

# 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:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
<b><i>Theory:</i></b>		
1. Mathematics I	03	03
2. Physics I	03	03
3. Chemistry I	03	03
4. Engineering Mechanics	03	03
5. Computer Programming and Graphics	04	04
<b><i>Practical:</i></b>		
6. Physics Lab	03	02
7. Computer Lab	03	02
8. Engineering Drawing	04	03
9. Workshop Practice	03	02
<b>Total for I/II Semester</b>	<b>29</b>	<b>25</b>

**II – Semester for FIRST group of students/I Semester for SECOND group of students**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
<b><i>Theory:</i></b>		
1. Mathematics II	03	03
2. Physics II	03	03
3. Chemistry II	03	03
4. Thermodynamics	03	03
5. Environmental Studies	04	04
6. Professional Writing	03	03
<b><i>Practical:</i></b>		
7. Physics Lab	03	02
8. Chemistry Lab	03	02
9. Workshop Practice	03	02
<b>Total for II/I Semester</b>	<b>28</b>	<b>25</b>
<b>Total for Part -I</b>		<b>50</b>

**Second Year****III – Semester:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
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 I	03	02
AC-2301: Chemistry Lab(Polymers and Reaction kinetics)	03	02
AM-2301: Computer Lab(Programs on C/C++)	03	02
<b>Total</b>	<b>27</b>	<b>24</b>

**IV – Semester:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
Theory:		
AC-2201: Chemical Thermodynamics	03	03
AC-2202: Chemistry of Main Group Elements	03	03
AC-2203: Stereo-Chemistry and Mechanism in Organic Chemistry	03	03
AP-2204: Fluid Dynamics	03	03
AM-2201: Numerical Analysis	03	03
EE-2201A: Electrical Engineering	04	04
Practicals:		
AP-2401: Physics Lab II	03	02
AC-2401: Chemistry Lab(Thermodynamics &Chemical Analysis)	03	02
AM-2401: Computer Lab (based on AM-2201)	03	02
<b>Total</b>	<b>28</b>	<b>25</b>

**Third Year****V – Semester:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
Theory:		
AC-3101: Analytical Techniques in Chemistry	03	03
AC-3102: Statistical Thermodynamics	03	03
AC-3103: Chemistry of Transition & Inner Transition Elements	03	03
CH-3111A: Process Calculations	04	04
CH-3111B: Unit Operations I	03	03
MS-3106: Synthesis and Preparation of Materials	03	03
Practical:		
AC-3301: Chemistry Lab. (Qualitative Inorganic Analysis)	03	02
AC-3302: Chemistry Lab. (Organic Analysis)	03	02
AC-3303: Chemistry Lab. (Analytical Chemistry)	03	02
<b>Total</b>	<b>28</b>	<b>25</b>

**VI – Semester:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
Theory:		
HU 320x: Humanities* (open elective)	03	03
AC-3201: Instrumental Method of Chemical Analysis	04	04
AC-3202: Nuclear and Radiation Chemistry	03	03
AC-3203: Environmental Chemistry	03	03
CH-3211A: Instrumentation & Process Control	03	03
CH-3211B: Unit Operations II	03	03
Practical:		
AC-3401: Chemistry Lab (Quantitative Inorganic Analysis)	03	02
AC-3402: Chemistry Lab	03	02
AC-3403: Chemistry Lab (Environmental Chemistry)	03	02
<b>Total</b>	<b>28</b>	<b>25</b>

**\* 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:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
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-4111A: Chemical Reactor Analysis	03	03
Practical:		
CH-4311A: Chemical Engg. Lab	03	02
AC-4301: Chemistry Lab (Corrosion & Chemical Sensors)	03	02
Seminar/ Group Discussion	03	02
Summer Practical Training Evaluation	03	02
<b>Total</b>	<b>30</b>	<b>26</b>

**VIII – Semester:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
Theory:		
AC-4201: Molecular Simulation and Cheminformatics	03	03
AC-4202: Industrial Inorganic Chemistry	03	03
AC-4203: Chemistry of Coordination Compounds	03	03
AC-4204: Synthetic Organic Chemistry	03	03
AC-4205: Biosensors	03	03
*Any one of the courses mentioned below:	03	03
Practical:		
AC-4401: Chemistry Lab (Computational Chemistry)	03	02
AC-4402: Chemistry Lab (Synthetic Organic and Inorganic Chemistry)	03	02
Project	06	04
<b>Total</b>	<b>27</b>	<b>26</b>

- \* 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  
 5. AC-4206 Corrosion Inhibitors  
 6. AC-4207 Solid State Chemistry

**Fifth Year****IX – Semester:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
Theory:	03	
AC-5101: Industrial Organic Chemistry	03	03
AC-5102: Industrial Waste Management	09	03
Electives – I, II, III		09
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PG Practical		
AC-5301 Chemistry Lab (Industrial organic Chemistry)	03	02
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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 Bioremediation
3. AC-5105 Spectroscopic Identification of Organic Compounds
4. AC-5106 Advanced Treatment Processes for Water & waste Water
5. AC-5107 Petrochemicals
6. CR-5204 Electrical & Electronic Ceramics
7. CH-5107 Membrane Separation Processes
8. CH-5108 Interfacial and Colloidal Phenomena
9. CH-5109 Multicomponent Separation
10. BC-5114 Enzyme Engineering and Technology
11. BC-5101 Microbiological Engineering
12. BC-5102 Fundamentals of Microbiology and Biochemistry
13. MS-5122 Nanomaterials and Nanostructures
14. MS-5125 Advanced Polymers

**X – Semester:**

<b>Subjects</b>	<b>Contact Hrs./ Week</b>	<b>Credit</b>
AC-5401: PG Seminar	02	01
AC-5402: Dissertation evaluation AC-5402	-	10
AC-5403: Dissertation open defence	-	05
Total	-	16

## Chemistry-I

### AC – 1101/1201

First and Second Laws of thermodynamics, Concepts of entropy and free energy, Third law of thermodynamics, unattainability of absolute zero. Fundamental equations of thermodynamics. Maxwell relations and their applications. Partial molar quantities. Chemical potential. Gibbs-Duhem equation. Phase and reaction equilibria. Clapeyron equation. Phase rule and its derivation. Phase diagrams, distribution law. Ideal solution and colligative properties. Binary solutions, fractional distillation. Henry's law. Concepts of rate, rate constant, order and molecularity of elementary and multi-step reactions. First and second-order reactions, determination of rate law. Reversible, consecutive and concurrent first order reactions. Chain reactions. Laws of photochemistry, photo-physical processes: fluorescence, phosphorescence. Photosensitization. Electrolytic conductance and conductometry. Galvanic, concentration and fuel cells. pH-metric and potentiometric titrations. Liquid junction potential and its elimination.

#### Recommended Books:

1. Ira N. Levine, Physical Chemistry, Tata Mcgraw Hill , 5<sup>th</sup> edition, 2002
2. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley & Sons 3<sup>rd</sup> edition, 2002.
3. G. W. Castellan, Physical Chemistry, Narosa Publishing House, 3<sup>rd</sup> edition, 2004.
4. T. Engel and P. Reid , Physical Chemistry, Pearson Education Inc, 2006.
5. K.L.Kapoor, Elements of Physical Chemistry,

## Chemistry II

### AC 1102/1202

Mechanism and stereochemistry of nucleophilic substitution reactions, neighbouring group participation, mechanism and stereochemistry of elimination reactions (Hoffman and Saytzeff elimination reactions), electrophilic addition reactions. Concept of aromaticity-Huckel's rule, electrophilic aromatic substitution, directive influence of groups in aromatic compounds. Types of polymers and polymerization, tacticity of polymers, fibers, plastics and elastomers, synthesis and uses of commercially important polymers. Biopolymers. Oil, fats, soaps and detergents, quality assessment. Application of oleochemicals in lubrication. Valence bond and crystal field theories as applicable to metal complexes, crystal field splitting in octahedral and tetrahedral complexes, factors affecting crystal field parameter  $\Delta$ , spectrochemical series, Jahn-Teller distortion, limitations of crystal field theory, magnetic properties and colour of complexes. Classification and general methods of synthesis of organometallic compounds, bonding characteristics of electron deficient organometallic compounds, metal carbonyls, metal alkenes and metal arenes. Application of organometallic compounds in polymerization and catalysis. Titrimetric analysis with reference to acid-base, redox, precipitation and complexometry.

#### Recommended Books:

1. R.T. Morrison and R. N. Boyd, Text book of Organic Chemistry, Prentice Hall, New Delhi, 6<sup>th</sup> edition, 1992,
2. Peter Sykes, Guide book to Reaction Mechanism in Organic Chemistry, Longman, London, 6<sup>th</sup> edition, 1996.
3. T.W.G. Solomon, Organic chemistry, John Wiley & Sons, New York.
4. J. D. Lee, Concise Inorganic Chemistry, Chapman and Hall, 5<sup>th</sup> edition, 1997.
5. F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochman, Advanced Inorganic Chemistry, John Wiley & Sons, 6<sup>th</sup> edition.
6. F. A. Cotton, G. Wilkinson and Paul L. Gaus, Basic Inorganic Chemistry, Wiley Eastern Ltd, 5<sup>th</sup> edition, 1987.

7. Vogel's Textbook of Quantitative Chemical Analysis, Longman, 6<sup>th</sup> edition, 1999.

### **AC-2101 Chemistry of Polymers**

Overview of polymers and polymerization, chain and step growth polymerization, mechanism of free radical, cationic, anionic and coordination polymerization, stereochemistry of polymers, degradation mechanism of polymers, reactions of polymers and their significance, techniques of polymerization, chemistry of selected organic and inorganic polymers.

Molecular weight & size of polymer dissolution, methods for determination of polymers, molecular weight and degree of polymerization, polydispersity & molecular weight distribution in polymers, kinetics of polymerization, glass transition temperature & crystallinity of polymers, thermodynamics of polymers, Florry Huggin theory, conducting polymers, mechanical properties of polymers.

#### **Recommended Books:**

1. R.B. Seymour, C.E. Carraher, Polymer Chemistry, CRC Press, 7th edition, 2008, Boca Raton.
2. J R Fried, Polymer Science and technology, Prentice Hall of India New Delhi 2nd edition 2005.
3. R. Gowariker, N.V. Viswanathan and J. Sreedhar, Polymer Science, Wile Eastern limited, New Delhi, 2003.
4. F W Billmeyer, Text book of Polymer Science, Willey -Interscience New York, 4<sup>th</sup> Ed. 1981.
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. 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. Kinetics and Mechanism of Ionic chain reactions. Kinetic treatment of diffusion in liquids and solutions.

#### **Recommended Books:**

1. K.J. Laidler, Chemical Kinetics, 3<sup>rd</sup> 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 Heisenberg pictures, Canonical commutations.

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

## AM – 2101 Mathematical Methods

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, Poisson, 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

Behaviour of real gases: Deviations from ideal behaviour, the vander Waals equation, Other equations of state: Dietrici equation, Berthelot equation, Clausius equation, Radlich-Kwong equation, the virial equation of state, boyle temperature, the critical phenomena, critical temperature, pressure and volume, determination of critical constants, continuity of state, vander waals equation and critical state, the principle of corresponding states, Liquefaction of gases: Joule-Thomson effect, Joule-Thomson coefficient for vander waals gas, Joule-Kelvin effect, Joule-Kelvin coefficient. Fugacity of gases, determination of fugacity, variation of fugacity with temperature and pressure, fugacity of liquid and solids. Thermodynamics of non-ideal solutions: activity and activity coefficient of solvent and solutions, mean activity and mean activity coefficient of electrolytic solution, determination of activity, activity coefficient, mean activity and mean activity coefficient. Vapour pressure of non-ideal solutions. Phase diagrams of two component system including liquid-liquid and solid-solid systems.

#### Recommended Books

1. I. N. Levine, Physical Chemistry, Tata McGraw Hill.
2. G.W. Castellan, Physical Chemistry, Narosa Publishing House.
3. C. H. P. Lupis, Chemical Thermodynamics of Materials, Elsevier, 1983.

### AC – 2202 The Chemistry of Main Group Elements

General chemistry of non-transition elements, stereochemistry and bonding in hydrides, halides, oxides, peroxides, superoxides, suboxides, hydroxides, oxoacids, organic and organometallic compounds and coordination complexes. 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, 6<sup>th</sup> Ed., 1999.
2. D.F. Shriver, P.W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press 4<sup>th</sup> Edn. 2006.
3. N.N. Greenwood and E.A Earnshaw, Chemistry of Elements, Pergamon Press, 1989.
4. S.J Lippard & J.M Berg, Principles of Bio-inorganic Chemistry, University Science Books, Mill Valley 1994.
5. I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valente, Bio-inorganic Chemistry, Univ. Sci. Books, Mill Valley, 1994.
6. R.W. Hay – Bio-Inorganic Chemistry, Ellis Hollwood Ltd. 1984.

### AC-2203 Stereochemistry & Mechanism in Organic Chemistry

Optical isomerism due to one and two asymmetric carbon atoms, Optical activity due to molecular dissymmetry, racemic modifications, relative and absolute configurations, conformations and stereoisomerism of acyclic and cyclic systems, asymmetric synthesis. Geometrical isomerism. Reactivity, stability and stereochemistry of carbocations, carbanions, free radicals, carbenes and nitrenes. Methods of determining reaction mechanisms. Nucleophilic and free radical reactions, addition to carbon-carbon and carbon-hetero multiple bonds. Mechanism of selected photochemical reactions.

#### Recommended Books:

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

### **AP-2204 Fluid Dynamics**

Neutral fluids, Boltzmann equation, collisions in a dilute neutral gas, collision integral, Maxwellian distribution, Conservation equations, Moment equations, Zero-order approximation, transport phenomena, hydrodynamic properties of ideal fluids, macroscopic derivation of hydrodynamic equations, equations of motions, equation of energy, vorticity equation, incompressible and barotropic fluids, hydrodynamic equations in conservative forms, Bernoulli's principle for steady flows, tangential stress in Newtonian fluid, Navier-Stokes equation, flow through a circular pipe, scaling and Reynold's number, viscous flow past solid bodies, boundary layers, aerodynamic lift, accretion discs in astrophysics, thermodynamic properties of a perfect gas, acoustic waves.

### **Recommended books**

1. D. N. Roy, Applied Fluid Mechanics, Affiliated East-West Press Pvt. Ltd.
2. C. V. Sesshadri and S. V. Patankar, Elements of Fluid Mechanics, Prentice Hall.

### **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, Kirchhoff'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.

### **AC-3101 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. Chromatographic methods of analysis; paper chromatography, thin layer chromatography, column chromatography, gas chromatography. Electrophoretic methods of analysis; free electrophoresis, zone electrophoresis; paper electrophoresis, gel electrophoresis, capillary electrophoresis, isoelectric focusing. Electroanalytical methods of analysis; potentiometry, voltammetry and electrogravimetry. Kinetic methods of analysis.

#### **Recommended Books:**

1. Skoog, West, and Harris, Analytical Chemistry: an Introduction, Saunders, College Publishing, 7<sup>th</sup> Edition 1999.
2. Skoog, Holler and Nieman, Principles of Instrumental Analysis, Brooks/Cole-Thompson Learning Publishers, Fifth Edition.
3. Vogel's Quantitative Chemical Analysis, Longmans, 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, Academic Press, New York, 2nd Edition, December 2000.
6. G. D. Christian, Analytical Chemistry, Wiley India, 6<sup>th</sup> edition, 2007.

### **AC- 3102 Statistical Thermodynamics**

Basics of statistical thermodynamics; ensembles, types of ensembles, postulates. Evaluation of probabilities and allowed energies, thermodynamics properties, fluctuations. Classical statistical mechanics. Ideal monatomic gas, monatomic crystals. Introduction to lattice statistics, ideal diatomic and polyatomic gases. Chemical equilibrium and rate of chemical reactions in ideal gas mixtures. Models of interacting subsystems, particularly, lattice gas approach, Bragg-William model, regular solutions, quasichemical model. Distribution functions in classical monatomic fluids.

#### **Recommended Books**

1. T. L. Hill, An Introduction to Statistical Thermodynamics, Dover Publications, 1987.
2. J. B. Hudson, Thermodynamics of Materials: A Classical and Statistical Synthesis, Wiley-Interscience, 1996.
3. Sarina Bromberg and Ken A. Dill, Molecular Driving Forces: Statistical Thermodynamics in Chemistry & Biology, Garland Publishing, 2002.

### **AC-3103 Chemistry of 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 iron, cobalt, copper, zinc and molybdenum. Structural and functional characteristics of some important biomolecules.

### Recommended books

1. J.E. Huheey, E. Keiter, Inorganic Chemistry, 4<sup>th</sup> Ed. Harper Collins, College Publisher, 1993.
2. C. Elschenbroich & A. Salzer, Organometallics, Wiley, 2<sup>nd</sup> Ed., VCH, 1992.
3. G.O. Spessard, G.L. Miessler, Organometallic Chemistry, Prentice Hall, 1997.
4. F.A. Cotton, G. Wilkinson, C.A. Murillo & M. Bochmann, Advanced Inorganic Chemistry, John Wiley, 6<sup>th</sup> Ed., 1999.
5. N. N. Greenwood & E. A. Earnshaw, Chemistry of Elements, Pergamon Press, 1989.

### CH-3111A Process Calculations

Unit and dimensions: conservation of mass and energy, problem solving techniques; computer based tools; sources of data.

Ideal gas laws: Real gas relationships, vapour pressure, vapour-liquid equilibria for binary and multi-component systems; saturation; partial saturation and humidity.

Overall and component material balances; material balance with and without chemical reactions; material balance involving multiple sub-systems; recycle, bypass and purge; material balance involving phase change.

Enthalpy changes; energy balance with and without chemical reactions; reversible process and mechanical energy balance; heats of solution and mixing; humidity charts and their use in solving humidification, dehumidification and water cooling problems.

Combustion; adiabatic flame temperature.

Degrees of freedom in steady state processes; simultaneous material and energy balance problems using flow sheeting codes; unsteady state material and energy balances.

Material and energy balance calculations of some selected process plants such as sulfuric acid, ammonia, urea, caustic soda etc.

### Recommended books

1. B. L. Bhatt and S. M. Vora, Stoichiometry, Tata-McGraw Hill Publishing Company, New Delhi.
2. O. A. Hougen, K. M. Watson and R. A. Ragatz, Chemical Process Principles Part-I, John Wiley & Sons.
3. D. M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Prentice Hall Inc.
4. "Process Calculations for Chemical Engineering", 2<sup>nd</sup> edition, Chemical Engineering Education Development Centre, IIT Madras.

### 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.

Characterization 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,

### **CH-3111B Unit Operations-I**

Properties and Classification of fluids; Laminar and turbulent flows; Pressure drop and friction factor, Mechanical energy balance and Bernoulli's equation.

Dimensional analysis; Dimensionless numbers and their physical significance; Specifications of standard pipes and tubes; Pipe fittings and valves; Flow measuring devices.

Mixing of fluids: Types of mixers and their selection; Power requirements.

Pumps, blowers and compressors: Working principles; Characteristics; Selection.

Screening and screen analysis; Screen effectiveness; Size reduction: Crushing, grinding, pulverization, ultrafine grinding, Sedimentation; Free and hindered settling;

Mixing of solids

Constant pressure and constant rate filtration; Filtration rate calculation; Filtration equipment.

Flow through packed and fluidized beds; Flooding and loading.; Liquid and gas fluidization.

Mechanism of heat transfer; Conduction: Heat losses and insulation; Selection of insulating materials.

Convection: Natural and forced convection; Film and overall heat transfer coefficients; Heat exchanger: Types of heat exchanger; Co-current and counter-current flows; Heat transfer with phase change: Condensers; Boiling regimes; Reboilers and vaporizers, Evaporators

### **AC-3201 Instrumental Methods of Chemical Analysis**

Molecular symmetry and symmetry groups, representation of groups, group theory and quantum mechanics, symmetry adapted linear combinations. Basic theory and instrumentation of microwave spectroscopy, infrared spectroscopy, ultraviolet-visible, nuclear magnetic resonance, electron spin resonance and atomic absorption spectroscopy. Induction coupled plasma emission spectroscopy. Mass spectrometry.

### **Recommended Books**

1. Skoog, West, and Harris, Analytical Chemistry: an Introduction Saunders, College Publishing, 7<sup>th</sup> Edition, 1999.
2. Skoog, Holler and Nieman, Principles of Instrumental Analysis, Brooks/Cole-Thompson Learning Publishers, Fifth Edition.

### AC-3202 Nuclear and Radiation Chemistry

Classification of nuclides, nuclear stability, binding energy and nuclear models. 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 fission, nuclear fuels and nuclear reactors, nuclear fuel reprocessing, fast breeder reactors, radiological safety aspects and radioactive waste managements. Interaction of radiation with matter, effect of ionizing/non-ionizing radiations on water, aqueous solutions and on organic compounds, radiation dosimetry. Preparation and separation of radioactive isotopes, application of radioisotopes and radiations in various fields, isotopic dilution techniques, neutron activation analysis and its applications.

#### Recommended Books

1. G. Friendlander, J.W. Kennedy & J.M. Miller Nuclear and Radiochemistry, Wiley Interscience, New York.
2. B.G. Harvey, Introduction to Nuclear Physics & Chemistry, Prentice - Hall, Englewood Cliffs (N.J)/ Prentice-Hall, India, 3rd Edn.
3. R.T. Overman, Basic concept of Nuclear Chemistry, Chapman & Hall.
4. A. N. Nesmeyanov, Radiochemistry, MIR Publication, Moscow.
5. J.W.T. Spinks & R.J. Woods, An Introduction to Radiation Chemistry, Wiley, New York.
6. H. J. Arnikaar, Essentials of Nuclear Chemistry, Wiley Eastern Ltd., 2<sup>nd</sup> Edition.

### AC-3203 Environmental Chemistry

Components and segments of environment. 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. 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. 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). 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, 6<sup>th</sup> 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, 2<sup>nd</sup> Ed.
5. A.K. De, Environmental Chemistry, New Age International (P) Ltd., 5<sup>th</sup> Ed.
6. J. Helichlen, Atmospheric Chemistry

### CH-3211A Instrumentation & Process Control

Types of Process Control. Automatic/semiautomatic control process. Two position, proportional and integral control. Combined proportional and integral control. Integral and derivative modes. Open loop & closed loop systems as applied in ceramic industry. Flow measuring instruments. Pilot's tube, Venturimeter, Foxboro & Flow raters (rotameters). Pressure relief valve. Compressed air pressure

regulators. Adjustable part valve. Sensitrol valve, Ratiotrol, injectors. Feeder temperature measuring instruments. Dynamic characteristics of physical systems, elements of process dynamics-resistance, capacitance, time constants in industrial processes and its analytical treatment with suitable examples.

### **CH-3211B Unit Operations -II**

Molecular and eddy diffusion; Mass transfer flux and rate; Diffusivity of gases and liquids, Interphase mass transfer: Individual and overall mass transfer coefficients;

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

Humidification and dehumidification operations; Drying: Drying rates; Batch and continuous driers.

Crystallization: Nucleation and crystal growth; Industrial crystallizers.

Distillation: Vapour-liquid equilibrium and enthalpy concentration diagrams; Principles of distillation; Batch distillation with and without reflux; Steam distillation; Fractionating columns; Calculation of number of plates by McCabe-Thiele and Ponchon-Savarit methods; Feed plate location; Optimum reflux; Open steam;

Solid-liquid extraction: Single and multi stage extraction; Number of equilibrium stages

Liquid-liquid extraction: Ternary liquid-liquid equilibrium; Batch and continuous liquid-liquid extraction;

Adsorption equilibria; Batch, stagewise and continuous adsorption; Industrial adsorbers; Pressure and temperature swing adsorption.

Chromatography and Ion-exchange, Membrane separation Processes: Reverse osmosis, ultrafiltration, micro-filtration, nano-filtration and dialysis; Analysis and modeling of membrane separation processes; Membrane modules and application; Foam and bubble separation: Principle; Classification; Separation techniques; Column operations.

Cryogenic separation; Super-critical fluid extraction.

### **AC-4101 Chemical sensors**

Introduction, Fundamentals of chemical sensors, Selectivity and role of flow injection in chemical sensing. Chemical sensors based on mode of transduction; mass sensors, optical sensors, electrochemical sensors and thermal sensors. Chemical sensors based on chemically sensitive layer; semi-conductor gas sensors, solid electrolyte gas sensors, ion-selective electrode sensors, humidity sensors, field effect transistor sensors and bio-sensors, Sensors arrays and Micro Total Analysis System.

### **Recommended Books**

1. Encyclopedia of Sensors, American Scientific Publisher.
2. Peter Grundle, Chemical Sensors, In Introduction for Scientists and Engineers, Springer-Verlag, ISBN 978-3-540-45743-5, 2007,
3. D A Skoog, F J Holler and T A Nieman, Principles of Instrumental Analysis. , J. Janata, Principles of Chemical Sensors, Springer; 1<sup>st</sup> edition 1989.
4. R W Cattrall, Chemical Sensors, Oxford University Press, 1999.
5. 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. Evans' diagrams. Intrinsic and

extrinsic forms of corrosion. Electrochemical methods for corrosion testing. Corrosion prevention by metallic, organic, inorganic coatings, corrosion inhibitors. Cathodic and anodic protection techniques. Corrosion in industries with reference to thermal power plants, concrete, 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**

Nomenclature, structures, and reactivities of heterocyclic compounds with special reference to five-membered heterocyclic compounds with one and two hetero atoms such as pyrrole, furan, thiophene, pyrazole, benzopyrazole, imidazole and thiazole. Chemistry and reactivity of six-membered heterocyclic compounds with one and two hetero atoms such as pyridine, pyrimidine, quinoxaline, quinoxalines. Chemistry and reactivity of bicyclic condensed ring systems such as indoles, and quinolines. Chemistry of selected industrially important heterocyclic compounds.

### **Recommended Books**

1. J. A. Joule, K Mills and GF Smith, Heterocyclic chemistry, III Ed., East West Press vt Ltd, ND.
2. A. R. Katrizky and JA Boulton, Advances in Heterocyclic chemistry, Vol 1-27, Academic Press, NY.
3. R.M. Acheson, An Introduction to the Chemistry of Heterocyclic Compounds, 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, 8<sup>th</sup> 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. Banwell, 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 Molecular Simulation and Chemoinformatics**

Model systems and interaction potentials. Studying small systems, periodic boundary conditions, truncating interaction potentials. Molecular dynamics; numerical integration of equations of motion; conserved quantities. Monte Carlo methods; importance sampling, Metropolis method. Measuring system properties; calculation of thermodynamic, structural and dynamical properties. Introduction to chemoinformatics. Representation of chemical compounds. Representation of chemical reactions. Data acquisition and processing. Databases and data sources in chemistry. Searching chemical structures. Quantum mechanical models. Molecular mechanics (empirical force field models). Semi-empirical implementations of molecular orbital theory.

### **Recommended Books**

1. D. Frenkel and B. Smit, Understanding Molecular Simulation, Academic Press; 2 edition , 2001.
2. M.P. Allen and D.J. Tildesley, Computer Simulation of liquids, Oxford University Press, USA; Reprint edition , 1989.
3. Alan Hinchliffe, Molecular Modeling for Beginners, John Wiley & Sons.
4. Andrew Leach, Molecular Modeling: Principles and applications, Prentice Hall, 2<sup>nd</sup> Ed.
5. J. Gasteiger, Chemoinformatics, John Wiley & Sons.
6. A. R. Leach and V. J. Gillet, An Introduction to Chemoinformatics, Springer.

### AC-4202 Industrial Inorganic Chemistry

Study of the following industries with reference to manufacture, availability of raw materials and applications. Hydrogen, oxygen, nitrogen, synthesis gas inert gases. Sulfur & sulfuric acid, sodium thiosulfate, alums. Ammonia, Urea, Calcium ammonium nitrate, nitric acid, phosphoric acid, phosphatic and other fertilizers, Bio fertilizers. Caustic soda, chlorine, chlor-alkali, hydrochloric acid, bleaching powder and soda ash. Glass, refractory, cements, enamels white wares, porcelain and glazes. Titanium dioxide, lead and zinc based pigments.

#### Recommended Books:

1. G.T. Austin, Shreve's Chemical Process Industries, McGraw-Hill Book co.
2. C.E. Dryden, Outlines of Chemical Technology, Affiliated East-West press.
3. Chemtech Volume –I-IV, Chemical Engineering Education Development Centre, I.I.T. Madras.

### AC-4203 Chemistry of Coordination Compounds

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, 2<sup>nd</sup> Ed., 1991.
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, 1967.
5. B.N.Figgis, Introduction to Ligand Field Theory

### AC - 4204 Synthetic Organic Chemistry

Introduction to synthesis, strategies of synthesis, basic principles for designing of conventional and green synthesis, techniques for synthesis of organic compounds. Important reagents ( such as dimethyl carbonate polymer supported per acids poly N-Bromosuccinimide etc) and reactions. of synthetic importance. Application of ionic liquids in organic synthesis. Identification of organic compounds by chemical and spectroscopic methods (IR, UV, NMR and Mass).

#### Recommended books

1. PT Anastas & J C Warner, Green Chemistry Theory & Practice ,Oxford University Press 1999.
2. B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A. R. Tuchell, Vogel's Text book of Practical Organic Chemistry ;
3. J.R. Dyer, Applications of Absorption Spectroscopy of Organic compounds; Prentice-Hall, Englewood Cliffs, N.J., 1965
4. I. Flemming and D.H. Williams, Spectroscopic methods in organic Chemistry; (4<sup>th</sup> edition), McGraw-Hill Book company (UK) Limited, 1987.

5. R.M. Silverstein, G.C. Bassler and T.C. Mornil Spectroscopic Identification of Organic Compounds; (5<sup>th</sup> edition), John Wiley & Sons, Inc, New York, 1991.

### AC – 4205 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, ISBN 1-58883-056-X.
2. Enzyme and Microbial Biosensors: Techniques and Protocols. Humana Press, Totowa, NJ.
3. Optical Biosensors: Present & Future by Frances S. Ligler (Editor), Chris A. Taitt.
4. Biosensors: Fundamentals and Applications by Anthony P.F. Turner, Isao karube, George S. Wilson.

### AC – 4206 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. Corrosion Inhibitors, Principles & Applications, V.S. Sastry, John Wiley & Sons.
2. Corrosion Vol. II Shreir L.L. Newness-Beetterworths, Edward Arnold Ltd. London.
3. Corrosion Inhibitors, C.C. Nathan, NACE, Houston, Texas.

### AC – 4207 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. Introduction of Solids by L.V. Azaroff, Tata McGraw hill Publishing Compl Ltd. Delhi.
2. Solid State Chemistry: An Introduction by Von Lesley Smart and Moore Elaine A, CRC Press.
3. Solid State Chemistry: selected Papers of C.N.R. Rao, Edited by S.K. Joshi and R.A. Mashelkar, world Scientific Series in 20<sup>th</sup> Series Chemistry, Vol. 4.
4. New Directions in Solid State Chemistry by C.N.R. Rao and J. Gopalkrishnan, Cambridge University Press, U.K.

### **CH – 5219 Design and Development of Heterogeneous Catalysts**

Structure of solid surfaces; Chemisorption and physisorption; Thermodynamics and kinetics of surface processes; Principles of heterogeneous catalysis; Preparation, characterization and classification; Structure and activity; Lattice imperfection; Geometric and electronic factors

Preparation 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 photocatalysis.

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 acids; Microbial production of antifungal antibiotics and broad spectrum antibiotics; Microbial transformation of steroids; Microbiological assay techniques and microbiological 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 Industrial Organic Chemistry**

Characteristics, classification and manufacture of important explosives and propellants. General perspectives, classification, uses and synthesis of representative pesticides. Requirements of a dye, chemical nature, classification, chemistry of representative important dyes, chemicals derived from biomass. Manufacture of industrially important alcohols, Colours and pigments, Pulp and paper. Synthesis of antipyretics, analgesics, antibiotics, antimalarial, anti-cancer and anti-AIDS drugs.

#### **Recommended Books**

1. G. N. Pandey, A textbook of Chemical Technology, Vol. II.
2. Emil Raymond Riegel, Industrial Chemistry.
3. Frank Hall Thorpe, Outlines of Industrial Chemistry.

### **AC-5102 Industrial Waste Management**

Sources, classification 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., 1985.
2. R. A. Corbitt, Started Handbook A Environmental Engineering; Mcgraw Hill New York, 1990.
3. A. M. Martin (ed), Bio-conservation of waste Materials to Industrial Products; Elsevier, Amsterdam, 1991.
4. O.P. Kharbanda and E. A. Stellworthy, Waste Management- towards a Sustainable Society, Gower, 1990.
5. E. Mortensen, Introduction to Solid Waste, Lecture Notes to Graduate Diploma in Environmental Engineering, University College, Ireland, 1990-1993.
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 2002.

**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. Transition Metal clusters B.F.G. Johnson, Wiley, 1980.
2. Organometallic clusters of Transition metals Robert H. Crabtree, John Wiley, 1988.
3. F.A. Cotton G. Wilkinson, Advance Inorganic Chemistry, John Wiley, 6<sup>th</sup> Ed.

**AC – 5104 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. Sorption and Biosorption by B. Volesky.
2. Environmental Microbiology by Raina M. Maier, Ion L. Peper, Charles P. Gerbe first edition, Amazon Publications.
3. Environmental Microbiology: Principal and Applications by Patrik K. Ijenbe.
4. Environmental Microbiology by A.H. Varnam M. Evans Black well Publishing.
5. Environmental Microbiology: Methods and protocol by Spencer, John F.T. Alicia L. Ragout de Spencer. Humana Press.

**AC-5105 Spectroscopic Identification of Organic Compounds**

Basic Principles of UV Spectroscopy, Application of Woodward-Fiser rule in interpretation of Organic compounds, Basic principles of IR Spectroscopy, Identification of Functional groups of various classes of organic compounds, Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect in interpretation of NMR spectra, Significance of decoupling phenomenon and Isotopic exchange reaction in NMR. Basic principles Mass Spectrometry, Application of fragmentation rule in characterization of organic compounds. Problems on structure elucidation of organic compounds based on spectral data.

**Recommended Books**

1. I Flemming & B.H. Williams, T.C. Mornil (4<sup>th</sup> edition) McGraw Hill Book Company 1987.
2. R.M. Silverstein, G.C. Bassler, T. C. Mornil (5<sup>th</sup> edition) John Wiley & Sons, Inc New York, 1991.

**AC – 5106 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 Biological 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 Waste water from specific industries, Case Studies.

### **Recommended Books**

1. G.L. Culp and R.L. Culp, New Concepts in Water Purification, Van Nostrand Reinhold Co. NY, 1978.
2. S.E. Jorgenson, Industrial wastewater Management, Elsevier Sci. Pub., NY, 1989.
3. G.N. Pandey and G.C. Carney, Environmental Engineering, Tata McGraw Hill Pub. Ltd., ND, 1994.
4. H.S. Peavy, D.R. Rowe and Techobanoglous, McGraw Hill Book Co. NY, 1985.

### **AC-5107 Petrochemicals**

An overview of chemistry of petroleum, primary raw materials for petrochemicals, hydrocarbon intermediates, crude oil processing and production of hydrocarbon intermediates. Non- hydrocarbon intermediates, chemicals based on methane, ethane and higher paraffin's- ethylene, propylene, C<sub>4</sub> olefins and diolefins-, benzene, toluene, and xylenes, Synthetic petroleum-based polymers. .

### **Recommended Books:**

S.Matar,L.F. Hatch; Chemistry of petrochemical process, Second edition(Mcgraw-Hill Handbook)  
Robert A. Meyers; Handbook of Petrochemicals Production Processes (Mcgraw-Hill Handbook);

### **CR - 5204 Electrical & Electronic Ceramics**

Symmetry and other criteria of ferro-electricity ,ferroelectric transitions in BaTiO<sub>3</sub>,PbTiO<sub>3</sub> and other related materials. Effect of compositional modifications and grain size. Relaxor ferroelectric. Performance categories of ceramic capacitors with typical compositions. Powder synthesis, electroding and packaging of discrete, multilayer and barrier layer capacitors.

Symmetry considerations and equations of state for piezoelectric and electrostrictive effects. Poled ferroelectric ceramics. Measurement of coupling factor and strain coefficient. Phase diagram, preparation and properties of PZT ceramics. Thin films of PZT. Piezoelectric positioners, loud speakers and gas ignitors. Pyroelectric and electro-optic ceramics with their applicatons. NTC and PTC thermistors, ZnO varistors.

Classification and structural features of super -ionic solids. Applications in oxygen sensoes, fuel cells, high density energy storage batteries. Magnetic ceramics and their crystal structure. Effect of composition on magnetic behaviour. Processing, microstructure, properties and applications of magnetic ceramics.

### **Recommended Books:**

1. R.C. Buchanan, Ceramic Materials for electronics, Marcel Dekker, New York.
2. L.L. Hench & J.K. West, Principles of electronic ceramics, John Wiley & Sons.

### **CH-5107 Membrane Separation Processes**

Principles, characteristic and classification of 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 (vapor) mixtures.

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

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

### **CH-5108 Interfacial and Colloidal Phenomena**

Thermodynamics of interfaces :Gibb's dividing surface ;Interfacial tension ;Gibb's adsorption isotherm ;Young- Laplace equation ;Wetting and contact angle ;Thin fluid films ;Combination of van der Waal's 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-5109 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.

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.

### **BC – 5114: Enzyme Engineering and Technology**

Source and structure of enzyme; Biosynthesis, regulation and control of enzyme in microorganisms

Kinetics of enzymatic reaction, Single and multiple substrate systems, systems, Inhibition – substrate, product and inhibitors, Analysis of kinetic data, Active and legend binding sites, Mechanism of 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.

### **BC-5101 Microbiological 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 – Principle and design; Characteristics of biological fluids.

### **BC-5102 Fundamentals of Microbiology and 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 Xenophobic compound; Steroid transformation.

### **MS - 5122 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 nanocomposites. Nanostructured materials in catalysis and electrocatalysis. Carbon clusters compounds, Preparation and properties of carbon nanotubes. Inorganic nanotubes and nanorods, nanoporous materials.

#### **Recommended Books:**

1. Nanostructures and Nanomaterials, G. Cao.
2. Introduction to Nanotechnology, Charles P. Poole Jr. and F.J. Owens.
3. Nanostructured Materials, Carl C. Coch.

### **MS - 5125 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 polymers. Multiphase polymeric systems. Interpenetrating networks. Graft and block copolymers. Molecular composites.

Conducting polymer: Types of conducting polymers. Chemical and electrochemical routes of synthesis. Doping and dedoping of conjugated polymers. Solatrons 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.