid.

D. pH metric –titrations

1. Acid base titrations.
2. Mixtures of acids with a base.

E. Gas Chromatography

1. Analysis of a Liquid Organic Mixture by Gas Chromatography.
2. Examine the phosphoric acid catalyzed dehydration of 2-methylcyclohexanol using Gas chromatography.
3. To study the effect of column gas flow rate and temperature on the separation of a BTEX mixture (mixtures of benzene, toluene, and the three xylene isomers, all of which are aromatic hydrocarbons.)

F. Cyclic voltammetry

1. Determine the redox potential of potassium ferricyanide and calculate the diffusion coefficient of potassium ferricyanide.
2. Cyclic Voltammetric Study of ferrocyanide/ferricyanide Redox Couple.

3. To study the redox processes and solvent hydrogen bonding effects in 2,3,5,6-tetramethyl-1,4-benzoquinone

Books Recommended

1. L.M., Harwood, and C.J., Moody, Experimental Organic Chemistry, 1st edition, Blackwell Scientific Publishers, 1989.
2. A.I., Vogel, Text Book of Practical Organic Chemistry, ELBS, 5th edition, Longman Group Ltd., 1989.
3. F.G., Mann, and B.C., Saunders, Practical Organic Chemistry, 4th edition, New Impression, Orient Longman Pvt. Ltd., 1981.
4. K.S., Tewari, N.K. Vishnoi, and S.N., Mehrotra, A Textbook of Organic Chemistry, 2nd edition, Vikas Publishing House, 1976.
5. J., Leonard ,B., Lygo, Advanced Practical Organic Chemistry, J. Leonard, B. Lygo, Chapman and Hall, 1995.

Semester-II
(Course MIC-514)
Polymer Chemistry Practical

Course Objectives: The Course is introduced to impart practical knowledge of the different methods of polymer synthesis as well as their characterisation. The course also helps the students to find out the molecular weight and glass transition temperature of the polymers to develop their experimental skills and creativity.

Course Outcomes:

CO 1: Develop the ability to synthesize polymers using different methodologies.
CO 2: Determine the functional group percentage, saponification and acid values in the given polymers.
CO 3: Perform experimentation and evaluate the molecular weight of polymers.
CO 4: Learn data handling and analysis and also to find out the glass transition temperatures.
CO 5: Develop the ability to compile interpreted information in the form of lab record and to face viva-voce.

Time: 6 Hours/week **Credit: 3**
Syllabus **Max. Marks: 50**

Polymer Synthesis

1. Condensation polymerization of amino caproic acid to prepare Nylon-6.
2. Polyamide formation via diamine and diacid chloride monomer through step growth polymerization at Room temperature.
3. Synthesis of conducting polymers.

Polymer Characterisation-I

4. Determination of percentage of NCO groups in a polymer sample.
5. Determination of saponification value in a polymer sample.
6. Determination of acid value in a polymer sample.

Polymer Characterisation-II

7. Determination of molar mass of Nylon or any other amide by end group analysis.
8. Determination of number average molecular weight of a polymer by hydroxyl end group analysis.
9. Determination of viscosity average molecular weight of polystyrene in toluene by dilute solution viscosity method.
10. Determination of glass transition temperature of a polymer sample.

Books Recommended

1. G., Svehla, B., Sivasankar 2013, Vogel's Qualitative Inorganic Analysis, 7th Edition, Pearson.
2. S M A Ashraf, Laboratory Manual of Polymers; I K International Publishing, Vol 1.
3. B. P. Levitt Findlay's Practical Physical Chemistry, , Longman, London.
4. James and Prichard. Experiments in Physical Chemistry.
5. Yadav, Advanced Practical Physical Chemistry, 1989.

Semester-II
(Course MIC-515)
Medicinal Chemistry Practical

Course Objectives: To understand intricacies of the subject and to develop the experimental skills by providing sophisticated chemistry laboratory. The practical work has been designed to give hands on experience of various analytical techniques used in chemistry to make the student competent to design, perform and analyses the experiments by using these techniques

Course Outcomes:

CO 1: Learn representations of various molecules in different file formats and develop and extract information from various databases.

CO 2: Acquire information regarding chemical databases and data mining.

CO 3: Perform pharmacophore hypothesis building, docking and build combinatorial libraries.

Time: 6 Hours/week **Credit: 3**

Syllabus **Max. Marks: 50**

Molecular Representations and Chemical Databases

1. Practical session for chemical structure representation and storage in special file formats (SMILES, WLN, sd and mol).
2. Importance of 3D structures and method of generation from 1D & 2D representations.
3. A brief introduction to building molecular databases with special emphasis on retrieval using structure input.

Chemical Databases and Data Mining

4. Chemical Databases and Data Mining: Cambridge Structural Database CCDC CSD; Crystallographic Open Database COD; Protein Data Bank PDB Ligand Explorer; Chemspider; Other Data Bases
5. Quantitative Structure Activity/Property/Toxicity Relationship Studies
6. Substructure/Exact/similar structure-based searching.

Computer-Aided Drug Design

7. Computer-Aided Drug Design Tools (Molecular Modeling Tools; Structural Homology modeling Tools; Docking Tools and Screening Tools; Other tools)
8. Pharmacophore hypothesis and searching.
9. Docking studies (Rigid, Flexible & library based).
10. Design and analysis of focused combinatorial library.

Books Recommended

I. Andrew R. Leach, Valerie J. Gillet, Cluwer, Introduction to Cheminformatics, Academic Publisher, Netherlands, 2003.

II. Lisa B. English (Editor), Combinatorial Library Methods and Protocols, Humana Press Inc, Volume: 201, 2002.

III. Frank Jensen, Introduction to Computational Chemistry, Wiley Publisher, Second Edition, 2006

IV. Johann Gasteiger (Editor), Thomas Engel (Editor), Chemoinformatics: A Textbook, Wiley Publisher ISBN: 978-3-527-30681-7, 2003.

V. Rajarshi Guha (Editor), Andreas Bender (Editor), Computational Approaches in Cheminformatics and Bioinformatics Wiley-Blackwell, 2012.

VI. Fan Li, Developing Chemical Information Systems: An Object-Oriented Approach Using enterprise JAVA, John Wiley & Sons, 2006.

SEMESTER-III

Semester-III
(Course MIC-601)
Natural Products

Course Objectives:

To understand general aspects of isolation and structure elucidation of natural products including terpenoids, carotenoids, alkaloids, steroids and other essential molecules of life viz. carbohydrates, proteins, aminoacids and vitamins. To provide the knowledge about the synthesis and biosynthesis of these natural products

Course Outcomes:

CO 1: Understand the concept of natural product isolation and structural elucidation of terpenoids.
CO 2: Apply the general methods of structure elucidation to analyze alkaloids.
CO 3: Analyse the structure elucidation methods and biosynthesis of steroids.
CO 4: Describe the general methods of structure determination of carotenoids.
CO 5: Understand the different methods of carbohydrates, protein and peptide synthesis.
CO 6: Ability to understand about the chemistry and biological importance of vitamins.

Note: *(i)* ***TEN*** *questions will be set by the examiner selecting* ***TWO*** *from each unit. As far as possible every question will be divided into* ***Two -Three Parts****. The students shall attempt* ***FIVE*** *questions selecting* ***ONE*** *from each unit.*

Lectures: 60
Syllabus

Credit: 4
Max. Marks (Theory): 80
(IA): 20

Unit- 1 Terpenoids and Carotenoids

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, biosynthesis and synthesis of the following representative molecules: Monoterpenoids: Citral, α-terpeneol, menthol (monocyclic). Sesquiterpenoids: Farnesol (acyclic), zingiberene (monocyclic), santonin (bicyclic), General methods of structure determination of Carotenes: β-carotene.

Unit- 2 Alkaloids and Steroids

Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, synthesis and biosynthesis of the following: Ephedrine, Coniine, Nicotine, Atropine, Quinine. Isolation, structure determination and synthesis of Androsterone, Testosterone, Estrone, Progestrone.

Unit- 3 Carbohydrates

Types of naturally occurring sugars: Deoxy-sugars, amino sugars, branched chain sugars. General methods of structure and ring size determination with particular reference to maltose, lactose, sucrose, pectin, starch and cellulose, photosynthesis of carbohydrates.

Unit-4 Amino acid, Peptides and Proteins

General methods of peptide synthesis, sequence determination, Purines and nucleic acid, Chemistry of uric acid, adenine, protein synthesis.

Unit-5 Vitamins

A general study, detailed study of chemistry of thiamine (Vitamin B1), Ascorbic acid (Vitamin C), Pantothenic acid, biological importance of vitamins.

Books recommended:

1. Natural Products- Chemistry and Biological Significance, J. Mann, R.S. Davidson, J. B. Hobbs, D.V. Banthrope and J. B. Harborne, Longman, Essex.
2. Organic Chemistry Vol. II, I.L. Finar, ELBS.
3. Stereo selective synthesis- A Practical Approach, M. Nogradi, VCH.
4. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
5. Chemistry, Biological and Pharmacological Properties of Medicinal Plants From the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
6. New Trends in Natural Product Chemistry, Atta-ur-Rahman M. I. Choudhary, Harwood Academic Publishers.

Semester-III
(Course MIC-602)
Agrochemical Chemistry

Course Objectives: The key objective to frame this course is to acquire a foundational understanding of various agrochemical products used in farming industry. The course is designed to help the students to understand the different types of pests and various types of pesticides used to control these pests. The course also provides a functional understanding of the fertilisers used to increase the crop production.

Course Outcomes:

CO 1: Understand the concept of pests and pesticides needed to eradicate the pests.
CO 2: Ability to classify the pesticides into different classes based on their target species and structure.
CO 3: Understand the general mode of action and structures of insecticides, fungicides and herbicides.
CO 4: Describe the essential plant nutrients and their classification.
CO 5: Understand the role of fertilisers to improve crop quality and to increase the crop production.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Lectures: 60 **Credit: 4**
Syllabus **Max. Marks (Theory): 80**
(IA): 20

Unit-1 Agrochemicals and Pests

Introduction, Classification and Role of agrochemicals in agriculture. Pests: Introduction and Types of pests, Pest control: Natural and applied control [Physical, mechanical, cultural, biological, genetic, regulatory, chemical controls], Integrated pest management, Attractants, Repellents and Pheromones,

Unit-2 Pesticides-I

Pesticides: Introduction, Classification of pesticides based on mode of action, according to target species and chemical nature, Toxicity of pesticides, Formulation of pesticides-Dry formulation: Dusts, granules, wettable powders, seed disinfectants, liquid formulations: Emulsions, suspensions, etc.
Herbicides: Introduction and chemistry of Aromatic acid herbicides: 2,4-D, 2, 4-DB, 2, 4-DES, MCPB, 2, 4, 5-T. N-dimethylureas: Monuron, diuron, and sulfonylureas.

Unit-3 Pesticides-II

Fungicides: General introduction, structure and chemistry of Inorganic fungicides- Sulphur, Lime sulphur, copper sulphate, copper oxychloride, cuprous oxide, mercurous chloride. Dithiocarbamates: Ziram, Ferbam, Thiram, Nabam, Zineb, Maneb, Quinones: Chloranil. Benzimidazole: Carbendazim, Thiabendazole.
Rodenticides: Hydroxycoumarin, Dicoumarin, Warfarin, Zinc-phosphide and bromodiolone

Unit-4 Pesticides-III

Insecticides: Inorganic insecticides- Arsenic insecticides, Paris green, fluoro insecticides. Insecticides of plant origin– Nicotine, nornicotine, Pyrethroids, rotenoids, allethrin. Structure, and mode of action of Chlorinated hydrocarbons (DDT, DDD, BHC, Chlordane, Heptachlor, Aldrin, Dieldrin, Endrin, Endosulfan), Organophosphorus Insecticides (Dichlorovos, Naledphosphinon), and Carbamate Insecticides (Carbaryl, Isolan, Mesurol, Zectran, Baygon).

Unit-5 Fertilizers

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.
Manufacture and general properties of Fertilizer products: Nitrogenous Fertilizers: Ammonium Nitrate, Calcium Ammonium Nitrate, 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 Phosphates, Di-Ammonium Phosphate (DAP), Nitro phosphates, Urea Ammonium Phosphates, NPK Complex Fertilizers,

Books recommended:

1. Melnikov N.N., Chemistry of Pesticides, Pubs: Springer-Verlag, New York, 1971.
2. Frear D.E.H., Chemistry of Insecticides and Fungicide, Pubs: Van Nostrand, New York,1942.

3. Panda, H; The Complete Technology Book on Pesticides, Insecticides, Fungicides and Herbicides with Formulae & Processes; NIIR Project Consultancy Services, 2003
4. N.K. Roy, Chemistry of pesticides.
5. K.A. Hussel, Chemistry of pesticides.
6. Hand Book of Agrochemical Industries (Insecticides & Pesticides) by EIRI Board of Consultants & Engineers
7. R. Cremlyn,Pesticides:preparation and mode of action.
8. M.B. Green, G.S.Hartley West: Chemicals for crop protection and pest managements (pergamon)
9. K.H. Buchel, Chemistry of Pesticides.
10. U. S. SreeRamulu,Chemistry of Insecticides and Fungicides, Oxford and IBM Pub., 1979
11. Van Wade. Velkenburg, Pesticides Formulations, 1973.
12. Gunter and Zweig, Analytical Methods of Pesticides and Plant Growth Regulators and Food Additives, Vol. I –IV, 1968.
13. K. S. Yawalkar, J. P. Agrawal, S. Bokde, Manures and Fertilizers , 1967.
14. G. H. Collings, Commercial Fertilizers , 2002.
15. S. K.Handa, Principles of pesticide chemistry. Agrobios (India); 2012.
16. D.S.Hill, Agricultural insect pests of the tropics and their control. CUP Archive; 1983.
17. S. B.Chattopadhyay, Principles and procedures of plant protection. Oxford & IBH Publishing Company, Pvt. Limited; 1991.
18. A. S. Atwal, Agricultural Pests of India and South-East Asia. Agricultural pests of India and South-East Asia. 1976.

Semester-III
(Course MIC-603)
Organic Synthesis

Course Objectives: The basic objective of this course is to understand mechanistic details of different types of oxidations, reduction and rearrangement reactions. As part of this course, students will know about some common reagents used in organic synthesis and their applications. To get knowledge about various types of pericyclic reactions and symmetry of molecular orbitals of some organic molecules.

Course Outcomes:

CO 1: Explain the mechanistic implications of some common reagents used in organic synthesis and their applications.
CO 2: Understand the concept of oxidation reactions and their applications.
CO 3: Understand the concept of reduction reactions and their applications.
CO 4: Mechanistic implications of rearrangement reactions and their applications.
CO 5: Analyze the concept of molecular orbital symmetry to apply in pericyclic reactions.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Lectures: 60 **Credit: 4**

Syllabus **Max. Marks (Theory): 80**

(IA): 20

Unit- 1 Organic Reagents

Reagents in organic synthesis: Willkinson catalyst, Lithium dialkylcuprates (Gilman's reagents), Lithium diisopropylamide (LDA), 1,3-Dithiane (Umpolung) Dicyclohexylcarbobiimide (DCC), and Trimethylsilyliodide, DDQ, SeO2, Baker yeast, Tri-n-butyltinhydride, Nickel tetracarbonyl, Trimethylchlorosilane, Grubbs Catalysts.

Unit- 2 Oxidations

Introduction, Different oxidative process. Aromatiztion of six membered ring, dehydrogenation yielding C-C double bond, Oxidation of alcohols, Oxidation involving C-C double bond, Oxidative cleavage of ketones, aldehydes and alcohols, double bonds and aromatic rings, Ozonolysis, Oxidative decarboxylation, Bisdecarboxylation, Oxidation of methylene to carbonyl, Oxidation of olefines to aldehydes and ketones

Unit- 3 Reductions

Introduction, Different reductive processes. Reduction of carbonyl to methylene in aldehydes and ketones, Reduction of nitro compounds and oximes, Reductive coupling, Bimolecular reduction of aldehydes or ketones to alkenes, metal hydride reduction, Acyloin ester condensation, Cannizzaro reaction, Tishchenko reaction, Willgerodtreaction.

Unit- 4 Rearrangements

General mechanistic considerations-nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Backmann, Hofmann, Curtius, Schmidt, Benzidine, Baeyer-Villiger, Shapiro reaction, Witting rearrangement and Steven's rearrangement.

Unit- 5 Pericyclic Reactions

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5 hexatrienes and allyl system. Classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions: conrotatory and disrotatory motions, 4n and 4n+2 and allyl systems. Cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and chelotropic reactions. Sigmatropic rearrangements-Suprafacial and Antarafacial shifts of H, sigmatropic shifts involving carbon moieties, Claisen, Cope and aza-Cope rearrangements, Ene reaction.

Books Recommended:

1. Designing Organic Synthesis, S. Warren, Wiley.
2. Organic Synthesis- Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, Verlage VCH.
3. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
4. Modern Synthetic Reactions, H.O. House, W. A. Benjamin.
5. Advanced Organic Chemistry-Reactions Mechanisms and Structure, J. March, Wiley.
6. Principles of Organic Synthesis, R. Norman and J.M. Coxon, Blakie Academic and Professional.
7. Advanced Organic Chemistry Part-B, F.A. Carey and R. J. Sundburg, Plenum Press.
8. Organometallic Chemistry-A Unified Approach, R.C. Mehrotra, A. Singh.

Semester-III
(Course MIC-604)
Medicinal Chemistry

Course Objectives: The main objectives of the course is to provide basic as well as advance knowledge of medicinal chemistry. To provide the knowledge about structure-activity relationships (SAR) and mode of action of some antibiotics and anti-infective drugs. To know about the SAR and mode of action of some central nervous system depressant and stimulants drugs, along with some antineoplastic, cardiovascular, antihistaminic, antifertility and diuretics agents.

Course Outcomes:

CO 1: Understand the SAR and mode of action of antibiotics.
CO 2: Know the neurotransmitters SAR and their mode of action.
CO 3: Understanding of mode of action of neurotropic drugs and CNS stimulants.
CO 4: Ability to understand chemotherapy and role of antineoplastic in treatment of cancer.
CO 5: Analyze the structure-activity relationships and mode of action of some cardiovascular and diuretics agents.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Credit: 4
Lectures: 60
Max. Marks (Theory): 80
Syllabus
(IA): 20

Unit- 1

Antibiotics and Antiinfective Drugs: Antibiotics: Historic development in the structural modifications of Penicillin antibiotics. Structure, SAR and biological action of antibiotics. Examples: penicillin: penicillin-G, penicillin-V, ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracycline and streptomycin. Sufonanmides: Structure, SAR and mode of action of sulfonamides, sulfonamide inhibition and probable mechanisms of bacterial resistance to sulfonamides. Examples: sulfodiazinesulfofurazole, Acetyl Sulfafurazole, Sulfaguanidine, Dapsone, Introduction and general mode of action of Local antiinfective drugs, Examples: sulphonamides, furazolidone, ciprofloxacin, norfloxacin, chloroquine.

Unit- 2

Psychoactive Drugs: Introduction, neurotransmitters-receptor interaction, CNS depressants and stimulants. SAR and Mode of action, Central Nervous System Depressant: **General anaesthetics, Sedatives & Hypnotics:** Barbiturates and Benzodiazepines. Anticonvulsants: Barbiturates, Oxazolidinediones, Succinimides, Phenacemide and Benzodiazepines.

Unit- 3

Psycotropic Drugs: The neuroleptics (Phenothiazines and butyrophenones), antidepressants (Monoamine oxidases inhibitors and Tricyclic antidepressants) and anti-anxiety agents (Benzodiazepines). **Central Nervous System Stimulants:** Strychnine, Purines, Phenylethylamine, analeptics, Indole ethylamine derivatives.

Unit- 4

Therapeutic Agents, SAR and Their mode of Action: Antineoplastic Agents: Cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer. Biological action of mechlorethamine, cyclophosphamide, melphalan, uracil,and 6-mercaptopurine.

Unit- 5

Cardiovascular Drugs: Antihypertensive and hypotensive drugs, antiarrrhythemic agents, vasopressor drug, Direct acting arteriolar dilators. Biological action of methyldopa, propranolol, amyl nitrate, verapamil, Atenolol.
Diuretics: Mercurial diuretic, Non mercurial diuretics (Thiazides, carbonic-anhydrase inhibitors, xanthine derivatives, pyrimidine diuretics and osmotic diureteics)

Books Recommended:

1. An Introduction to Medicinal Chemistry, Graham L. Patrick.
2. Medicinal Chemistry: Principles and Practice Edited by F.D. King.
3. Textbook of Organic Medicinal and Pharmaceutical Chemistry, Edited by Charles O. Wilson, et al.
4. Introduction to Medicinal Chemistry, Alex Gringuage.
5. Principles of Medicinal Chemistry, William O. Foye, Thomas L. Lemice and David A. Williams.
6. Introduction to Drug Design, S.S. Pandeya and J. R. Dimmock, New Age International.
7. Burger's Medicinal Chemistry and Drug Discovery, Vol-1 Ed. M.E. Wolff, John Wiley.
8. Goodman and Gilman's Pharmacological Basis of Therapeutics, Mc Graw-Hill.
9. The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic Press.
10. Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley.

Semester-III
(Course MIC-605)
Natural Products Practical

Course Objectives: The objective of this course is to provide the practical knowledge of the isolation of active component from natural sources and to know the concept of stepwise synthesis. To be acquainted with various combinations of reactions that can be exploited to form a product and to have experience to work under different reaction conditions.

Course Outcomes:

CO 1: Apply the knowledge of basis procedure of isolation for the isolation of active component from natural sources.
CO 2: Understand the concept of multistep synthesis under different reaction conditions.
CO 3: Develop the ability to compile interpreted information in the form of lab record.
CO 4: Able to interpret the structure of synthesized organic compound by applying the spectroscopic techniques.
CO 5: Know about how to defend viva-voce.

Time: 6 Hours/week **Credit: 3**
Syllabus **Max. Marks: 50**

1. Extraction of Organic Compounds from Natural Sources:
   a) Isolation of Caffeine from tea leaves.
   b) Casein from milk (the students are required to try some typical color reactions of proteins).
   c) Lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported).
   d) Isolation of diosgenin from Fenugreek seeds (Methi seeds).
   e) Lycopene from tomatoes and β- carotene from carrots.
2. Extraction of essential oils.
3. Determination of lactose in normal cow's milk.
4. **TLC and Paper Chromatography**: Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

Books Recommended:

1. Experiments and Techniques in Organic Chemistry, D.Pasto, C. Johnson and M.Miller, Prentice Hall.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C.Heath.
3. Systematic Qualitative Organic Analysis, H.Middleton, Adward Arnold.
4. Handbook of Organic Analysis-Qualitative and Quantitative, H.Clark, Adward Arnold.
5. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
6. Laboratory Experiments in Organic Chemistry, R. Adams, J. R. Johnson and C. F. Wilcox. The Macmillan Limited, London.

Semester-III
(Course MIC-606)
Agrochemical Chemistry Practical

Course Objectives: The Course is introduced to impart practical knowledge of the synthesis of some agrochemical, The course also provides some valuable insights about the analysis of pesticides, fertilisers in water and soil samples. It will enable the students to develop their experimental skills and also measure the extent of soil and water pollution.

Course Outcomes:

CO 1: Understand the mechanism and various method of synthesis of pesticides and fertilisers.
CO 2: Ability to use the various analytical techniques for the determination of agrochemicals.
CO 3: Knowledge of various agrochemical pollutants of soil and water and the of the analytical methods to monitor their concentration.
CO 4: Analyze the organic content of fertilizers and manures.

Time: 6 Hours/week **Credit: 3**
Syllabus **Max. Marks: 50**

A. Analysis of Pesticides:

1. To estimate amount of Copper from Copper Fungicides.
2. To estimate amount of sulphur from given Sulphur Fungicides.
3. Estimation of nitro group by stannous chloride method.
4. Estimation of Simazine by colorimetric method.
5. Estimation of Ziram by hydrolysis method.

B. Analysis of Fertilizers:

1. Determination of amount of Nitrogen from given fertilizer sample.
2. Estimation of Calcium from superphosphate sample.
3. Analysis of organic manures.
   a) Moisture content.
   b) Organic matter and ash content.
4. Determination of available NPK in soil and Fertilizer samples.
5. Determination the percentage of phosphorus present in terms of P_2O_5 from a fertilizer sample volumetrically.

C. Soil and Water Analysis:

1. Determination of salinity of given soil sample conductometrically.
2. Estimation of amount of phosphorous from given soil sample colorimetrically.
3. Determination of concentration of sulphate ions from water samples.
4. Determination of total Sulphur in soil sample.
5. Determination of apparent specific gravity or bulk density, particle density or true density of the soil, water holding capacity of the soil.
6. Analysis of chalcopyrite, magnetite and ilmenite.
7. Determination of fluoride in drinking water by spectrophotometry and ion selective electrodes.

D. Preparation of Agrochemicals:

1. 2- Naphthoxy acetic acid.
2. Chlorophenoxy acetic acid.
3. Maleic hydrazide.
4. Phthallyl hydrazide.
5. Dimethyl phthalate.
6. Coumarin.
7. Dithiocarbamate pesticides.

Books Recommended:

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.
6. Physicochemical Experiments, J. Rose.
7. Vogel's Text Book of Quantitative Chemical Analysis(5th Ed), G.H.Jeffrey, J.Bassette, J.Mendham and R.C.Denny, Longman, 1999.
8. Methods of pesticides analysis- U. S. SreeRamulu, Oxford- IBH

Semester-III
(Course MIC-607)
Organic Synthesis Practical

Course Objectives: The main objectives of the practical course are to understand the basics of quantitative analysis and application in analysis of functional groups in organic compounds. To understand the concept of stepwise synthesis of a product and their purification. To know the practical applicability of different types of organic reactions.

Course Outcomes:

CO 1: Apply the basic concepts of quantitative analysis to analyze the functional groups in organic compounds.
CO 2: Understand the concept of stepwise synthesis of a product and their purification.
CO 3: Perform experimentation and evaluate the results.
CO 4: Develop the ability to compile interpreted information in the form of lab record.
CO 5: Know about how to face viva-voce.

Time: 6 Hours/week **Credit: 3**
Syllabus **Max. Marks: 50**

A. **Quantitative Analysis:**
1. Determination of the percentage/ number of hydroxyl groups in an organic compound by acetylation method.
2. Estimation of amines/ phenols using bromate – bromide solution/ acetylation method.
3. Determination of iodine and sponification values of an oil sample.
4. Determination of DO, COD and BOD of water sample.

B. **Multistep Synthesis:**
1. Cannizzaro reaction: 4-chlorobenzaldehyde as substrate.
2. Benzilic Acid Rearrangement: Benzaldehyde → Benzoin →Benzil → Benzilic acid.
3. Hofmann bromamide Rearrangement: Phthalic anhydride→ Phthalimide→ Anthranilic acid
4. Beckmann Rearrangement: Benzene→ Benzophenone→ Benzophenone oxime →Benzanilide.
5. Skraup Synthesis: Preparation of quinoline from aniline.
6. Synthesis using Phase Transfer Catalysis: Alkylation of diethyl malonate or ethyl acetoacetate and an alkyl halide.
7. Synthesis of p- nitro aniline and any other reaction as per requirement.

C. **TLC and column chromatography.**
All the students must submit the recrystallised product along with yield, melting point and Rf valuefor all the stages of preparation.

Books Recommended:

1. Experiments and Techniques in Organic Chemistry, D.Pasto, C. Johnson and M.Miller, Prentice Hall.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C.Heath.
3. Systematic Qualitative Organic Analysis, H.Middleton, Adward Arnold.
4. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold.
5. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.

SEMESTER-IV

Semester-IV
(Course MIC-608)
Physical Chemistry

Course Objectives: The main objective of this course is to introduce the students towards the concept of colloidal state, quantum chemistry and photochemistry. The course will also help the students to understand the different theories of electrochemistry along with some basic concepts of statistical thermodynamics.

Course Outcomes:

CO 1: Know about the colloidal state of the matter and various electrical properties of colloids. Explain various terms and concepts used in statistical thermodynamics.
CO 2: Understand the basics of quantum chemistry and their use in solving various problems.
CO 3: Know about the various photophysical processes and their kinetics.
CO 4: Know about the various theories and laws of electrochemistry.
CO 5: Use of concepts of statistical thermodynamics to derive various expressions and equations.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Lectures: 60 **Credit: 4**
Syllabus **Max. Marks (Theory): 80**
(IA): 20

Unit- 1

Colloidal State: Classification of colloids, charge and stability of colloidal dispersions, Hardy-Schulze Law, gold number, electrical properties of colloids, electrical double layer and its structure, Stern's theory of double layer, zeta-potential, electrophoresis and electro-osmosis, emulsions and their classification, emulsifiers, gels and their classification.

Unit- 2

Operators in quantum mechanics: Introduction to angular momentum, Eignvalues and eignfunctions, Hermitian operator, Postulates of quantum mechanics, Time dependent and time independent Schrodinger wave equations, Some analytically soluble problems (complete solutions) of particle in a one and three dimensional box, harmonic – oscillator, the rigid rotor, the hydrogen atom and the quantum mechanical tunnelling.

Unit- 3

Photochemistry: Photophysical processes of electronically excited molecules (Jablonski Diagram), Franck-Condon principle, Kinetics of Excimer and exciplex formation, Energy transfer from electronically excited molecules (Stern – Volmer mechanism), E- type and P- type delayed fluorescence.

Unit- 4

Electrochemistry: Quantitative treatment of Debye - Hückel and Debye-Hückel-Onsagar (D-H-O) theory of conductance of electrolyte solution their limitations and modifications, Pair-wise association of ions (Bjerrum and Fuoss treatment), Determination of association constant (KA) from Debye – Huckel Limiting Law, Extended Debye – Huckel Law, Qualitative treatment of ion – solvent interactions (ion solvation).

Unit- 5

Statistical Thermodynamics: Basic Terminology: probability, phase space, micro and macro states, thermodynamic probability, statistical weight, assembly, ensemble, The most probable distribution: Maxwell-Boltzmann distribution, quantum statistics: The Bose- Einstein statistics and Fermi- Dirac Statistics, Thermodynamic probability (W) for the three types of statistics, Lagrange's undetermined multipliers, Stirling's approximation, Molecular partition function and its importance.

Books Recommended:

1. Physical Chemistry of Surfaces: A.W. Admson
2. Foundation of Colloid Science Vol. I and II: R.J. Hunter
3. Physical Chemistry: P.W. Atkins
4. Principal of Physical Chemistry: P.S. Pathania

Semester-IV
(Course MIC-609)
Fuel and Energy Technology

Course Objectives: The course will cover energy resources and their role in modern society, with both national and global perspectives. The present and future impacts of nuclear and fossil fuels on the environment will be explored. Energy technologies and use of solar, wind, hydro, fuel cells and biomass energy resources will be introduced, and the relationship between public policy and resource usage will be discussed.

Course Outcomes:

CO 1: Apply energy conversion device principle and evaluate their operation and performance.
CO 2: Identify the working principle of different resources of energy.
CO 3: Understand the basic chemistry of fuel cell, nuclear and hydrogen fuels.
CO 4: Working principle of alternate energy sources like solar and wind energy.
CO 5: Knowledge of the other sources of energy such as biomass energy and ocean energy.

Note: *(i)* ***TEN*** *questions will be set by the examiner selecting* ***TWO*** *from each unit. As far as possible every question will be divided into* ***Two -Three Parts****. The students shall attempt* ***FIVE*** *questions selecting* ***ONE*** *from each unit.*

Credit: 4
Lectures: 60
Max. Marks (Theory): 80
Syllabus
(IA): 20

Unit-1 Fuels

Types and properties of solid, liquid and gaseous fuels; Solid Fuels: Origin, classification and analysis of coal; gasification; oxidation; hydrogenation and liquefaction of coal; solid fuel handling and storage. Liquid Fuels: Origin and classification and properties of petroleum, liquid fuels from other sources; storage and handling of liquid fuels. Gaseous Fuels: Natural gases, methane from coal mines, manufactured gases, producer gas, water gas, refinery gas, LPG; cleaning, purification and handling of gaseous fuel compounds.

Unit-2 Fuel Cells and Fuels

Fuel Cell: Basics, difference between batteries and fuel cells, components of fuel cells, principle of working of fuel cell, performance characteristics of fuel cells, fuel cell types: alkaline fuel cell, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, problems with fuel cells, applications of fuel cells.

Nuclear Fuel: Basic principles, elements of nuclear power plant, nuclear reactor and fuels, advantage and disadvantages of nuclear power plants.

Hydrogen Fuel: Its merit as a fuel; production, applications and storage methods

Unit-3 Renewable Energy Sources and Devices

Solar Energy: solar collectors, solar energy storage system, solar photovoltaic cell, solar hydrogen energy, solar pumps, heaters, dryers, cookers and refrigerators.

Wind Energy: Basic principle and conversions, site selection, wind mills, application and safety system, environmental aspects, wind energy conversion system.

Unit-4 Energy from Biomass

Introduction, Biomass energy, Photosynthesis process, Biomass fuels, Biomass Gasification, Types and application of gasifier, Biomass to Ethanol Production, Biogas production from waste biomass, Types of biogas plants, Factors affecting biogas generation, Energy farming.

Unit-5 Geothermal and Ocean Energy

Geothermal energy: Introduction, origin and distribution of geothermal energy, Types and analysis of geothermal resources, Applications of geothermal energy. Tidal energy, origin and nature of tidal energy and its limitations, Ocean Wave Energy: wave energy conversion devices, ocean thermal energy, Principles of ocean thermal energy conversion OTEC.

Books Recommended:

1. Robert Curley, Fossil Fuels (Energy: Past, Present, and Future) Rosen Education Service, 2011.
2. Julie Richards, Fossil Fuels Benchmark Books, 2009.
3. Andrew Solway,Hydrogen Fuel (Energy for the Future and Global Warming), Gareth Stevens Publishing, 2007.
4. Christopher A. Simon, Lanham, Maryland, Alternative Energy: Political, Economic, and Social Feasibility Maryland: Rowman & Littlefield, 2006.
5. Ghazi A. Karim,Fuels, Energy, and the Environment, CRC Press, 2012.
6. S. Basheer Ahmed,Nuclear Fuel and Energy Policy, 1979.
7. Donald L. Klass,Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, 1998.
8. Steven Seidenberg, Gareth Stevens, Fuel and Energy, 1992
9. R Luque, J Campelo and J Clark, Handbook of Biofuels Production: Processes and Technologies Edited, Woodhead Publishing, 2010.

Semester-IV
(Course MIC-610)
IPR, Quality Control and Assurance

Course Objectives: The main objective of the course is to introduce the fundamental aspects of Intellectual property Rights to students who are going to play a major role in development and management of innovative projects in industries and Research. To disseminate knowledge on patents, patent regime in India and abroad and registration aspects. To disseminate knowledge on copyrights and its related rights and registration aspects and to aware about current trends in IPR and Govt. steps in fostering IPR and case studies.

Course Outcomes:

CO 1: Provide adequate knowledge on patent and copyright for their innovative research works.
CO 2: Pave the way for the students to catch up Intellectual Property(IP) as a career option.
CO 3: Create a foundational understanding of copyrights and trademarks and their registration process.
CO 4: Use the concepts of quality control and quality assurance to maintain uniform standards of industrial products.

*Note: (i) **TEN** questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two -Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.*

Lectures: 45 **Credit: 3**
Max. Marks (Theory): 40
Syllabus **(IA): 10**

Unit-1

Concept and fundamentals of IPR, need and economic importance of IPR, detail description of various IP Properties (Patents, Trademarks, Copyrights, Geographical Indications Industrial Designs and Trade secrets), IPR with emphasis on patent regime, factors affecting IP protection, penalties for violation or infringement, trade related aspects of IPR, concepts behind World Trade Organization (WTO), General Agreement on Tariffs and Trade (GATT), General Agreement on Trade in Services(GATS), Trade-Related Aspects of Intellectual Property Rights (TRIPS), Trade-Related Investment Measures (TRIMs).

Unit-II

Patents and DraftingPatents - Elements of Patentability: Novelty , Non Obviousness (Inventive Steps), Industrial Application - Non - Patentable Subject Matter -Registration Procedure.
Government standards like Agmark, Bureau of Indian Standards (BIS) Hallmark, Indian Standards Index (ISI), Indian Pharmacopoeia (IP), an introduction to International Organization for Standardization (ISO), US Food and Drug Administration (USFDA), ICH Guidelines, Food and Agriculture Organization (FAO), Food Safety and Standards Authority of India (FSSAI).

Unit-III

Nature of Copyright - Subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound recordings - Registration Procedure, Term of protection, Filing and Drafting the Copyrights.
Trademarks and Trading licencesConcept of Trademarks - Different kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks) - Non Registrable Trademarks - Registration of Trademarks -Trading licence importance of exports and imports in trading.

Unit-IV

Concept of quality and quality control, nature of variability's, design of QC laboratory for chemical, instrumental and microbiological laboratories, standardization of reagents, labeling of reagents, control samples, data generation and storage, QC documentation, LIMS sampling techniques, sampling plans, steps to improve quality with reference to ISO and total quality management (TQM), total quality control (TQC), six sigma, preparation of control charts, sampling, inspection, cost reduction & quality improvement.

Unit-V

Concepts of quality assurance (QA), philosophy of GMP and cGMP, preparation of audit, conducting audit, audit analysis, audit report and audit follow up, premises: location, design, plant layout, construction, maintenance of sterilized areas, control of contamination.

Books Recommended:

1. Rimmer, M. (2008). Intellectual property and biotechnology: biological inventions. Edward Elgar Publishing.
2. Nithyananda, K V. (2019). Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited.

3. Neeraj, P., &Khusdeep, D. (2014). Intellectual Property Rights. India, IN: PHI learning Private Limited.
4. Subramanian, N., &Sundararaman, M. (2018). Intellectual Property Rights – An Overview. Retrieved from http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf
5. World Intellectual Property Organisation. (2004). WIPO Intellectual property Handbook. Retrieved from https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf
6. Ramakrishna, Basic principles and acquisition of Intellectual Property Rights, CIPRA, NSLIU 2005.
7. T Ramakrishna, Ownership and Enforcement of Intellectual Property Right, CIPRA, NSLIU-2005.
8. B. L.Wadhera, Intellectual Property Law Handbook, Universal Law Publishing Co. Ltd. 2002.
9. P.M. Bhandari, Handbook of Small Scale Industry.
10. The Trade marks Act 1999 (Bare Act with short comments)-Universal Law Publishing Co. Ltd. 2005.
11. The Patents Act, 1970 (Bare Act with short comments) - as amended by Patents (Amendment) Rules2006 w.e.f. 5-5-2006. Commercial law publishers (India) Pvt. Ltd. 2006.
12. Thomas T Gordon and Arthur S Cookfair, Patent Fundamentals for Scientist and Engineers, CRC Press.

Semester-IV
(Course MIC-611)
Industrial Training and Project Report

Course Objectives: The main objective of the course is to introduce the students to industrial environment. To attain certain skill regarding the work in industries and also to obtain work experience.

Course Outcomes:

CO 1: Get familiar with the work environmental in different industries
CO 2: Understand the working of different instruments/apparatus in industries.
CO 3: Apply the knowledge of previous courses to work in a specific industry and prepare a detailed report on the work.
CO 4: Get work experience certificate on a specific project from the industry.

Time: 3 months **Credit: 10**

Syllabus **Max. Marks: 250**

Each candidate has to undergo three months of industrial training and produce a detailed project report on the work performed by him/her in the industry.

Semester-IV
(Course MIC-612)
Seminar

Time: 30 min **Credit: 4**

Syllabus **Max. Marks: 50**

Every candidate will have to deliver a seminar of 20-30 minutes duration on the project work performed in industry which will be chosen by him / her in consultation with the teacher of the department. The seminar will be delivered before the students and teachers of the department. A three member committee (one coordinator and two teachers) duly approved by the departmental council will be constituted to evaluate the seminar. The following factors will be taken into consideration while evaluating the candidate.

(i) Content
(ii) Expression
(iii) Presentation
(iv) Depth of the subject matter and answers to the questions.