Department of Applied Chemistry
Institute of Technology
Banaras Hindu University

COURSE STRUCTURE & SYLLABUS OF

FIVE YEAR INTEGRATED

M.TECH. (INDUSTRIAL CHEMISTRY)

Department of Applied Chemistry
Institute of Technology
Banaras Hindu University

Proposed course structure for Five Year Integrated M. Tech. (Industrial Chemistry).

First Year

I – Semester:

Subjects		Contact Hrs./ Week	Credit
Theory:			
Same as B. Tech. Part – I (1st Semester)		17	17
Practicals:			
Same as B. Tech. Part – I (1st Semester)		12	8
	Total	29	25

II – Semester:

Subjects		Contact Hrs./ Week	Credit
Theory:			
Same as B. Tech. Part – I (2nd Semester)		20	20
Practicals:			
Same as B. Tech. Part – I (2nd Semester)		9	6
	Total	29	26

Second Year

III – Semester:

Subjects	Contact Hrs./ Week	Credit
Theory:		
AC-2101: Chemistry of Polymers	03	03
AC-2102: Reaction Kinetics	03	03
AP-2102: Quantum Mechanics	03	03
AM-2101: Mathematical Methods	03	03
EC-2110 A: Electronics & Instrumentation	03	03
MS-2101: Introduction to Materials Science	03	03
Practicals:		
AP-2301: Physics Lab	3	2
AC-2301: Chemistry Lab	3	2
AM-2301: Computer Lab	3	2
Total	27	24

IV – Semester:

Subjects	Contact Hrs./ Week	Credit
Theory:		
AC-2201: Chemical Thermodynamics	03	03
AC-2202: Chemistry of Main Group Elements	03	03
AP-2203: Electromagnetic Theory & Wave Guides	03	03
AM-2201: Numerical Analysis	03	03
EE-2201 A: Electrical Engineering	03	03
CH-2203: Mass Transfer Operations-1	04	04
Practicals:		
AP-2401: Physics Lab	3	2
AC-2401: Chemistry Lab	3	2
AM-2401: Computer Lab	3	2
Total	28	25

Third Year

V – Semester:

Subjects	Contact Hrs./ Week	Credit
Theory:		
AC-3101: Stereo-Chemistry and Mechanism in Organic Chemistry	03	03
AC-3102: Analytical Techniques in Chemistry	03	03
AC-3103: Environmental Chemistry	03	03
AC-3104: Chemistry of Transition & Inner Transition Elements	03	03
MS-3105: Crystallography & Crystal Structure	03	03
MS-3106: Synthesis and Preparation of Materials	03	03
Practical:		
AC-3301: Chemistry Lab.	03	02
AC-3302: Chemistry Lab	03	02
AC-3303: Chemistry Lab	03	02
Total	27	24

VI – Semester:

Subjects	Contact Hrs./ Week	Credit
Theory:		
HU 320x: Humanities* (open elective)	03	03
AC-3201: Instrumental Methods of Chemical Analysis	03	03
AC-3202: Industrial Organic & Inorganic Chemistry	03	03
AC-3203: Nuclear and Radiation Chemistry	03	03
AC-3204: Statistical Thermodynamics	03	03
CH-3202: New Separation Processes	03	03
Practical:		
AC-3401: Chemistry Lab	03	02
AC-3402: Chemistry Lab	03	02
AC-3403: Chemistry Lab	03	02
Total	27	24

*** Any one of the following**

HU-3201 History of Science & Technology
HU-3202 Industrial & Organizational Psychology
HU-3203 Intellectual Property Rights
HU-3204 Energy Management
HU-3205 Industrial Sociology
HU-3206 Ethics Philosophy & Values
HU-3207 Entrepreneurship Development

♦**Summer Practical Training – 6 weeks duration**

Fourth Year

VII – Semester:

Subjects	Contact Hrs./ Week	Credit
Theory:		
AC-4101: Chemical Sensors	03	03
AC-4102: Corrosion	03	03
AC-4103: Chemistry of Heterocyclic Compounds	03	03
MS-4114: Materials Characterization	03	03
MS-4115: Industrial Polymers	03	03
CH-5103: Chemical Reactor Analysis	03	03
Practical:		
AC-4301: Chemistry Lab	03	02
AC-4302: Chemistry Lab	03	02
Seminar/ Group Discussion	03	02
Summer Practical Training Evaluation	-	02
Total	27	26

VIII – Semester:

Subjects	Contact Hrs./ Week	Credit
Theory:		
AC-4201: Computational Techniques for Molecular Simulation	03	03
AC-4202: Industrial Waste Management	03	03
AC-4203: Chemistry of Coordination Compounds	03	03
AC-4204: Organic Synthetic Methods	03	03
*Any one of the courses mentioned below:	03	03
Practical:		
AC-4401: Chemistry Lab	03	02
AC-4402: Chemistry Lab	03	02
Project	06	04
Total	27	24

* 1. CH-5219 Design and Development of Heterogeneous Catalysts.
2. CH-5223 Fuel Cell Technology
3. PH-5222 Pharmaceutical Chemistry IV (Drug Design)
4. BC-5215 Advanced Fermentation Technology

Fifth Year

IX – Semester:

Subjects	Contact Hrs./ Week	Credit
Theory:		
AC-5101: Cheminformatics	03	03
AC-5102: Photochemistry	03	03
Electives – I, II, III	09	09
PG Practical		
AC-5301 Chemistry Lab	03	02
Dissertation interim evaluation	09	05
Seminar on Dissertation	-	05
Total	27	27

List of Electives (Electives I, II, III)

1. AC-5103 Metal Clusters
2. AC-5104 Biosensors
3. AC-5105 Bioremediation
4. AC-5106 Corrosion Inhibitors
5. AC-5107 Spectroscopic Identification of Organic Compounds
6. AC-5108 Solid State Chemistry
7. AC-5109 Chemistry of Electronic Ceramics
8. AC-5110 Advanced Treatment Processes for Water & waste Water
9. CH-5114 Membrane Separation Processes
10. CH-5115 Interfacial and Colloidal Phenomena
11. CH-5116 Multicomponent Separation
12. BC-5101 Microbiological Engineering
13. BC-5102 Fundamentals of Microbiology and Biochemistry
14. BC-5114 Enzyme Engineering and Technology
15. MS-5116/ MS-5215 Nanomaterials and Nanostructures
16. MS-5109/ MS-5208 Advanced Polymers

X – Semester:

Subjects	Contact Hrs./ Week	Credit
PG Seminar	02	01
Dissertation evaluation	-	10
Dissertation open defense	-	05
Total	-	16

AC-2101 Chemistry of Polymers

Introduction- Definition, classification, mechanism of polymerization, addition polymerization, condensation polymerization, thermosetting, thermoplastic polymers. Chemical geometrical structures, glass transition temperature crystallinity of polymers. Chemistry of selected organic polymers, Chemistry of selected inorganic polymers, polymer degradation mechanisms, polymer reactions, polymer processing, molecular weight & size of polymer dissolution, thermodynamics of polymers, Florry Huggin theory, viscosity of polymer solution, size and shape of polymers.

Recommended Books:

1. R.B. Seymour, C.E. Carraher, E. Charles, Marcel Dekker: Polymer Chemistry: An Introduction, New York.
2. P. Bahadur & N.V. Shastry: Principle of Polymer Science, Narosa Publishing House, New Delhi.
3. V.R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar: Polymer Science, Halsted Press, John Wiley & Sons, New york.
4. George Odian: Principles of Polymerization, John Wiley & Sons. 4th Ed.
5. B. Vollmert: Polymer Chemistry, Springer-Verlag, Berlin.

AC-2102 Reaction Kinetics

Fundamental aspects of Reaction Kinetics, Collision and Transition state theories of reactions rates. Kinetics and mechanisms of homogeneous and heterogeneous catalytic reactions. Kinetics of electrochemical reactions with special reference to hydrogen evolution reaction and electrodeposition.

Complex reactions; Mechanism of complex reaction, derivation of differential rate equations, steady state and rate limiting approximations as applied for complex reactions, fast reactions, techniques for study of fast reactions. Explosion reactions. Ionic chain reactions; Mechanism of ionic chain reactions and their kinetics. Kinetic treatment of diffusion in solids, liquids and solutions.

Recommended Books:

1. K.J. Laidler: Chemical Kinetics, 3rd Ed. Pearson Education Inc.
2. J. Rajaram, J.C. Kuriacose: Kinetics and Mechanisms of Chemical Transformations, McMillan. India Ltd.
3 S.K. Upadhayay: Chemical Kinetics and Reaction Dynamics, Anamaya Publishers, New Delhi
4. J.O'M. Bockris and A.K.N. Reddy: Modern Electrochemistry Vol II, Plenum Press, New York.

AP- 2102 Quantum Mechanics

Foundation and formulation of quantum theory, Schrödinger equation, potential well, Kronig Penny model, Angular momentum, Two and three dimensional problems, Degeneracy, Central potentials, Hydrogen atom, Identical particles, Symmetric and Antisymmetric States. Helium atom, Schrödinger and Heisnberg pictures, Canonical commutations.

Approximation methods for bound states, WKB approximation, Time- independent and Time- dependent perturbation theory, Scattering theory.

AM – 2101 Mathematical Mathods

Solutions in series, Bessel function and Legendre function: Self – adjoint differential equations, Power series method of solving second order differential equation, Bessel's functions of first kind $J_n(x)$ and second kind $Y_n(x)$, Recurrence relations, Generating functions of $J_n(x)$, Orthogonal property of Bessel functions, Legendre's equation, Legendre polynomials $P_n(x)$, Rodrigues formula, Generating function of $P_n(x)$, Orthogonal property of $P_n(x)$, Sturm-Liouville problem.

Integral Transform: Laplace transform and its properties, Inverse Laplace Transform. Use of partial fractions, Convolution theorem. Applications in solving differential equations. Fourier transform and its properties. Inverse Fourier Transform. Convolution theorem. Application of Fourier Transform in solving initial and boundary value problems. Laplace equation. Heat equation and Wave equation.

Probability and Statistics: Probability: definitions, addition and multiplication laws, Baye's Theorem. Random variables Discrete and continuous probability distributions. Binomial, Possion, normal and exponential distributions, mean variance moment Generating function, Characteristic function of a probability distribution. Joint probability distribution of two random variables. Linear regression and correlation analysis.

Recommended Books:

1. E. Kreyszig: Advanced Engineering Mathematics John Wiley & Sons.
2. R. K. Jain, S.R.K. Iyenger: Advanced Engineering Mathematics Narosa Publishing.
3. Irwin Miller and John E. Freund: Probability and Statistics for Engineers, Prentice Hall of India.

EC- 2110 A: Electronics and Instrumentation

Semiconductor diode characteristics; Load lime; Half wave and full wave rectifiers; Filters.

Power supply; Regulators (723).

Amplifying devices (BJT, FET) and their characteristic with LF equivalent circuits.

Single stage and multi stage RC coupled amplifiers (including types of coupling); Calculation of voltage gain; Impedance; Frequency response; Feedback; High input impedance circuits.

Oscillators.

Operational amplifiers and its application; Filters; V.C.O. and PLL.

Timer and applications to systems.

Logic gates and basic logic circuits (SSI, MSI and basis systems ICs).

Transducers.

Cathode ray oscilloscope and multimeters (Analogue and digital).

A/D and D/A for instrumentation.

MS -2101 : Introduction to Materials Science

Classification of engineering materials and their applications : Metals and alloys, Ceramics and glasses, Polymers, Composites and Novel Materials. Price and availability of materials. Processing of engineering materials.

Chemical bonding and properties of materials: Mechanical, Electrical, Magnetic, Optical, Thermal; Oxidation and degradation behaviour of engineering materials.
Levels of structure: Nuclear structure, Crystal structure, Nanostructure, Microstructure and Macrostructure. Processing – structure – property correlations.

Recommended Books:

1. W.D. Callister. Jr.: Materials Science & Engineering : An Introduction.
2. K.G Budinski, M.K. Budinski: Engineering Materials: Properties & Selection.
3. D.R. Askeland: The Science and Engineering of Materials.
4. V. Raghavan: Materials Science and Engineering,.
5. Ashby and D.R.H. Jones: Engineering Materials Part 1 & 2.
6. Richard Tilley: Understanding Solids.
7. R. E. Newnham: Properties of Materials.

AC – 2201 Chemical Thermodynamics

An overview of the First and Second Laws of Thermodynamics. The Third Law of Thermodynamics. Unattainability of Absolute Zero. Fundamental equations of Thermodynamics. Partial molar quantities. Thermodynamic potentials. Material equilibrium. Chemical potential and material equilibrium. Phase and reaction equilibria.
Real gases. Real-gas equations of state. Critical state. The law of corresponding states. Non-ideal gas mixtures, fugacity and fugacity coefficient.
Real solutions. Activities and activity coefficients. Determination of activities and activity coefficients. Gibbs-Duhem equation. Reaction equilibrium in non-ideal systems.
The Clapeyron equation. Solid-solid phase transitions. Higher order phase transitions. Two-component phase diagrams. Thermodynamics of surfaces. Gibbs' adsorption equation.
Bio-chemical Thermodynamics.

Recommended Books:

1. Ira N. Levine: Physical Chemistry, Tata McGraw Hill.
2. G.W. Castellan: Physical Chemistry, Narosa Publishing House.
3. P.W. Atkins: Physical Chemistry, Oxford University Press2.
4. R. A. Alberty and R.J. Silbey: Physical Chemistry, John Wiley & Sons.

AC – 2202 The Chemistry of Main Group Elements

General chemistry of non-transition elements, stereochemistry and bonding in elements and their compounds namely hydrides, halides, oxides, peroxides, superoxides, suboxides, hydroxides, oxoacids, organic and organometallic compounds and coordination complexes, etc. Inorganic chains, rings and cages. Role of non-transition elements in biological processes. Bio-inorganic chemistry of sodium, potassium, magnesium and calcium.

Recommended Books:

1. F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann: Advanced

Inorganic Chemistry, John Wiley, 6th Ed.
2. D.F. Shriver, P.W. Atkins and C. H. Langford: Inorganic Chemistry, Oxford University Press 3rd Edn.
3. N.N. Greenwood and E.A Earnshaw: Chemistry of Elements, Pergamon Press .
4. S.J Lippard & J.M Berg: Principles of Bio-inorganic Chemistry, University Science Books, Mill Valley.
5. I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentime: Bio-inorganic Chemistry, Univ. Sci. Books, Mill Valley.
6. R.W. Hay : Bio-Inorganic Chemistry, Ellis Hollwood ltd.

AP- 2203 Electromagnetic Theory and Wave Guides

Electrostatics, Boundary value problems, Dielectrics, Steady currents, Magnetostatics, Time-varying fields; Maxwell equations, Lorentz force equation and motion of charges, Plane electromagnetic waves.
Wave guides and resonant cavities: Fields at the surface of and within a conductor, cylindrical cavities and wave guides, perturbation of boundary conditions, resonant cavities, power losses in a cavity, Earth and ionosphere cavity, dielectric wave guide.

AM – 2201 : Numerical Analysis

Errors and their estimation.
Interpolation: Finite differences; Newton's forward and backward interpolation formula; Lagrange's formula; Central differences; Formula of Gauss, Bessel and Everett curve fitting: Method of least squares; Cubic splines.
Solution of algebraic and transcendental equations: Iterative methods, Newton-Raphson method, convergence and efficiency of method.
Matrices: Eigen value and eigen vectors, matrix decomposition, inverse of matrix, norm of matrix.
Solution of System of Linear equations: Direct methods: Gauss elimination method, LU – Decomposition, Cholesky method, iteration methods: Jacobi method, Gauss-Seidel method; Ill conditioned systems.
Numerical integration and differentiation.
Numerical solution of ordinary differential equations: Euler method, Modified Euler method and Runge-Kutta method.
Finite difference method for solution of boundary value problems of ordinary and partial differential equations.

Recommended Books:

1. S. S. Sastry: Numerical Analysis, Prentice Hall of India Pvt. Ltd., New delhi.
2. M. K. Jain; Numerical Methods for Scientists and Engineers *et. al.*, New Age International Publishers, New Delhi.

EE - 2201A Electrical Engineering

Electrical Circuits: Network element- Voltage and current sources, Kirchchoff's voltage and current law, loop and nodal analysis, Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum Power Transfer theorem. Sinusoidal Steady State analysis- R L and C elements, power and power factor,

phasor diagram, resonance, Mutual inductance and coefficient of coupling. Three-phase circuits- Line and Phase relationship, Power measurement.
Electrical Machines: Transformer- Principle of working, EMF equation, Equivalent circuit, voltage regulation and efficiency, Open-circuit and short-circuit tests, autotransformer. DC Machines- Constructional features, DC Generators- No load Magnetization and external characteristic. DC motor- starting, speed-torque characteristic, speed control, applications. Induction Machines- Principle of operation, constructional details, torque-slip characteristic, starting and speed control. Synchronous Machines- Constructional features. Alternators- Voltage regulation and its determination by synchronous impedance method. Synchronous Motor- Starting, V and Inverted-V curves, Applications.
Distribution of Electrical Power: Tariff calculation. House and factory wiring.
Introduction to Electrical Measurements: Indicating instruments, voltmeter, ammeter, wattmeter and energy meter.

CH - 2203: Mass Transfer Operations - I

Molecular and eddy diffusion; Mass transfer flux and rate; Diffusivity of gases and liquids.

Interphase mass transfer: Individual and overall mass transfer coefficients; Stagnant film, penetration and surface renewal models; Wetted-wall columns.

Gas-liquid contactors: Sparged vessels; Mechanically agitated vessels; Plate columns; Packed columns.

Gas absorption and stripping: Equilibrium relations; Operating lines; Absorption factor, HETP; Plate efficiency; Design of plate and packed columns.

Humidification and dehumidification operations; Design of cooling towers.

Drying: Internal flow of moisture; Surface evaporation and shrinkage; Drying rates; Batch and continuous driers.

Crystallization: Nucleation and crystal growth; Controlled growth of crystals; Industrial crystallizers.

AC-3101 Streochemistry & Mechanism in Organic Chemistry

Specific rotation and its measurement, molecular dissymmetry, optical isomerism due to one and two asymmetric carbon atoms, racemic modifications. Reactive Intermediates: carbocations, carbanions, free radicals, carbenes and nitrenes. Methods of determining reaction mechanisms. Nucleophilic and electrophilic substitution reactions. Free radical reactions, addition to carbon-carbon and carbon-hetero multiple bonds. Elimination reactions

Recommended Books:

1. Jerry March: Advanced Organic Chemistry Reactions, Mechanism and structure, John Wiley.
2. E. Eliel: Streochemistry of Carbon Compounds, John Wiley.
3. S.M. Mukherji and S. P. Singh: Reaction Mechanism in Organic Chemistry, Macmillan.

AC-3102 Analytical Techniques in Chemistry

Basic concept of Analytical Chemistry and its application in chemical analysis. Statistical methods of data analysis. Industrial chemical analysis. Signal processing: analog and digital. Sensitivity, detection limit, resolution, dynamic range, selectivity in analysis.

Electroanalytical Chemistry: Charge transfer at the electrode-solution interface, polarizable and non-polarizable electrodes, Introduction to voltammetry, Diffusion current, cyclic voltammetry, Potential programs used in Electroanalysis, Surface modified electrodes, Bioelectrochemistry. Use of dropping mercury electrode in metal ion analysis, ion selective electrodes and their applications.

Recommended Books:

1. Skoog, West, and Harris: Analytical Chemistry: An Introduction, Saunders College Publishing , 7th Edition.
2. Skoog, Holler and Nieman: Principles of Instrumental Analysis, Fifth Edition,. Brooks/Cole-Thompson Learning Publishers.
3. Vogel's Quantitative Chemical Analysis, 6th Edition.
4. Kenneth A. Rubinson: Contemporary Instrumental Analysis, Culinary and Hospitality Industry Publications Services.
5. Allen J. Bard, Larry R. Faulkner: Electrochemical Methods: Fundamentals and Applications, 2nd Edition.

AC-3103: Environmental Chemistry :

Components and segments of environment.
Atmospheric Chemistry: Composition and segments of atmosphere and their significance, classification of air pollutants, sources, pathway and fate of air pollutants. Vehicular emission and their associated effects; Air pollution control technology and ambient air quality.
Aquatic Chemistry: Water resources, Chemistry of natural water, water quality parameters and standards, Potability of water, various types of water pollutants and their detrimental effects, nutrient enrichment and its effect, water quality assessment, Chemical principles underlying municipal, industrial and wastewater treatments.
Chemical Toxicology: Toxic chemicals in environment, ecological concept of toxicity, impact of toxic chemicals and biochemical effects of trace metals, pesticides, ozone and some other organic compounds (carcinogens).
Environmental Chemical Analysis: Sampling and analysis of various air and water pollutants; Estimation of BOD, COD and TOC in wastewater. Methods of analysis of air and water pollutants.

Recommended Books:

1. S.E. Manahan: Environmental Chemistry, CRC Press, USA, 6th Ed.
2. M.L. Davis & D.A. Cornwall: An Introduction to Environmental Engineering PWS Engineering. Boston.
3. M.C. Das & P.C. Mishra: Man & Environment, McMillan India Ltd.
4. G.M.Masters: Introduction to Environmental Engineering. & Science, Prentice-Hall, 2nd Ed.
5. A.K. De: Environmental Chemistry, New Age International (P) Ltd., 5th Ed.

6. J. Helichlen: Atmospheric Chemistry, Academic Press, New York.

AC-3104 The Chemistry of The Transition and Inner Transition Elements

General chemistry of the elements of the first, second and third transition series, lanthanides and actinides with special reference to their organometallic and coordination compounds. Transition metal clusters, polymetallates and heteropolymetallates. Homogeneous and heterogeneous catalytic synthesis of organic chemicals by transition metal complexes. Bio-inorganic chemistry of transition metal ions in general and that of iron, cobalt, copper, zinc and molybdenum in particular. Structural and functional characteristics of some important biomolecules.

Recommended Books:

1. J.E. Huheey , E. Keiter: Inorganic Chemistry, Harper Collins College Publisher, 4th Edition.
2. C. Elschenbroich & A. Salzer: Organometallics, Wiley, VCH, 2nd Edition.
3. G.O. Spessard, G.L. Miessler: Organometallic Chemistry, Prentice Hall.
4. A.B.P. Lever: Inorganic Electronic Spectroscopy, Elsevier.
5. F.A. Cotton, G. Wilkinson, C.A. Murillo & M. Bochmann: Advanced Inorganic Chemistry, John Wiley, 6th Ed.
6. N.N Greenwood & E.A. Earnshow: Chemistry of Elements, Pergamon Press.

MS – 3105 Crystallography and Crystal Structure

Bonding and cohesive energy. Crystalline and non crystalline materials. Point group symmetries in crystals. Bravais lattices. Miller and Miller-Bravais indices. Space group and space group symmetries. Quasiperiodic lattices.
Close packing of spheres. Structure of common metals, alloys, ionic, covalent and molecular crystals, Fullerenes and high temperature superconductors.
Production and properties of x-rays: Continuous and characteristic spectrum. Absorption edges and x-ray filters. X-ray sealed tube and rotating anode generators. Synchrotron sources of x-rays. X-rays monochromators. Line and area detectors.
Interaction of x-rays with matter. Laue equations. Bragg's law. Reciprocal lattice concept and its applications to rotation, Laue and Debye Scherrer techniques. Powder diffractometry. Indexing of powder diffraction patterns.
Atomic scattering factor and structure factor. Lattice and space group extinctions. Phase problem and determination of crystal structures.
Elementary ideas about electron and neutron diffraction.

Recommended Books:

1. L.V. Azaroff: Elements of X-ray crystallography.
2. B.E. Warren: X-ray diffraction.
3. A.R. Verma and O.N. Srivastava: Crystallography applied to solid state physics.
4. C. Giacovazzo: Fundamentals of crystallography.

MS - 3106 Synthesis and Preparation of Materials

Ceramic powder synthesis methods: Solid state reaction method. Chemical routes: coprecipitation, spray drying, freeze drying, sol-gel method, hydrothermal and combustion. Microwave synthesis.
Characterzation of powders: Size and surface area.
Green Body Forming: dry pressing, slip and tape casting, extrusion, injection molding and sol-gel. Sintering. Hot pressing. Microwave sintering. Powder coating, flame and plasma spraying. Electrodeposition.
Polymer Synthesis: Types of synthesis: free radical, addition, condensation suspension polymerization, emulsion, ionic polymerization, copolymerization, block copolymer, grafting.
Thin film preparations: Epitaxial, grain oriented and polycrystalline thin films. Fundamentals of vacuum instruments. Thermal and electron beam evaporation. Sputtering methods: DC, RF and Magnetron. Laser ablation. Chemical vapour deposition. MOCVD. Electro-deposition. Molecular beam epitaxy. Spin coating.
Crystal growth techniques: Bridgman, Stockbarger and Czochralski techniques. Aqueous solution growth. Hydrothermal growth. Molten salt growth. Vapour phase growth.

Recommended Books:

1. G. Odian: Principles of Polymerization.
2. Maisel: Hand book of thin films.
3. A. Goswami: Thin Film.
4. David W. Richerson: Modern Ceramic Engineering.
5. M.N. Rahman: Ceramic Processing and Sintering.
6. James S. Reed: Principles of Ceramic Processing.
7. J.J. Gilman: Art and Science of Growing Crystals.
8. R.A. Laudise: The Growth of Single Crystals,

AC-3201 Instrumental Methods of Chemical Analysis

Basic theory, instrumentation, laboratory techniques and analytical application of the following:
Absorption Spectrophotometry: UV-visible, Fourier Transform Infrared Spectroscopy, Nuclear Magnetic Resonance, Electron Spin Resonance, Mass Spectrometry and Atomic Absorption Spectroscopy, Emission Spectrophotometry: Induction Coupled Plasma Emission Spectroscopy, X-Ray Photoelectron Spectroscopy. Chromatography: Adsorption, Ion-exchange and High Pressure Liquid Chromatgraphy.

Recommended Books:

1. Skoog, West, and Harris: Analytical Chemistry: an Introduction Saunders, College Publishing, 7th Edition.
2. Skoog, Holler and Nieman: Principles of Instrumental Analysis, Fifth Edition,. Brooks/Cole-Thompson Learning Publishers.
3. Vogel's Quantitative Chemical Analysis, 6th Edition.
4. Kenneth A. Rubinson: Contemporary Instrumental Analysis, Culinary and Hospitality Industry Publications Services.
5. Allen J. Bard, Larry R. Faulkner: Electrochemical Methods: Fundamentals

and Applications, 2nd Edition.

AC-3202 Industrial Organic and Inorganic Chemistry

Chemical explosives: characteristics, classification and manufacture of important explosives. Pesticides: general perspectives, classification, uses and synthesis of representatives pesticides. Polymerization technology: classification of polymers, plastics, fibres, elastomers. Dyes: Requirments of a dye, chemical nature, classification, chemistry of representative important dyes. Pharmaceuticals: sulfadrugs, antipyretics and analgesics, antibiotics, antimalarials.
Caustic soda & Chlorine. Hydrochloric acid. Sulphur & sulphuric Acid. Cement and ceramic materials.

Recommended Books:

1. J.P. Mukhlyonov: Fundamentals of Chemical Technology.
2. M.G. Rao, M.Sittig: Dryden's out line of Chemicals Technology.
3. Emil Raymond Riegel: Industrial Chemistry.
4. Frank Hall Thorp: Outlines of Industrial Chemistry.

AC-3203 Nuclear and Radiation Chemistry

Nuclear Properties: Classification of nuclides, nuclear stability, binding energy a and nuclear models.
Radioactivity: characteristics of radioactive decay, decay kinetics, parent-daughter decay growth relationships, detection and measurement of radioactivity, advances in the solid and liquid scintillation counting techniques, methods for the determination of half -life period of single and mixed radionuclides.
Nuclear reactions: Nuclear fission, nuclear fuels and nuclear reactors, nuclear fuel reprocessing, fast breeder reactors, radiological safety aspects and radioactive waste managements.
Radiation Chemistry: Interaction of radiation with matter, effect of ionizing/ non-ionizing radiations on water, aqueous solutions and on organic compounds.
Radiochemistry: Preparation and separation of radioactive isotopes, application of radioisotopes and radiations in various fields, radiolysis, radiation dosimetry, isotopic dilution techniques, neutron activation analysis and its applications.

Recommended Books:

1. G. Friendlander, J.W. Kennedy & J.M. Miller: Nuclear and Radiochemistry, Willey Interscience, New York.
2. B.G. Harvey: Introduction to Nuclear Physics & Chemistry, Prentice - Hall, Englewood Cliffs (N.J)/ Pentice-Hall, India, EEE Edn.
3. R.T. Overman: Basic concept of Nuclear Chemistry, Chapman & Hall
4. M. Haissinsky: Nuclear chemistry and its application, Addision Wesley Reading.
5. An. N. Nesmeyanov: Radiochemistry, MIR Publication, Moscow.
6. J.W.T. Spinks & R.J. Woods: An Introduction to Radiation Chemistry Willey, New York.
7. A.J. Swallow: Radiation Chemistry of Organic Compound,

Pergmon Press, Oxford.
8. H.J. Arnikar: Essentials of Nuclear Chemistry, Wiley Eastern Ltd., 2nd Edition.
9. C.B. Amphlett: Treatment & Disposal of Radioactive Wastes, Pergaman Press, Oxford.

AC- 3204 Statistical Thermodynamics

Basics of statistical thermodynamics: Ensembles, types of ensembles, postulates. Evaluation of probabilities, Evaluation of allowed energies, Ensembles and thermodynamics
Models for single component systems: Monoatomic ideal gas, Introduction to lattice statistics, polyatomic ideal gases, solid models, simple liquids, phase equilibrium.
Models for multicomponent systems: Lattice gas with interactions, solutions (Bragg-William model and regular solutions, Quasichemical model).
Ideal gas mixtures: Chemical equilibrium, Rate of chemical reactions.

Recommended Books:

1. T. L. Hill: An Introduction to Statistical Thermodynamics. Dover Publications.
2. J. B. Hudson: Thermodynamics of Materials: A Classical and Statistical Synthesis, Wiley-Interscience.
3. S. Bromberg and K. A. Dill: Molecular Driving Forces: Statistical Thermodynamics in Chemistry & Biology, Garland Publishing.

CH – 3202 New Separation Processes

Principle of membrane separations process; Classification, characterization and preparation of membrane.

Reverse osmosis, ultrafiltration, micro-filtration, nano-filtration and dialysis; Analysis and modeling of membrane separation processes; Membrane modules and application; Ion selective membranes and their application in electro-dialysis; Pervaporation and gas separation using membranes; Electrophorosis; Liquid membranes and its industrial applications.

Foam and bubble separation: Principle; Classification; Separation techniques; Column operations.

Zone melting, zone refining and zone leveling.

Pressure and temperature swing adsorption.

Cryogenic separation; Super- critical extraction.

Parametric pumping: Batch, continuous and semi-continuous pumping; Thermal, pH and heatless parametric pumping.

Multicomponent separation.

AC-4101 Chemical sensors

Introduction to chemical sensing, Potentiometry: fundamental principles, membrane potentials, Applications of potentiometry: ion-selective electrodes, Amperometry: fundamental principles, diffusion limited currents, Applications of

amperometry: the Clark oxygen electrode, glucose sensors in diabetes: enzyme electrodes, immunosensors, ELISA., Piezoelectric devices: quartz crystal microbalance, Luminescent sensors and electrochemiluminescence. Optical sensors: Selective detection of gases and applications in atmospheric chemistry and environmental science. Miniaturisation and Lab-on-a-chip devices, applications in molecular biology and clinical chemistry and elementary idea of MEMS Technology

Recommended Books:

1. Encyclopedia of Sensors, American Scientific Publisher.
2. D A Skoog, F J Holler and T A Nieman: Principles of Instrumental Analysis.
3. C*hemical Sensors*.
4. T.E. Edmonds, Chapman and Hall: *Principles of Chemical Sensors*, J Janata, Plenum Press .
5. R W Cattral: Chemical Sensors, Oxford University Press .
6. Enzyme and Microbial Biosensors: Techniques and Protocols. Humana Press, Totowa.

AC-4102 Corrosion

Corrosion and its economical aspects, Thermodynamics of corrosion –Pourbaix diagrams, Immunity, corrosivity and passivation. Mechanism and kinetics of corrosion. Evan's diagrams. Intrinsic and extrinsic forms of corrosion. Electrochemical methods for corrosion testing.
Corrosion Prevention Techniques: Metallic coatings, organic paints, varnishes, corrosion inhibitors, cathodic and anodic protection. Corrosion in industries with reference to thermal power plants, mining and petroleum industries, prevention of microbial corrosion.

Recommended Books:

1. M.G. Fontana: Corrosion Engineering, McGraw Hill International Book Co. London.
2. L.L. Shreir: Corrosion, Vol I and Vol II, Newness Butterworths, Edward Arnold Ltd, London.
3. J.C. Scully: Fundamental of Corrosion, Pargmon Press Inc. New York, USA.

AC 4103 Chemistry of Heterocyclic Compounds

Introduction, nomenclature, structures, and reactivities of heterocyclic compounds. Chemistry and reactivity of five membered heterocyclic compounds with one and two hetero atoms: pyrrole, furan, thiophene, pyrazole, imidazole, and thiazole. Chemistry and reactivity of six membered heterocyclic compounds with one and two hetero atoms: pyridine, pyrimidine, quinozoline, quinoxalines. Chemistry and reactivity of byclic condensed ring systems: indoles and quinolines. Chemistry of selected industrially important heterocyclic compounds.

Recommended Books:

1. J.A. Joule, K. Mills and G.F. Smith: Heterocyclic chemistry, III Ed., East West Press vt Ltd, ND.
2. A.R. Katrizky and J.A. Boulton: Advances in Heterocyclic chemistry, Vol 1-27, Academic Press, NY.
3. R.M. Achesion: An Introduction to the Chemistry of Heterocyclic Copmpounds, II Ed, NY.
4. D.W. Young: Heterocyclic chemistry, Longmans, London.

MS - 4114 Materials Characterization

Scope and methods used for materials characterization.
Optical microscopy techniques including polarized light and phase contrast. Quantitative metallography and its applications.
Transmission electron microscopy: Description of TEM. Formation of images and selected area diffraction patterns. Interpretation of electron diffraction patterns. Specimen preparation techniques.
Scanning electron microscopy: Description of SEM. Image formation methods in SEM.
Scanning probe microscopy: STM and AFM.
Analytical Electron Microscopy: EDS and WDS and EELS. Electron probe microanalysis (EPMA).
Auger electron spectroscopy. Electron spectroscopy for chemical analysis (ESCA). X-ray fluorescence analysis. SIMS. XPS.
UV-visible and IR spectroscopy
Corrosion behaviour of materials and corrosion testing techniques.

Recommended Books:

1. Metals Handbook Vol. 8, 8th edition.
2. G.L. Kehl: Principles of Metallographic Laboratory Practice,
3. Ian M. Watt: The Principles and Practice of Electron Microscopy,
4. P.J. Grundy and G.A. Jones: Electron Microscopy in the Study of Materials,
5. U. Valdre: Electron Microscopy in Materials Science.
6. J. R. Dyer: Application of Absorption spectroscopy.
7. C.N. Bannwell: Fundamentals of Molecular Spectroscopy.

MS - 4115 Industrial Polymers

Preparation of polymers: Petroleum based, plant products and synthetic routes.
Polymers in fiber industry : Fiber forming polymers. Synthesis, structure and properties of fibers. Application of fibers.
Polymers for paints and coatings: Basics of paint technology. Polymeric binders, pigments, extenders and additives. Essential concepts of paint formulations. Properties of paints.
Polymers as adhesives: Polymer based adhesives. Adhesion improvers. Thermal and mechanical behaviour of adhesives. Mechanism of adhesion.
Electronic polymers: Polymers used in electronic industries. Physical, chemical and morphological properties of electronic polymers and their applications. Piezo and pyroelectric polymers. Electric and dielectric properties of polymers.

Polymers in information technology: Polymers in optical media data storage devices.

Various types of polymers used in information technology, their synthesis and properties. Fabrication of CD substrates.

Polymers in tyre industries.

CH – 5103 Chemical Reactor Analysis

Behaviour of chemical reactors: Residence time distribution; Segregated and non-segregated flow models; Order and segregation; Effect of non-segregated mixing upon yield and selectivity; Non-isothermal reactor performance; Uniqueness of the steady state.

Conservation equations for reactors: Transport coefficients; Determination of dispersion coefficients; Homogeneous reactor design; Semibatch reactor; Transient behaviour.

Gas – liquid and liquid - liquid reaction system: Gas-liquid reaction models; Regime identification; Multi-phase reactor models; Multiplicity of steady states; Selectivity and yield.

Fluid – solid noncatalytic reaction system: Models; Kinetics; Non-isothermal reactions; Reactor design; Liquid-solid reactions – Ion exchange.

Analysis and design of heterogeneous catalytic reactors: Fixed bed reactor; Peclet number for heat and mass transfer; Adiabatic fixed bed reactor; Non-isothermal non-adiabatic fixed bed reactor; Fluidized bed reactor; Slurry reactor, Trickle bed reactor; Reactor suffering catalyst deactivation; Decay affected selectivity.

Reactor stability and optimization.

Scale up of reactors.

AC – 4201 Computational Techniques for Molecular Simulation

Introduction: Model systems and interaction potentials, Basics of Monte Carlo and Molecular Dynamics simulation techniques.

Monte Carlo simulations in various ensembles: Micro-canonical, Canonical and Grand-Canonical. Molecular dynamics in various ensembles: Constant temperature, constant pressure ensembles.

Free energy and phase equilibria: Methods of free energy calculations, The Gibb's ensemble, Coexistence, Free energy of solids.

Recommended Books:

1. D. Frenkel and B. Smit: Understanding Molecular Simulation, Academic Press.
2. M.P. Allen and D.J. Tildesley: Computer Simulation of Liquids, Oxford University Press, USA.
3. A. Hinchliffe: Molecular Modeling for Beginners, John Wiley & Sons.
4. A. Leach: Molecular Modeling: Principles and applications, Prentice Hall.

AC-4202 Industrial Waste Management

Definition, Classification, sources and composition of solid, liquid and gaseous wastes, hazardous and non-hazardous wastes, special waste materials. Storage and transport of wastes. Transportation and collection systems. Management of wastes,

minimization, reuse and recycling. waste utilization and materials recovery. Treatment of wastes: biological treatment, composting, anaerobic digestion, combustion, incineration and landfills, ultimate disposal.

Recommended Books:

1. H.S. Peavy: D.R. Rowe and G. Techbanoglous: Environmental Engineering, McGraw Hill Books Co.
2. R.A. Corbitt: Started Handbook: A Environmental Engineering; McGraw Hill New York.
3. A.M. Martin: Bio-conservation of waste Materials to Industrial Products; (ed), Elsevier, Amsterdam.
4. O.P. Kharbanda and E. A. Stellworthy: Waste Management- towards a Sustainable Society, Gower.
5. E. Mortensen: Introduction to Solid Waste, Lecture Notes to Graduate Diploma in Environmental Engineering, University College, Ireland.
6. K.L. Zirm: The Management of hazardous Substances in the environment, Applied Science, N.Y.
7. R.K. Somasekhar and Mariyengar(ED): Solid Waste Management- Current Status and Stratagies for Future, , Allied Publishers, Mumbai.

AC-4203 Chemistry of Coordination Compounds

Ligand Field and Molecular Orbital Theories of bonding in transition metal complexes. Magnetic Properties, basic equations of magnetic susceptibility, diamagnetism, paramagnetism, ferromagnetism and antiferromagnetism, Curie-Weiss Law, temperature independent paramagnetism. Electronic spectra of transition metal complexes, selection rules, ground state terms for the metal ions, Orgel energy diagrams in different ligand fields. Kinetics and mechanisms of acid-base, redox, substitution and photochemical reactions of metal complexes.

Recommended Books:

1. R.G. wilkins: Kinetics and Reaction Mechanism of Transition metal Complexes, VCH, New York,2nd Ed.
2. F. Basolo and R.G. Pearson: Mechanism of Inorganic Reactions, Wiley.
3. V. Balzani & V. Carasity: Photochemistry of coordination compounds, Academic Press.
4. A.B.P Lever: Inorganic Electronic Spectroscopy, Elsevier.

AC-4204 Organic Synthetic Methods

Introduction to synthesis, strategy of synthesis, Retrosynthesis. Designing of green synthesis: choice of starting materials, reagents, catalysts and solvents. Basic principles of green chemistry and synthesis of organic compounds involving basic principles of green chemistry methodology of synthesis. Mechanism of reaction for synthesis of important organic compounds, new methods in organic synthesis: microwave technique, use of phase transfer catalyst in organic synthesis. Functional group exchange reactions. Oxidation. Reduction. Hydroboration. Protecting Groups. Stereocontrol.

Recommended Books:

1 P.T. Anastas, J.C. Warner: Green Chemistry: Theory and Practice. Oxford University Press.
2 C. M. Starks and M Halpen: Phase Transfer Catalysts Chapman and Hall, NY.
3 V.K. Ahaluwalia and R. Agrawal: Organic Synthesis: Special Techniques. Narosa Publishing House, New Delhi.
4. K.S Suslick: Modern Synthetic Methods, Academic Press.

CH – 5219 Design and Development of Hetrogeneous Catalysts

Structure of solid surfaces; Chemisorption and physiosorption; Thermodynamics and kinetics of surface processes; Principles of heterogeneous catalysis; Preparation, characterization and classification; Structure and activity; Lattice imperfection; Geometric and electronic factors
Prepartion and characterization of catalysts.
Kinetics of heterogeneous reactions.
Physical, chemical and mathematical description of catalyst deactivation; Deactivation by fouling, poisoning and sintering.
Deactivation and regeneration of catalyst pellets.
Deactivation and regeneration of fixed beds.
Dynamics of polyfunctional catalysts.
Electrocatalysis and photocatalyis.
Mechanism and kinetics of some typical heterogeneous catalytic reactions.
Applications in fertilizer, petroleum, petrochemical industries and pollution control.

CH – 5223 Fuel Cell Technology

Fundamentals and classification of fuel cells; Thermodynamic efficiency.

Electromotive force of fuel cells: Standard electrode potentials; Effect of concentration; Nernst equation.

Rate of electrode processes: Types of polarization; Surface reactions; Oxygen electrodes; Hydrogen electrodes; Overall performance.

Low temperature fuel cells: Hydrogen–oxygen fuel cells– alkaline and polymeric membrane types; Active catalyst and its dispersion; Heat and mass transfer; Construction and design; Limiting problems; Low temperature fuel cells of other types – methanol fuel cell, hydrocarbon fuel cell.

High temperature fuel cells: Advantages; Molten electrolyte fuel cell; Solid electrolyte fuel cell; Construction.

Air depolarised cells; Biochemical fuel cells; Regenerative cells; Micro fuel cells.

Fuel cell operation: Supply of fuel; Electrical arrangement; Removal of products; Materials for battery construction; Production and purification of fuels.

Application of fuel cell systems: Large scale power generation; Power plant for vehicles; Domestic power; Fuel cells in space.

Fuel cell economics; Future trends in fuel cells.

PH – 5222 Pharmaceutical Chemistry – IV[Drug Design]

1. Drug Design: Principles and applications of SAR and PAR (QSAR).

2. Chemical Parameters in Drug Design:
   Stereochemistry, Biological isosterism, pro-drugs and analogous.
3. Analog Design.
4. Physicochemical parameters in Drug Design.
5. Study of Artificial Enzymes.
6. Computer-Aided Drug Design (CADD) and Molecular modeling.

BC – 5215 Advanced Fermentation Technology

Selection and genetical improvement of industrial microorganisms; Chemistry and biosynthesis of antibiotics and vitamins, Metabolic regulations in industrial fermentation; Microbial production of amino acids-lysine, glutamic acid; Microbial production of antifungal antibiotics and broad spectrum antibiotics; Microbial transformation of steroids; Microbial assay techniques and microbial estimation of antibiotics and vitamins; Application of antibiotics in animal nutrition and food preservation; Mycotoxins and microbial insecticides; Large scale fermentation development of recombinant microorganisms.

AC – 5101 Chemoinformatics

Introduction. Representation of chemical compounds. Representation of chemical reactions. Data acquisition and processing. Databases and data sources in chemistry. Searching chemical structures.
Calculation of physical and chemical data: Quantum mechanical models, Molecular mechanics (empirical force field models), Semi-empirical implementations of molecular orbital theory.
Calculation of structure descriptors. Some applications of chemoinformatics: LFER, QSPR, Spectra simulation etc.

Recommended Books:

1. J. Gasteiger: Chemoinformatics, John Wiley & Sons.
2. A. R. Leach and V. J. Gillet: An Introduction to Chemoinformatics, Springer.

AC – 5102 Photochemistry

Inorganic Photochemistry: Kinetics of photochemical reactions, photochemistry of excited states. Photochemical reactions: substitutions, decomposition & fragmentation, rearrangement and redox reactions. Inorganic photochemistry in biological processes and their model studies.
Organic Photochemistry: An overview, pericyclic reactions, cycloadditions, sigmatropic and electrocyclic reactions.

Recommended Books:

1. Jerry March: Advanced organic chemistry. John Wiley.
2. Guoy & Chapman: Organic Photochemistry.
3. Clayden: Organic chemistry: Oxford.
4. G.L. Geoffery and M.S. Wrighton: Organometallic Photochemistry, Academic Press .
5. K.K. Rohatagi-Mukherjee: Fundamentals of Photochemistry, Wiley Eastern.
6. M.S. Wrighton: Inorganic and organometallic photochemistry, ACS pub.

7. V. Balzani and V. Carasiti: Photochemistry of Co-ordination compounds, Academic press.

Electives:

AC – 5103 Metal Clusters

Metal – Metal bonds and metal atom clusters, low nuclearity (M_3 and M_4) clusters, Isoelectronic and isolobal relationships, High nuclearity carbonyl clusters (HNCCs), Hetero atoms in metal atom clusters, electron counting schemes for HNCCs, the capping rule.

Recommended books:

1. B.F.G. Johnson: Transition Metal clusters, Wiley.
2. H. Crabtrree: Organometallic clusters of Transition metals Robert, John Wiley.
3. F.A. Cotton G. Wilkinson: Advance Inorganic Chemistry, John Wiley, 6th Ed.

AC – 5104 Biosensors

Biosensors: Basics & Applications, Relevant Biology, Enzymes and Kinetics, Design Considerations. Optical Spectroscopy for Biosensing, Optical Glucose Sensing, Optical Biosensors, SPR and Luminiscence, Luciferase Biosensors. Electrochemical Biosensors: Potentiometric Biosensors, Amperometric Biosensors. Calorimetric Biosensors. Affinity Biosensors: Antibodies and Immunosensors, DNA Sensors, PCR Presentation.

Recommended Books:

1. Encyclopedia of Sensors, American Scientific Publisher.
2. Enzyme and Microbial Biosensors: Techniques and Protocols. Humana Press, Totowa, NJ.
3. Frances S. Ligler (Editor), Chris A. Taitt: Optical Biosensors: Present & Future
4. Anthony P.F. Turner, Isao Karube, George S. Wilson: Biosensors:Fundamentals and Applications.

AC – 5105 Bioremediation

Bioremediation, Bioaccumulation and Biosorption. Metal-microbes interaction. Use of microbes for heavy metal detoxification. Binding mechanism of metal on the surface of microbes. Biomass engineering for biosorbent. Role of enzymes and metabolites in bioremediation. Sequestration by phytochelatins and metallothionins. intracellular sites for metal complexation. Kinetic studies of bioremediation. Sorption isotherms.

Recommended Books:

1. B. Volesky: Sorption and Biosorption .
2. Raina M. Maier, Ion L. Peper, Charles P. Gerbe:

Environmental Microbiology, first edition, Amazon Publications.
3. Patrik K. Ijenbe: Environmental Microbiology: Principal and Applications.
4. A.H. Varnam M. Evans: Environmental Microbiology, Black well Publishing.
5. Spencer, John F.T. Alicia L. Ragout de Spencer: Environmental Microbiology: Methods and protocol Humana Press.

AC – 5106 Corrosion Inhibitors

Introduction to corrosion and its mechanism. General method for corrosion prevention. Conditioning of environment to reduce corrosion. Basics and classification of corrosion. Inhibitors. Mechanisms of corrosion inhibition. Techniques for evaluation of inhibition efficiency. Application of corrosion inhibitors for boiler corrosion, cooling water systems, reinforced concrete, chemical and petrochemical industries. Inhibitors for microbial corrosion.

Recommended Books:

1. V.S. Sastry: Corrosion Inhibitors, Principles & Applications, John Wiley & Sons.
2. Shreir L.L.: Corrosion Vol. II Newness-Beetterworths, Edward Arnold Ltd. London.
3. C.C. Nathan: Corrosion Inhibitors, NACE, Houstion, Texas.

AC – 5107 Spectroscopic Identification of Organic Compounds

UV-Visible Spectroscopy: Introduction, Theory and Instrumentation, Sample Handling, Characteristic Absorption of Organic Compounds, Infrared Spectroscopy: Theory and Instrumentation, Sample Handling, Interpretation of Spectra, Characteristic Group Absorption of Organic Compounds.
PMR-Spectroscopy: Theory, Instrumentation and Sample Handling, Chemical Shift, Spin-Spin Coupling, AMX, ABX and ABC Systems with three Coupling Constants, Long-Range Coupling, Shift Reagents. ^{13}C NMR Spectroscopy: Interpretation of ^{13}C Spectra Chemical Shifts, Spin Coupling, Peak Assignments problems, Quantitative Analysis. Mass Spectroscopy: Theory and Instrumentation, The Mass Spectrum Determination of a Molecular Formula, Molecular Ion Peak, Fragmentation, Rearrangements, Mass Spectra of Some Chemical Classes.

Recommended Books:

1. Silverstein, Bassler and Morill: Spectrometric identification of Organic Compounds: John Wiley and Sons, Inc.
2. William Kemp: Organic Spectroscopy: Palgrave.

AC – 5108 Solid State Chemistry

Geometrical crystallography, the Structure of Crystals, Atomic packing in crystals, Imperfection in atomic packings, Properties of metals: Electrical and Magnetic properties, Properties of Semiconductors: Conductivity, optical properties and

junction properties, Properties of Insulators: Electricals, Optical and Magnetic properties, Structure of Insulators.

Recommended Books:

1. L.V. Azaroff: Introduction of Solids Tata McGraw hill Publishing Compl Ltd. Delhi.
2. Von Lesley Smart and Moore Elaine A: Solid State Chemistry: An Introduction, CRC Press.
3. S.K. Joshi and R.A. Mashelkar: Solid State Chemistry: selected Papers of C.N.R. Rao, Edited , world Scientific Series in 20th Series Chemistry, Vol. 4.
4. C.N.R. Rao and J. Gopalkrishnan: New Directions in Solid State Chemistry Cambridge University Press, U.K.

AC – 5109 Chemistry of Electronic Ceramics

Properties of ceramic insulators, Ceramic capacitor materials, Piezoelectric and electro-optic ceramics, Ferrite (magnetic) ceramics, Ceramic sensors, Application and characterization of ZnO varistors, Highly Conductive Ceramics, Materials aspects of thick film technology, Multilayer Ceramic technology.

Recommended Books:

1. R.C. Buchanan, Marcel Dekker: Ceramics Materials for Electronics, Edited Inc.
2. W.D. Kingrey: Introduction to Ceramics, John Wiley & Sons.
3. L.L. Hench and J.K. West: Principles of Electronic Ceramics John Wiley & Sons.
4. Barosum: Fundamental of Ceramics McGraw Hills.

AC – 5110 Advanced Treatment processes for Water and Wastewater.

World water resources and water resources of India, Hydrological cycle. Physical, Chemical and Biological pollution of Water, methods of Sampling and Monitoring of Water, Water Quality parameters. Pre and primary treatment, Equalization, neutralization, Sedimentation and Flotation. Biological Water and Wastewater Treatment processes, lagoons and Stabilization Basins, Activated Sludge processes, Trickling Filtration and Rotating Biologtical Contactors, handling and Disposal of Sludge. Advanced Treatment Processes, Latest Advances in Water and Wastewater Treatment Processes, Adsorption, Ion Exchange and Chemical Oxidation. Treatment of Wastewater from specific industries, Case Studies.

Recommended Books:

1. G.L. Culp and R.L. Culp: New Concepts in Water Purification, Van Nostrand Reinfold Co. NY.
2. S.E. Jorgenson: Industrial wastewater Management, Elsevier Sci. Pub., NY.
3. G.N. Pandey and G.C. Carney: Environmental Engineering, Tata McGraw Hill Pub. Ltd., ND.
4. H.S. Peavy, D.R. Rowe and Techobanoglous: McGraw Hill Book Co. NY.

CH - 5114 Membrane Separation Processes

Principles, characteristic, and classification of membrane separation processes; Membrane materials, structures, and preparation techniques; Membrane modules;Plant configurations.

Membrane characterization: Pore size and pore distribution; Bubble point test; Challenge test; Factors affecting retentivity, concentration polarization, gel polarization, fouling, cleaning and regeneration of membranes.

Mechanisms of separation: Porous membranes, dense membranes, and liquid membranes.

Membrane separation models: Irreversible thermodynamics; Capillary flow theory; Solution diffusion model; Viscous flow models; Models for separation of gas (vapour) mixtures;

Science and technology of microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis and electrodialysis, pervaporation, liquid membrane permeation, gas permeation.

Membrane reactors: Polymeric, ceramic, metal and bio-membrane.

CH - 5115 Interfacial and Colloidal Phenomena

Thermodynamics of interfaces: Gibbs dividing surface; Interfacial tension; Gibbs adsorption isotherm; Young-Laplace equation; Wetting and contact angle; Thin fluid films; Combination of van der Waals forces, double layer potential etc. to disjoin pressure.

Fluid statics and dynamics of interfaces and thin films; Equilibrium shapes of menisci; Drop formation; Stability of thin films; Wetting of solids; Coating flows and fluid displacement in pores.

Application of colloidal systems; Foams, emulsions, oil recovery and other special topics.

CH - 5116 Multicomponent Separation

Fundamentals, characteristic and classification of separation processes; Selection of feasible separation process; Thermodynamics of separations; Factors affecting product purity.

Approximate process for multicomponent, multistage operations: Fenske-Underwood-Gilliland method; Kremscr group method.

Equilibrium based methods for multicomponent absorption, stripping, distillation and extraction: Theoretical model for an equilibrium stage; General strategy of mathematical solution; Equilibrium tearing procedure; Tridiagonal matrix algorithm; Inside-out method.

Enhanced distillation; Homogeneous and heterogeneous azeotropic distillation; Reactive distillation.

Rate based models for distillation:Thermodynamics properties and transport expressions; Methods for estimating transport coefficient and interfacial area; Vapour and liquid flow pattern.

Methods of calculations: Chem Sep program; RATEFRAC program.

Batch distillation, batch stripping and complex batch distillation.

Pressure swing adsorption; Supercritical fluid extraction

MS 5116/ MS 5215 Nanomaterials and Nanostructures

Preparation methods: Thermal and ultrasound decomposition methods. Reduction methods. Coprecipitation, spray drying, sol-gel and hydrothermal methods. Capped semiconductor nanoparticles. High energy ball milling and mechanical attrition.

Thermal evaporation. Sputtering. Laser ablation. Chemical vapour deposition. Molecular beam epitaxy. Thermal spraying. Electro and electroless deposition.

Characterization techniques: TEM, SEM, AFM and STM. Optical and vibrational spectroscopy.

Properties: Quantum wells, wires and dots. Size and dimensionality effects. Excitons. Single electron tunneling. Applications in infrared detectors and quantum dot lasers.

Magnetic properties of nanocrystalline materials.

Nanostructured ferroelectric materials and their properties.

Mechanical properties of nanocrystalline materials and nanocomposites.

Nanostructured materials in catalysis and electrocatalysis

Carbon clusters compounds, Preparation and properties of carbon nanotubes. Inorganic nanotubes and nanorods, nanoporous materials.

MS 5109/ MS 5208 Advanced Polymers

Solid and gas phase polymerization. Group transfer polymerization. Living free radical polymerization.

Butyl rubber. Nitrile rubber. Styrene butadiene rubber. Telechelic polymers. Hetero-chain polymers. Ethylene propylene diene rubber (EPDM). Nanocomposites.

Foams. Thermosetting Resins. Ionomers. Hydro-gel. Polymeric liquid crystals. Polymeric gel. Heat resistant polymers. Multiphase polymeric systems. Interpenetrating networks. Graft and block copolymers. Molecular composites.

Conducting polymers: Types of conducting polymers. Chemical and electrochemical routes of synthesis. Doping and dedoping of conjugated polymers. Solatron and polaron formation in conducting polymers. Conduction mechanism.

Bio and natural polymers: Proteins, nucleic acids, lipids, cellulose and polysaccharides.

Medicinal and biomedical applications of polymers. Introduction of Inorganic Polymers and application. Biodegradable polymers. Polymer waste management.

BC – 5101 Microbial Engineering

Microbial growth; Aerobic and anaerobic growth phenomena; Synchronous culture; Mathematical modeling of microbial growth; Product synthesis kinetics; Batch, fed- batch and continuous culture cultivation techniques; Growth and non- growth associated product formation; principles and mechanism of media sterilization-Thermal and membrane filtration; Batch and continuous sterilization of media; Air sterilization- Principles and design; Characteristics of biological fluids.

BC – 5102 Fundamentals of Microbiology & Biochemistry

Isolation, identification and preservation of industrial microorganisms; Physiology and morphology of bacteria, yeast and fungi; Characteristics of viruses; Bioenergetics of metabolic pathways; Elementary mass balance; Energy balance; ATP generation and Y_{ATP}, Energy yielding and consuming metabolic pathway; Detoxification of Xenobiotic compound; Steroid transformation.

BC – 5114 Enzyme Engineering Technology

Sources and structure of enzyme; Biosynthesis, regulation and control of enzyme in microorganisms; Kinetics of enzymatic reaction, Single and multiple substrate systems, Inhibition- substrate product and inhibitors, Analysis of kinetic data, active and legend binding sites, Mechanism of enzyme action; Large scale production and purification of enzyme; Cofactors and their role in enzyme activity; Immobilization of enzyme and whole cells; Process design and operation strategies for immobilized enzyme reactors; External and diffusional mass transfer limitation, Effectiveness factor and modulus; Stabilization of enzyme, synzyme, Immobilization of multiple enzyme system; Protein engineering; Application of enzyme – Industrial, Analytical and Medical.