Curriculum & Syllabus for M.Sc. CHEMISTRY

(Four Semesters/ Full Time)

CURRICULUM

		SEMESTER I				
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1.	CHC6101	Organic Chemistry	3	0	0	3
2.	CHC6102	Thermodynamics and Electrochemistry	3	0	0	3
3.	CHC6103	Inorganic Chemistry	3	0	0	3
4.	CHC6104	Analytical Chemistry	3	1	0	4
5.		Elective				3*
6.	CHC6105	Organic Chemistry Practical	0	0	4	2
7.	CHC6106	Inorganic Chemistry Practical -I	0	0	4	2
8.	CHC6107	Physical Chemistry Practical - I	0	0	4	2
	CHC6108	Seminar		2		1
		Total credits				**23**

		SEMESTER II				
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	GEC6202	Research Methodology	**3**	**0**	**0**	**3**
2.	CHC6201	Synthetic Organic Chemistry	3	1	0	4
3.	CHC6202	Quantum Chemistry	3	1	0	4
4.	CHC6203	Coordination Chemistry	3	0	0	3
5.		Elective	3	1	0	4
7	CHC6204	Synthetic Organic Chemistry Practical	0	0	4	2
8.	CHC6205	Inorganic Chemistry Practical-II	0	0	4	2
9	CHC6206	Physical Chemistry Practical -II	0	0	4	2
		Total Credits				**24**

		SEMESTER III				
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1.	CHC7101	Advanced Organic Chemistry	3	0	0	3
2.	CHC7102	Physical Chemistry	3	0	0	3
3.	CHC7103	Advanced Inorganic Chemistry	3	0	0	3
		Elective				11**
	CHC7104	Internship (during summer vacation)				1
7	CHC7201	Project Phase -1				2***
		Total Credits				**21**

		SEMESTER IV				
S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1.	CHC7201	Project Phase -II	0	0		10
		Total Credits				**12*** **

Total credits

=80

*Elective should be chosen with credit not less than 3

**Elective should be chosen with total credit not less than 11

*** Credit for Project Phase ï I is incorporated in phase -II

LIST OF ELECTIVES

Course Code	**Course Title**	**L**	**T**	**P**	**C**
Basic Chemistry					
CHCY001	Green chemistry	3	0	2	4
CHCY002	Molecular spectroscopy	3	1	0	4

CHCY003	Photophysics and photochemistry	3	0	0	3
CHCY004	Photochemistry	3	0	0	3
Medicinal ,Pharmaceutical and Biological Chemistry					
CHCY005	Biochemistry	3	0	2	4
CHCY006	Pharmaceutical Technology	3	0	0	3
CHCY007	GMP, Quality Assurance and Validation	3	0	0	3
CHCY008	Medicinal and Pharmaceutical Chemistry	3	0	0	3
Materials and Technology					
CHCY009	Polymer Chemistry	3	0	2	4
CHCY010	Nanotechnology	3	0	2	4
CHCY011	Electrical Properties of Polymeric Materials	3	0	0	3
CHCY012	Polymer Structure and Property Relationship	3	0	0	3
CHCY013	Concepts and Techniques in Catalysis	3	0	0	3
CHCY014	Polymer Technology	3	0	0	3
CHCY015	Inorganic Chemical Technology	3	0	0	3
CHCY016	Organic Chemical Technology	3	0	0	3
CHCY017	Chlor-alkali Technology	3	0	0	3
CHCY018	Module Operations and module Processes	3	0	0	3
Energy ,Water and Environment					
CHCY019	Water and Waste Water Treatment	3	0	0	3
CHCY020	Solid Waste Management and Air Pollution	3	0	0	3
CHCY021	Industrial Electrochemistry	3	0	0	3
CHCY022	Corrosion and Corrosion Control	3	0	0	3
CHCY023	Electrochemical Protection Systems	3	0	0	3
CHCY024	Metal Coating Technology	3	0	0	3
CHCY025	Protective Coatings	3	0	0	3

CHCY026	Fuel Cells and Applications	3	0	0	3
CHCY027	Advanced Batteries and Systems	3	0	0	3
CHCY028	Electrochemical Material Science	3	0	0	3
CHCY029	Electrochemical Energy Conversion and Storage	3	0	0	3
CHCY030	Solar energy	3	0	0	3
Advanced/Special Electives					
CHCY031	Chemistry of Carbohydrates	3	0	0	3
CHCY032	Advanced Concepts in Organic Synthesis	3	0	0	3

CHC6101	**ORGANIC CHEMISTRY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To make the student conversant with

- The basic concepts in stereochemistry.
- Reactive intermediates in organic reactions
- Mechanism of nucleophilic substitution reaction
- concepts of aromaticity and aromatic electrophilic substitution reaction
- mechanism of addition reaction
- mechanism of elimination reactions

MODULE I	**STEREOCHEMISTRY I**	**9**

Introduction to molecular symmetry and point groups ï optical isomerism ï conditions for optical activity ï Newmann, Sawhorse and Fisher projection formulae ï Interconversion ï concept of chirality ï R,S-nomenclature - geometrical isomerism ï E,Z nomenclature ï determination of configuration of geometrical isomers using physical and chemical methods - optical activity of biphenyls, allenes and spiranes, cyclophanes, helical chirality - ANSA compounds.

MODULE II	REACTIVE INTERMEDIATES & REACTION MECHANISM	9
Formation and stability of carbonium ions, norbornyl cation and other non-classical carbocations and classical carbocations, Bredtôs rule - carbanions, carbenes, nitrenes, free radicals, arynes, ylides - methods of generation and reactivity and applications - Kinetic and nonkinetic methods to determine the reaction mechanism: Thermodynamic and Kinetic controlled reactions Non-kinetic methods -Kinetic methods ï methods of determining mechanism		
MODULE III	**NUCLEOPHILIC SUBSTITUTIONS**	**9**
S_N1, S_N2, Neighboring group participation and S_Ni, S_NAr mechanisms ï effects of substrate, attacking nucleophile, leaving group and solvent ï stereochemistry of nucleophilic substitution reactions ï substitutions at carbonyl, bridgehead, vinylic and allylic carbons, Ambident nucleophiles - O versus C alkylation ï activated aromatic nucleophilic substitution		
MODULE IV	**AROMATICITY AND AROMATIC ELECTROPHILIC SUBSTITUTION REACTIONS**	**9**
Aromaticity ï concept ï Huckel and Craig rules ï Aromatic and anti aromatic compounds ï benzenoid, non-benzenoid and homo aromatic compounds ï anti-aromaticity - Annulenes ï Aromaticity in cyclopentadienyl anion, tropolone, ferrocenes, fullerenes, azulenes, fulvenes, azirines, heteroaromatic systems and charged ring systems ï NMR and aromaticity - Reactions of aryl diazonium salts ï aromatic electrophilic substitution reactions and mechanisms.		
MODULE V	**ADDITION AND ELIMINATION REACTIONS**	**9**
Addition to carbon-carbon and carbon-hetero multiple bonds ï electrophilic, nucleophilic and free radical additions ï stereochemistry of addition to carbon-carbon multiple bonds ï orientation and reactivity, addition to conjugated systems and orientation ï addition to Ŭ,ƀ-unsaturated carbonyl groups ï E1, E2 and $E1_{CB}$ mechanisms ï stereochemistry of E2 elimination ï competition between elimination and substitution reactions ï orientation effects in elimination reactions ï effects of		

substrate structures, attacking base, leaving group and medium on E1 and E2 reactions ï pyrolytic eliminations - Chugaev and Cope eliminations ï Peterson's and Julia elimination.

			L – 45; Total Hours –45

REFERENCES:

1. Michael B. Smith and Jerry March, Advanced Organic Chemistry, Reactions, Mechanisms and Structure 7th Edition, Wiley Intersciences, New York, 2009.
2. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part A ï Structure and Mechanisms, 5th Edition, Springer, 2007.
3. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th Edition, Springer, 2007.
4. Morrison R.T., Boyd R.N. and Battacharjee S.K., Organic Chemistry, 7th Edition, Pearsons, 2007.
5. Eliel E.L. and Wilen S.H., Stereochemistry of Organic Compounds, John Wiley India, 2009.
6. Nasipuri D., Stereochemistry of Organic Compounds, 2nd Edition, Wiley Eastern Ltd., 1991.
7. Kalsi P.S., Stereochemistry of Organic Compounds, Wiley Eastern Ltd., New Delhi, 1992.
8. Peter Sykes, Guidebook to Mechanism in Organic Chemistry, Orient Longman, 2005.

OUTCOMES:

The students will be able to

- assign stereochemical configuration
- Distinguish the different types of organic reaction intermediates
- Postulate the mechanism of nucleophilic substitution reaction
- recognize the aromaticity and aromatic electrophilic substitution reaction
- suggest the mechanism of addition reaction
  depict the mechanism of elimination reactions

CHC6102	THERMODYNAMICS AND ELECTROCHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student conversant with

- laws of chemical thermodynamics
- applications of Vant Hoffôs equation in chemical thermodynamics
- application of partition function
- applications of onsager reciprocal relation
- various models of electrical double layer

  applications of Butler-Volmer equation and Tafel equation

MODULE I	CHEMICAL THERMODYNAMICS-1	9

First law of thermodynamics ï Joule-Thomson effect ï thermochemistry ï standard enthalpy changes ï standard enthalpies of formation ï second law of thermodynamics ï free energy and work function ï Maxwell relations ï third law of thermodynamics ï evaluation of absolute entropies of solids, liquids and gases.

MODULE II	CHEMICAL THERMODYNAMICS-2	9

Clausius-Clapeyron equation - *d*etermination of partial molar quantities - thermodynamic aspects of extract ion of metals- reduction of oxides and sulphides - Ellingham diagram and its significances - partial molar properties ï chemical potential ï vant Hoffôs equation ï Gibbs-Duhem equation.

MODULE III	STATISTICAL THERMODYNAMICS	9

Objectives of statistical thermodynamics ï probability ï microstates and macrostates for distinguishable and indistinguishable particles ï permutation and combinations ï Maxwell-Boltzmann statistics ï third law of thermodynamics and exception to this law

ï use of partition function for obtaining thermodynamic functions.		
MODULE IV	**NON-EQUILIBRIUM THERMODYNAMICS**	**9**
Steady state ï conservation of energy and mass ï entropy production and entropy flow in open system ï fluxes and forces ï transformation of properties of rates and affinity ï microscopic reversibility and Onsager reciprocal relation ï thermokinetic effect ï irreversible thermodynamics for non-linear regime.		
MODULE V	**ELECTROCHEMISTRY**	**9**
Ion-solvent and ion-ion interactions, ion transport in solutions ï electrochemical cells electrical double layer ï various models ï electrocapillary phenomena ï electrokinetic phenomena ï electroosmosis ï streaming potential and electrophoresis ï Tiselius apparatus ï kinetics of electrode processes ï Butler-Volmer equation - Tafel equation.		
		L – 45; Total Hours –45

REFERENCES:

1. Atkins P., and Paula J.D., Physical Chemistry, 7th Edition, Oxford University Press, London, 2002.
2. Alberty P.A. and Silbey R.U., Physical Chemistry, 1st Edition, John Wiley and Sons Inc., 1995.
3. Castellan G.W., Physical Chemistry, 3rd Edition, Narosa Publishing House, 2004.
4. Kuriacose J.C. and Rajaram J., Thermodynamics for Students of Chemistry, 3rd Edition, S. Chand and Co., New Delhi, 2001.
5. Crow D.R., Principles and Application of Electrochemistry, Chapman and Hall, 1988.

OUTCOMES:

The students will be able to comprehend the

- laws of chemical thermodynamics
- applications vant Hoffs equation in chemical thermodynamics

- application of partition function
- applications of onsager reciprocal relation and microscopic reversibility
- various models of electrical double layer
- applications of Butler-Volmer equation and Tafel equation

CHC6103	INORGANIC CHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student conversant with

- Periodic properties of elements ,
- Bonding in inorganic molecules,
- Types of non-valence forces,
- Concepts of non-aqueous solvents,
- Types of crystal structure.

MODULE I	ATOMIC STRUCTURE	9

Modern views on atomic structure ï Wave equation ï hydrogen atom and poly electron atoms, electronic configuration and term symbols, periodic properties of elements ï atomic size, ionization energy, electron affinity, electro negativity, covalent and ionic radii and magnetic properties.

MODULE II	COVALENT BOND	9

Valence bond theory ï hybridization and resonance ï diatomic and polyatomic systems - VSEPR theory - molecular orbital theory ï LCAO approximation for diatomic and polyatomic systems.

MODULE III	IONIC AND NON-VALENCE FORCES	9

vander waalsô forces ï hydrogen bond ï clathrates, metallic bond ï free electron

theory of metals, ionic solids ï lattice energy ï Born-Haber cycle.		
MODULE IV	**AQUEOUS AND NON-AQUEOUS CHEMISTRY**	**9**
Acid-base concepts, HSAB theory, super acids, non-aqueous solvents ï reactions in liquid ammonia, sulphuric acid, aprotic solvents - molten salts - electrode potentials and applications in inorganic systems.		
MODULE V	**CRYSTAL STRUCUTRE**	**9**
Radius ratio ï structures of AX, AX_2, A_2X_3, ABX_3 and A_2BX_4 type solids ï layer structure ï cadmium iodide - covalent solids ï diamond and graphite - Polymorphism and X-Ray Diffraction.		
		L – 45; Total Hours –45

REFERENCES:

1. Cotton F.A., Wilkinson G. and Gaus P.L., Basic Inorganic Chemistry, 3rd Edition, John Wiley and New York, 2003.
2. Atkins P.W., Overton T., Rourke, J., Weller, M. and Armstrong, F. Shriver and Atkins inorganic chemistry, 4th edition, Oxford University Press, 2006.
3. Huheey J.E., Keiter E.A. and Keiter R.L., Inorganic Chemistry, 4th Edition, Addision Wesley Publication, London, 1993.
4. Jolly W.L., Modern Inorganic Chemistry, 2nd Edition, McGraw ï Hill, Inc., 1991.
5. Lee J.D., Concise Inorganic Chemistry, 5th Edition, Blackwell Science, 2003.

OUTCOMES:

Students will be able to

- Demonstrate an understanding of the basic principles of periodicity.
- Demonstrate an understanding of VSEPR theory.
- Illustrate an understanding of the principles of molecular orbital theory.

- Recognize the different non valence forces and their influence on the physical & chemical properties
- Demonstrate an understanding of the basic principles of acid ï base chemistry and non ï aqueous solvents.
- Acquire the knowledge of structure of different types of solids.
- Learn structural arrangements and its stability based upon physical parameters.

CHC6104	ANALYTICAL CHEMISTRY	L	T	P	C
		3	1	0	4

OBJECTIVES:

To make the student

- identify the right analytical method for a given sample and information required
- state the principles and applications of different wet chemical methods
- analyze the principles, instrumentation and applications of spectroscopic methods
- describe the principles, instrumentation and applications of electroanalytical techniques
- state the principles and instrumentation of different separation techniques
- describe the different thermal analytical methods and their applications

MODULE I	QUANTITATIVE ANALYSIS	9

Volumetric analysis ï neutralization, precipitation, complexometric and redox titrations - Gravimetric analysis ï volatilization and precipitation methods - Types of error ï evaluation of analytical data - estimation of Na/K/Ca by flame photometer.

MODULE II	SEPARATION TECHNIQUES	9

Chromatography ï paper, column, TLC, GC, HPLC and GPC techniques ï ion exchange techniques ï Capillary electrophoresis ï principle, instrumentation and

applications- gel electrophoresis.		
MODULE III	**INTRODUCTION TO MOLECULAR SPECTROSCOPY**	**9**
Molecular spectroscopy: IR absorption - Fluorescence, phosphorescence and chemiluminescence methods - Atomic absorption and atomic fluorescence spectroscopy - Emission spectroscopy, flame photometry and ICP-AES principle, instrumentation and analytical applications.		
MODULE IV	**ELECTROANALYTICAL TECHNIQUES**	**9**
Conductometry and high frequency titrations - potentiometry, pH-metry and ion-selective electrodes - coulometry ï voltammetry - polarography, amperometric titrations and anodic stripping voltammetry - principle, practice and applications.		
MODULE V	**THERMAL METHODS OF ANALYSIS**	**9**
Thermal analytical techniques ï TGA, DTA, DSC,.DEA (dielectric thermal analysis) TOA (thermo optical analysis) Temperature-programmed Desorption/ Reduction/ Oxidation/ Sulfidation (TPD / TPR / TPO / TPS), ï principle, instrumentation and Applications		
		L – 45; T – 15; Total Hours –45

REFERENCES:

1. Skoog D.A., West D.M., Holler F.J. and Crouch S.R., Fundamentals of Analytical Chemistry, 8th Edition, Thomson Brooks/Cole Publication., Singapore, 2004.
2. Willard H.H., Merritt L.L., Dean J.A. and Settle F.A., Instrumental Methods of Analysis, 7th Edition, CBS Publication, New Delhi Reprint, 2004.
3. Skoog D.A., Holler F.J. and Nieman T.A., Principles of Instrumental Analysis, 5th Edition, Harcourt College Publication., Singapore, 1998.
4. Christian G.D., Analytical Chemistry, 6th Edition, John Wiley, Singapore, 2003.
5. Fifield F.W. and Kealey D., Principles and Practice of Analytical Chemistry, 5th Edition, Blackwell Publication, London, 2000.

6. Settle F. (Editor), Handbook of Instrumental Techniques for Analytical Chemistry, Pearson Education, Singapore, 2004.

OUTCOMES:

The student will be able to

- Identify the proper method and do the various chemical analysis
- isolate the compounds in a mixture by chromatographic techniques
- interpret the spectral data like UV-Visible,IR,
- apply electro analytical techniques
- interpret the thermal analysis data

CHC6105	ORGANIC CHEMISTRY PRACTICAL	L	T	P	C
		0	0	4	2

OBJECTIVES:

To make the student conversant with

- Separation of two component mixture
- analyze the functional groups present in simple organic compounds.
- Purification techniques of organic solvents and reagents

List of Experiments

1. Qualitative analysis of simple organic compounds
2. Separation of organic compounds with two component mixtures and its qualitative analysis.
3. Purification of organic solvents and reagents - Purification of liquids by distillation ï Purification of solids by recrystallization ï Determination of melting point ï Determination of boiling point by capillary method.

P - 60; Total Hours –60

REFERENCES:

1. A.I. Vogel, Vogelôs Textbook of Practical Organic Chemistry, 5th Edition, Prentice Hall, 2008.
2. V.K Ahluwalia, R. Agarwal Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2000.

OUTCOMES:

At the end of the course, the student will be able to

- Separate the different component mixtures of simple organic compounds.
- Analyze the functional groups present in simple organic compounds
- Purify the organic compounds by using recrystallisation and distillation techniques

CHC6106	INORGANIC CHEMISTRY PRACTICAL-I	L	T	P	C
		0	0	4	2

OBJECTIVES:

The students will be trained

- the purification process such as distillation, extraction, etc.
- to identify individual common and rare cations present in the given mixture
- to estimate the chloride ions present in water
- to estimate the various ions by titrimetry
- to estimate the ions such as iron, cobalt, nickel, chromium and manganese and spectral techniques

List of Experiments

1. Water distillation and solvent extraction
2. Semi-micro qualitative analysis: Analysis and identification of two common and two rare cations in a mixture including spot test confirmation
3. Estimation of chloride in water by Mohrûs method
4. Complexometric tirtrations: Estimation of Ca^{2+}, Mg^{2+}, $Mn^{2+}$and Zn^{2+}
5. Spectrophotometric analysis of iron, cobalt, nickel, chromium and manganese

			P - 60; Total Hours –60

REFERENCES:

1. Monograph on Green Chemistry Laboratory Experiments, Green Chemistry Task Force Committee, Department of Science and technology, India.
2. Rakesh K. Sharma, Indu Tucker Sidhwani and Mihir K. Chaudhuri, Green Chemistry Experiments: A Monograph, I K International Publishing House; 1st Edition, 2012.
3. J. Mendham, R.C. Denney, M.J.K. Thomas David and J. Barnes, Vogel's Quantitative Chemical Analysis, 6th Edition, Prentice Hall, 2000.
4. V.V. Ramanujam, Inorganic Semimicro Qualitative Analysis; 3rd Edition, The National Publishing Company, Chennai, 1974.
5. Mukhopadhyay R and Chatterjee P, Advanced Practical Chemistry, Books & Allied (P) Ltd., 2007.
6. Dinesh Sharma, A Handbook of Analytical Inorganic Chemistry, International Scientific Publishing Academy, India, 2005.

OUTCOMES:

The students will be able to

- Distill water and other organic solvents
- Analyze the common and rare cations present in the given mixture

- Estimate the ions present in the sample by titrimetry
- Estimate the ions such as iron, cobalt, nickel, chromium and manganese present in the sample by spectral methods

CHC6107	PHYSICAL CHEMISTRY PRACTICAL- I	L	T	P	C
		0	0	4	2

OBJECTIVES:

To make the students trained to

- Determine the equivalent conductance of strong electrolytes
- Verify the Ostwald dilution law
- do conductometric titrations
- Determine the rate constant of first and second order reactions
- Verify Beer ï Lambert law
- Determine the molecular weight of a polymer

List of Experiments

1. Equivalent conductance of strong electrolytes and verification of Debye Huckel Onsager equation
2. Verification of Ostwald dilution law using weak acid and determination of its dissociation constant
3. Conductometric titrations: acid-base and precipitation titrations
4. Determination of rate constant
5. Saponification of oils and fats
6. Temperature dependence of solubility of benzoic acid in water and DMSO
7. Determination of activity coefficients of an electrolyte at different molalities
8. Verification of Beer-Lambert equation
9. Determination of molecular weight of a polymer by viscometry

			P - 60; Total Hours –60

REFERENCES:

1. V.D. Athawale, Experimental Physical Chemistry, New Age International, 2007.
2. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand and Co., New Delhi, 2007.
3. B. Viswanathan and P.S. Raghavan, Practical Physical Chemistry, Viva Books Pvt. Ltd., 2005.
4. D.R. Satiya, Practical Chemistry, 2nd Edition, Allied Publishers, Madras, 1991.
5. D.P. Shoemaker and C.W. Garland, Experiments in Physical Chemistry, McGraw Hill, London, 1962.

OUTCOMES:

The students will be able to

- Determine the equivalent conductance of strong electrolytes
- Verify the Ostwald dilution law
- do conductometric titrations
- Determine the rate constant of first and second order reactions
- Verify Beer ï Lambert law
- Determine the molecular weight of a polymer

GEC6202	**RESEARCH METHODOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

The students will be trained to

- Select and Define a research problem
- Describe the Methodology of Research
- Acquire good laboratory practices
- Operate the software for Programming techniques
- Analyze and Interpret the Results
- Demonstrate the Plagiarism check by turtin

MODULE I	**RESEARCH METHODOLOGY- AN INTRODUCTION**	**9**

Research: Objectives, Motivation and types - Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Problems Encountered by Researchers - Introduction to ethics, scientific conduct and misconduct, Misconduct and why it occurs, Fabrication, Authorship issues, The investigation and punishment of scientific misconduct.

MODULE II	**GOOD LABORATORY PRACTICES AND SAFETY**	**9**

Introduction: History, definition, Principles, Good Laboratory Practices (GLP) and its application GLP training: Resources, Rules, Characterization, Documentation, quality assurance, Resources, Facilities: building and equipment, Personnel, GLP and FDA, Stepwise implementation of GLP and compliance monitoring. Safety Symbols, Science Safety Rules- Dress Code, First Aid, Heating and Fire Safety

MODULE III	**PROGRAMMING TECHNIQUES**	**9**

Data analysis using Excel, Origin and Sigma plot Analyzing the chemical data and drawing chemical structures using Chemdraw and Chemsketch. Basics of C and C++ programme ï MATLAB ï Numerical Methods ï Ordinary Differential Equation ï Partial Differential Equation ï Runge Kutta Method.

MODULE IV	**INTERPRETATION OF RESULTS AND ANALYSIS**	**9**

Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective) and cross verification,

correlation with published results, discussion, outcome as new idea, hypothesis, concept, theory, model etc.

Conceptions of error of measurement, true score theory and generalisability theory. Measures of central tendency or averages ï mean median and mode. Measures of dispersion ï range, variance, and standard deviation: The normal distribution and the normal probability curve.

MODULE V	**SCIENTIFIC WRITING, TECHNICAL PUBLICATION AND RESEARCH PROPOSAL**	**9**

Different types of scientific and technical publications in the area of research, and their specifications, Ways to protect intellectual property ï Patents, technical writing skills, definition and importance of impact factor and citation index - assignment in technical writing, The research problem, finding related literature, computer generated references sources and the research project, model research proposal. Plagiarism checking by Turtin ï demonstration

L – 45; Total Hours –45

REFERENCES:

1. Essentials of Research Design and Methodology Geoffrey R. Marczyk, David DeMatteo, David Festinger, 2005 John Wiley & Sons Publishers, Inc
2. Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, 2nd Edition, Irwin H. Segel, 1976 John Wiley & Sons Publishers, Inc
3. Guide to Publishing a Scientific paper, Ann M. Korner, 2004, Bioscript Press.
4. P Laake, H B Benestad, B R Olsen. Research Methodology in the medical and biological sciences. Academic Press, 2007.
5. R Arora. Encyclopaedia of Research Methodology in Biological Sciences. Anmol Publishing, 2004.
6. Kothari C.R., Research Methodology, Methods and Techniques, Wiley Eastern Ltd., NewDelhi, 1991.
7. Coghill M. and Gardson L.R., The ACS Style Guide Effective Communication

of Scientific Information, 3rd Edn., Oxford University Press, 2006.

8 Willa Y. Garner, Maureen S. Barge, James, P, Good Laboratory Practice Standards: Applications for Field and Laboratory Studies (ACS Professional References Book).

OUTCOMES:

At the end of this course, the students should be able to:

- recognize the basic concepts of research and its methodologies
- Identify appropriate research topics
- Select and define appropriate research problem and parameters
- Prepare a project proposal (to undertake a project)
- Organize and conduct research (advanced project) in a more appropriate manner
- Write a research report and thesis

CHC6201	SYNTHETIC ORGANIC CHEMISTRY	L	T	P	C
		3	1	0	4

OBJECTIVES:

To impart

- Knowledge of the increasingly important role played by organic and transition metals reagents and catalysts with their corresponding proposed reaction mechanisms.
- Knowledge for rational mechanism-based design of synthetic strategies for new and novel organic reactions.

MODULE I	STEREOCHEMISTRY II	9

Conformational analysis and reactivity of cyclic and acyclic systems ï topicity ï prochirality - enantiotopic and diastereotopic atoms, groups and faces ï asymmetric synthesis - stereoselective, stereospecific reactions - enantioselective synthesis - optical purity and enantiomeric excess - Cramôs rule ï Prelogôs rule ï Fehn Annôs model - methods of resolution ï kinetic, dynamic kinetic resolution - Sharpless epoxidation		
MODULE II	**MOLECULAR REARRANGEMENTS**	**9**
General mechanistic considerations, nature of migration, migratory aptitude - nucleophilic, electrophilic and free radical rearrangements ï Wagner-Meerwein, Demyanov, Favorskii, Fritsch-Butternberg - Wiechell, Neber, Hofmann, Curtius, Beckmann, Schmidt, Lossen, Wolff, Baeyer ï Villiger, Stevens, Wittig, Chapman, Wallach, Orton, Bamberger, Pummerer and Von Ritchter rearrangements.		
MODULE III	**REAGENTS IN ORGANIC SYNTHESIS**	**9**
Synthesis and application of - Diborane, $LiAlH_4$, $NaBH_4$, DIBAH, Bu_3SnH, SeO_2, NBS, DCC, PCC, Swern, Dess Martin, DDQ, LDA, Gilmanôs reagent, phase transfer catalysts, Wittig, Tebbe, Wilkinsonôs catalysts, Palladium and copper catalysts in coupling (Suzuki, Heck), Low valent titanium(McMurry), Co(Salen) complex (Jacobsen), BINAL(H), BINAP, Grubb and Schrock catalyst (Olefin Metathesis).		
MODULE IV	**MULTISTEP SYNTHESIS**	**9**
Strategies for synthetic analysis and planning ï functional group introduction, removal and interconversion - activating groups ï protection and deprotection of hydroxyl, amino, carbonyl and carboxylic acid groups - retrosynthetic analysis, synthons and synthetic equivalent groups - C-C, C=C, C-O bond forming reactions ï linear and convergent synthesis - control of stereochemistry ï reactive umpolung - analysis and synthesis of a few target molecules.		
MODULE V	**APPLICATIONS OF ORGANIC SPECTROSCOPY**	**9**
Structure determination of organic compounds - introduction to NMR spectroscopy-		

interpretation of molecular structure by ^{1}H, ^{13}C and Mass spectroscopic techniques.			
			L – 45; T-15; Total Hours –60

REFERENCES:

1. Jerry March, Advanced Organic Chemistry, 4th Edition, Wiley-Interscience, New York, 2007.
2. Morrison R.T., Boyd R.N. and S. K. Battacharjee Organic Chemistry, 7th Edition, Pearsons, 2007.
3. Lowry T.H. and Richardson K.S., Mechanism and Theory in Organic Chemistry, 2nd Edition, Harper and Row Publishers, 1981.
4. Michael B. Smith and Jerry March, Advanced Organic Chemistry, Reactions, Mechanisms and Structure 7th Edition, Wiley Intersciences, New York, 2009.
5. Finar I.L., Organic Chemistry, Volume II, 5th Edition, ELBS Longmann Group Ltd., London, 1980.
6. Stuart G. Warren, Organic Synthesis: The Disconnection Approach Wiley India, 2009.
7. Achesen R.M., Chemistry of Heterocyclic Compounds, Wiley Eastern, 1973.
8. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part A ï Structure and Mechanisms, 5th Edition, Springer, 2007.
9. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th Edition, Springer, 2007.

OUTCOMES:

The student will

- acquire the skills for correct stereo chemical assignment and interpretation in the cases of complex organic molecules.
- be equipped as a more competent synthetic organic chemist due to being capable of correct mechanistic approach and design of a synthesis.

CHC6202	**Quantum Chemistry**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

OBJECTIVES:

To make the student

- Å understand the origin of classical mechanics and the background of quantum mechanics
- Å derive and use of Schrodinger equation to simple systems
- Å able to construct the molecular orbital for molecules
- Å gain the basics of quantum statistics and how it is applied to systems of chemical interest
- Å learn the concepts symmetry elements and operations, able to assign the point group of molecules

MODULE I	**INTRODUCTION TO QUANTUM CHEMISTRY**	**9**

Review of essential mathematical concepts. General introduction to classical and quantum mechanics. Classical mechanics: black body radiation, photo electric effect, heat capacity of solids and inadequacy of classical mechanics. Quantum mechanics: historical background, principles and postulates. Operators and their properties. Eigen value ï Eigen functions.

MODULE II	**SOLUTIONS OF SCHRODINGER EQUATION AND APPROXIMATE METHODS**	**9**

Schrodinger equation, Discussion of solutions of the Schrodinger equation to few systems: particle in a box, the rigid rotor, the harmonic oscillators and the hydrogen atom.

Approximate methods: The variation theorem, linear variation principle. Perturbation

theory (introductory concept, degenerate and non-degenerate). Application of variation methods to the helium atom. Concept of Hartree Fock/SCF methods.

MODULE III	**QUANTUM AND PHOTOCHEMISTRY OF MOLECULES**	**9**

Born Oppenheimer approximation; VB and MO theory; Applications to $H2^+$ and H2 molecules. MO treatment of homo- and hetero nuclear diatomic molecules. Hukel molecular orbital theory and its application to ethylene, butadiene, benzene and cyclic systems.

Photochemistry: Law of photochemistry, Jablonski diagram, quantum yield, excimer and exciplex and quenching, Stern-Volmer relation, Photo induced electron and energy transfer, FRET (concept only); Measurement of fluorescence, phosphorescence and lifetime (introductory concept), chemiluminescence ï fluorescence based sensors and imaging applications.

MODULE IV	**QUANTUM STATISTICS**	**9**

Recapitulation of classical statistics and partition function, relationship between partition and thermodynamic functions, thermodynamic probability, derive the expression for translational, rotational, vibrational and electronic partition functions and its simple application to mono atomic gases (ortho-para hydrogen) and solids, Compare and distinguish between Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Applications of Bose-Einstein and Fermi-Dirac statistics.

MODULE V	**MOLECULAR SYMMETRY AND GROUP THEORY**	**9**

Symmetry elements and symmetry operations ï types of groups- group postulates - classification of point groups- Schoenflies symbol ï matrix representation of symmetry operations and point groups, representation of point group, reducible and irreducible representations, the great orthogonal theorem ï character table, construction of character table for C_{2v} and C_{3v} groups- symmetry adopted linear combinations (SALCs), assignments of point groups and geometry of various molecules- applications of group theory.

			L – 45; T – 15; Total Hours –60

REFERENCES:

1. McQuarrie D.A., Quantum Chemistry, First Edition, University Science Books, Mill Valley, California, 2003.
2. Levine I.N., Quantum Chemistry, Fifth Edition, Pearson Education, 2000.
3. Hanna M.W., Quantum Mechanics in Chemistry, Third Edition, Addition Wesley, London, 1981.
4. Prasad R. K., Quantum Chemistry, Fourth Edition, New Age International Publishers, 2008.
5. Chandra A. K., Introductory to Quantum Chemistry, Fourth Edition, Tata McGraw Hill Education Private Ltd.
6. C.L. Tien., J.H.Lienhard., Statistical thermodynamics, Revised Printing Edition, Hemisphere Publishing Corporation, Oxford.
7. N.M. Laurendeau, Statistical Thermodynamics, fundamentals and applications, 2005, Oxford University Press, Oxford.
8. Albert Cotton F., Chemical Applications of Group Theory, Third Edition, Wiley India Pvt Ltd.
9. P.K.Bhattacharya, Group theory and its Chemical Applications, 2nd Edn, Himalaya Publications, India.2012
10. A. Vincent., Molecular Symmetry and Group theory, A programmed introduction to chemical applications, 2nd Edition, Wiley,.2001

OUTCOMES:

The student will gain:

- Å Basic aspects of quantum chemistry of atoms and molecules
- Importance of quantum chemistry and how to apply this knowledge to atomic and molecular structure
- Able to understand clearly the microscopic and inner details of chemical reactions in chemistry point of view

- In depth knowledge and understanding of photochemical reactions
- Assign the symmetry elements and point group of molecules/ion/complexes
- Indentify the symmetry in molecules and explain the character table of C_{2v} and C_{3v} point groups

CHC6203	CO-ORDINATION CHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the students conversant with the

- Nomenclature and isomerism of coordination compounds
- Bonding theories of coordination compounds
- Spectra of coordination compounds
- Magnetic properties of coordination compounds
- Various reactions of coordination compounds
- Chemistry of lanthanides and actinides

MODULE I	COORDINATION COMPOUNDS	9

Nomenclature, structure and stability ï geometry and isomerism - absolute configuration ï ORD and CD spectra - stability of complexes ï thermodynamic aspects, successive and overall formation constants ï experimental methods.

MODULE II	THEORIES OF METAL- LIGAND BOND	9

Valence bond theory ï hybridization - crystal field theory ï crystal field splitting, crystal field stabilization energy ï thermodynamic and structural implications, Jahn Teller effects, ligand field theory - molecular orbital theory ï pi bonding.

MODULE III	SPECTRA OF CO-ORDINATION COMPOUNDS	9

Free ion terms, transformation in crystal field, energy diagrams in weak and strong

field cases ï Tanabe ï Sugano diagrams, selection rules - magnetic properties ï Van Vleck equation, magnetic susceptibility ï experimental methods - ESR spectra of transition metal ions.		
MODULE IV	**REACTIONS OF CO-ORDINATION COMPOUNDS**	**9**
Inert and labile complexes - substitution reactions in square-planar and octahedral complexes - electron transfer reactions - photochemical reactions.		
MODULE V	**COMPARATIVE CHEMISTRY OF OXIDATION STATES OF d AND f BLOCK ELEMENTS**	**9**
Lanthanides-occurrence, isolation, lanthanide contraction, oxidation states, spectral and magnetic properties, co-ordination complexes, actinides, comparative chemistry with transition metals and lanthanides.		
		L – 45; Total Hours –45

REFERENCES:

1. Cotton F.A., Wikinson G. and Gaus P., Basic Inorganic Chemistry, 3rd Edition, John Wiley and Sons, 2003.
2. Shriver D.F. and Atkins P.W., Inorganic Chemistry, 3rd Edition, (ELBS), Oxford University Press, Oxford, 2004.
3. Huheey J.E., Keiter E.A. and Keiter R.L., Inorganic Chemistry, 4th Edition, Addison Wesley Publication, London, 1993.
4. Cotton F.A., Wikinson G., Murillo C.A. and Bochmann M., Advanced Inorganic Chemistry, 6th Edition, John Wiley and Sons, New York, 2003.
5. Jolly W.L., Modern Inorganic Chemistry, 2nd Edition, McGraw Hill Inc., 1991.
6. Meissler G.L. and Tarr D.A., Inorganic Chemistry, 3rd Edition, Pearson Education, Singapore, 2004.

OUTCOMES:

Students will be able to

- Write the nomenclature of a coordination complex
- Find the number of isomers possible for coordination compound
- illustrate an understanding of the principles of theories of metal-ligand bond.
- demonstrate an understanding of spectra of coordination compounds.
- analyze the spectra of transition metal ions.
- analyze Tanabe ï Sugano diagrams.
- interpret the stability of complexes.
- understand the substitution reactions in transition metal complexes.
- demonstrate an understanding of chemistry of ódôand ðfôblock elements.
- analyze and compare the transition metals and lanthanides

CHC6204	SYNTHETIC ORGANIC CHEMISTRY PRACTICAL	L	T	P	C
		0	0	4	2

OBJECTIVES:

To make the students

- Identify organic compounds by TLC technique and purify them by column chromatography.
- expertise in multi step synthesis of organic compounds.

List of Experiments

1. Identification and purification of organic compounds by thin layer and column chromatographic techniques.
2. Single step and multistep synthesis of organic compounds - isolation and characterization of the products by various spectroscopic techniques.

P - 60; Total Hours –60

REFERENCES:

1. A.I. Vogel, Vogel's Textbook of Practical Organic Chemistry (4th Edition), Longmann group, 2008.
2. N.S. Gnanapragasam, G. Ramamurthy, Organic Chemistry ï Lab manual, S. Viswanathan Co. Pvt. Ltd., 1998.
3. V.K. Ahluwalia S Dhingra Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press, 2000.
4. Robert M. Silverstein, Francis X. Webster, David Kiemle, Spectrometric Identification of Organic Compounds, 7th Edition, Wiley, 2005.

Kemp W., Organic Spectroscopy, 3rd Edition, ELBS, McMillan, London, 1991.

OUTCOMES:

The students will be able to

- Independently perform multi step organic synthesis.
- Identify the synthesized compounds by TLC and purify it by column chromatography.

CHC6205	INORGANIC CHEMISTRY PRACTICAL-II	L	T	P	C
		0	0	4	2

OBJECTIVES:

The students will be trained to

- estimate the metal components present in alloys
- prepare different complexes
- characterize the complexes by spectral techniques
- synthesis of green reagents

List of Experiments

1. Estimation of alloys by gravimetry and titrimetry: brass (Cu & Zn), bronze (Cu & Sn) and ferro nickel (Fe & Ni)
2. Complex preparation and characterisation by UV-Visible and FT-IR spectroscopic techniques
   - (i) Preparation of 1-acetyl ferrocene
   - (ii) Preparation of bis(acetylacetanato)copper(II)
   - (iii) Preparation of tris(acetylacetanato)iron(III)
   - (iv) Preparation of tris(acetylacetanato)manganese(III)
   - (v) Solvent free and one pot synthesis of phthalocyanine complex of copper(II)
   - (vi) Synthesis of tetrabutyl ammonium tribromide (TBATBP) - A green reagent and its application

			P - 60; Total Hours –60

REFERENCES:

1. Monograph on Green Chemistry Laboratory Experiments, Green Chemistry Task Force Committee, Department of Science and technology, India.
2. Rakesh K. Sharma, Indu Tucker Sidhwani and Mihir K. Chaudhuri, Green Chemistry Experiments: A Monograph, I K International Publishing House; 1st Edition, 2012.
3. J. Mendham, R.C. Denney, M.J.K. Thomas David and J. Barnes, Vogel's Quantitative Chemical Analysis, 6th Edition, Prentice Hall, 2000.
4. V.V. Ramanujam, Inorganic Semimicro Qualitative Analysis; 3rd Edition, The National Publishing Company, Chennai, 1974.
5. Mukhopadhyay R and Chatterjee P, Advanced Practical Chemistry, Books & Allied (P) Ltd., 2007.
6. Dinesh Sharma, A Handbook of Analytical Inorganic Chemistry, International

Scientific Publishing Academy, India, 2005.
OUTCOMES:
The students will be able to • estimate the various metal ions present in alloys by titrimetry and gravimetry • prepare different complexes • characterize the complexes by spectral techniques • synthesis green reagents

CHC6206	**PHYSICAL CHEMISTRY PRACTICAL- II**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

OBJECTIVES:

To make the students

- expertise in the applied concepts of volumetric titrations, electrochemistry, phase equilibrium, adsorption, etc.
- draw structures and graph using softwares and prepare reports

List of Experiments

1. EMF measurement
2. Potentiometric titrations
3. Acid base titration by pH metry
4. Redox and precipitation titrations
5. Determination of CST in phenol-water system
6. Determination of activity coefficients of an electrolyte at different molalities

7. Determination of sucrose content in cane sugar by polarimetry
8. Determination of DEp of a redox system by cyclic voltametry
9. Verification of Freundlich isotherm - Adsorption of acetic acid, oxalic acid on activated carbon
10. Experiments on electroplating and electroless plating.
11. Uses of computer packages: Microsoft (word, excel and powerpoint), origin, chemsketch and chemdraw

			P - 60; Total Hours –60

REFERENCES:

1. V.D. Athawale, Experimental Physical Chemistry, New Age International, 2007.
2. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand and Co., New Delhi, 2007.
3. B. Viswanathan and P.S. Raghavan, Practical Physical Chemistry, Viva Books Pvt. Ltd., 2005.
4. D.R. Satiya, Practical Chemistry, 2nd Edition, Allied Publishers, Madras, 1991.
5. D.P. Shoemaker and C.W. Garland, Experiments in Physical Chemistry, McGraw Hill, London, 1962.

OUTCOMES:

The students will be able to

- determine the EMF of any cell
- measure the adsorption capacity of various materials
- draw the phase diagram for 2 and 3 component systems and analyze it
- draw chemical structures using chemsketch and chemdraw
- draw graphs using excel and origin software
- prepare the final dissertation report using MS word by themselves

CHC7101	ADVANCED ORGANIC CHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the students conversant with

- the structure and synthesis of various natural compounds.
- all major types of organic name reaction with mechanisms.
- all types of pericyclic and photochemicals reactions with its applications.

MODULE I	CARBOHYDRATES, PROTEINS, NUCLEIC ACIDS	9

Monosaccharides ï classification ï cyclic structure of monosaccharides ï mutarotation ï epimers ï glycals - glycosides ï Ferrier rearrangement ï anomers ï Hudson rules ï derivatives of monosaccharides ï Vitamin C - disaccharides ï trisaccharides ï polysaccharides ï nucleic acids : amino acids ï classification ï peptides - proteins ï classification - structure.

MODULE II	NAME REACTIONS	9

Stork enamine, Birch reduction - Aldol, Claisen, Benzoin, Stobbe condensations - Michael addition, Mannich reaction, Wittig, Robinson annulation, Dieckmann, Shapiro, Koenigs-Knorr, Polonowski, Hofmann-Loffler, Reformatsky, Darzens, Simmons-Smith, Gattermann-Koch, Mitsunobu reaction, Buchwald and Hartwig.

MODULE III	ORGANIC PHOTOCHEMISTRY	9

Thermal vs photochemical reactions ï n-pi* and pi-pi* transitions - allowed and forbidden transitions ï Jablonski Diagram - fluorescence and phosphorescence ï internal conversion and intersystem crossing -ï sensitization, quenching and quantum efficiency ï photochemical reaction of ketones ï Norrish type I and II, Paterno-Buchi and Barton reactions - photochemical oxidation and reduction, photochemical reactions of olefins - cis-trans isomerisation, di-pi-methane and Fries rearrangements.

MODULE IV	PERICYCLIC REACTIONS	9
Definition ï electrocyclic, cycloaddition, sigmatropic, chelotropic and ene reactions - Woodward-Hoffmann rules ï Frontier orbital, Mobius-Huckel and orbital symmetry correlation approaches - Stereospecificity and regiospecificity of pericyclic reactions ï pericyclic reactions in organic synthesis ï Diels-Alder reaction, 1,3-dipolar cycloaddition, Claisen, Cope, Aza cope.		
MODULE V	**HETEROCYCLES, ALKALOIDS, TERPENOIDS AND STEROIDS**	**9**
Nomenclature of condensed heterocycles - Synthesis and reactivity of indoles, quinolines, isoquinolines, benzopyran, chromones, coumarins - Alkaloids ï classification - synthesis of cocaine and atropine - terpenoids - Classification ï isoprene rule ï stereochemistry and synthesis of car-3-ene, menthol, zingiberene ï Steroids ï classification ï structure and stereochemistry of cholesterol, synthesis of cortisone, estrone.		
		L – 45; Total Hours –45

REFERENCES:

1. Jerry March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 4th Edition, Wiley Inter Science, New York, 2007.
2. Fleming I., Frontier Orbital and Organic Chemical Reactions, Wiley, 1976.
3. Graham Solomons T.W., Organic Chemistry, Volume I and II, 5th Edition, John Wiley and Sons, New York, 1992.
4. Finar I.L., Organic Chemistry, Volume II, 5th Edition, ELBS Longman Group Ltd., London, 1975.
5. Sankararaman S., Pericyclic reactions ï a Textbook: Reactions, Applications and Theory, Wiley-VCH, 2005.
6. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part A ï Structure and Mechanisms, 5th Edition, Springer, 2007.
7. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th Edition, Springer, 2007.

OUTCOMES:

The student will

- acquire the skill of relating all the biomolecules /natural products and propose synthetic routes.
- be skilled in photochemical and pericyclic reaction mechanism.

CHC7102	PHYSICAL CHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student learn

- the basic aspects of both experimental and theoretical chemical kinetics
- derive rate expressions for acid-base catalytic systems and enzyme catalysed systems
- Different type of phase equilibria
- write mechanisms for reactions catalysed by transition metal complexes
- relate the catalytic activity of heterogeneous catalysts to their physicochemical properties

  learn the principle and instrumentation of surface characterization techniques

MODULE I	KINETICS	9

Methods of determining rate laws ï reversible, consecutive and competing reactions ï Vant Hoffôs rule, Collision theory, *Bodenstein's* Theory, theory of absolute reaction rates ï transmission coefficient ï thermodynamic formulation of reaction rates ï kinetics ï classical treatment ï principle of microscopic reversibility - photochemical kinetics, ï fast reactions ï luminescence and energy transformations ï study of

kinetics by stopped flow techniques ï flash photolysis.		
MODULE II	**MECHANISM OF SOLUTION PHASE REACTION**	**9**
Lindemanôs theory ï Hinshelwood, Kassel and Slater treatments, reaction rates in solution ï effect of dielectric constant and ionic strength ï kinetic isotope effect ï linear free energy relationships ï Hammett equation ï Taft equation		
MODULE III	**PHASE EQUILBRIA**	**9**
Two component systems ï classification ï solid-gas (dehydration and rehydration of $CuSO_4$, $5H_2O$), solid-liquid systems ï benzene-picric acid system, salt-water system fractional distillation ï three component systems involving liquid-liquid equilibria		
MODULE IV	**CATALYSIS**	**9**
Acid-base catalysis ï general scheme ï Arrhenius complex ï Vant Hoffôs complex ï specific and general catalysis ï catalytic constants ï Bronsted relationship ï Hammett acidity functions ï mechanism of acid-base catalysed reaction ï catalysis by transition metal ions and their complexes ï supported transition metal complexes as catalysts ï enzyme catalysis ï theory and applications.		
MODULE V	**SURFACE PHENOMENA AND HETEROGENEOUS CATALYSIS**	**9**
Diffusion ï adsorption ï surface reaction ï various adsorption isotherms ï determination of surface area ï pore volume and pore size ï thermodynamics of interfaces ï solid catalysts ï metal-metal oxides ï geometric factor ï electronic factor - zeolites ï phase transfer catalysis ï colloidal electrolytes ï reactions on surfaces ï surface characterization techniques ï ESCA, AES and SIMS.		
		L – 45; Total Hours –45
REFERENCES:		
1. Laidler K.J., Chemical Kinetics, Harper and Row, New Delhi, 1987.		

2. Rajaram J. and Kuriacose J.C., Kinetics and Mechanism of Chemical Transformation, Mcmillan India Ltd., 1993.
3. Kuriacose J.C. and Rajaram J., Thermodynamics for Students of Chemistry, 3rd Edition, Shoban Lal Nagin Chand and Co., 1999.
4. Nash L.K. and Addison, Elements of Statistical Thermodynamics, Wiley Publication Co., 1971.
5. Gupta M.C., Statistical Thermodynamics, Wiley Eastern, New Delhi, 1990.
6. Sears F.W. and Salinger G.L., Thermodynamics, Kinetic theory and Statistical Thermodynamics, 3rd Edition, Narosa Publishing House, New Delhi, 1998.
7. Rohatgi, Mukharjii K.K., Fundamentals of Photochemistry- Wiley Eastern.

OUTCOMES:

The student will be acquainted with

- differential rate laws, integrated rate laws, temperature dependence of reaction rates,
- Derivation of rate law for the complex reactions such as parallel ,reversible and consecutive reactions
- the knowledge of phase equilibria for various systems
- different types of catalysts and catalyzed reactions
- Basic analytical techniques to analyze the catalyst

CHC7103	ADVANCED INORGANIC CHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student conversant with the

- structure and bonding of organometallic compounds
- catalytic reactions of organometallic compounds

- role of metals and non-metals inside the living organisms
- molecular polyhedra in inorganic solids
- inorganic solid state
- basics of photochemistry

MODULE I	**ORGANOMETALLIC COMPOUNDS**	**9**

18 electron rule: metal carbonyls, metal nitrosyls, metal alkyl and aryl complexes - preparation, structure, bonding, stereochemical non-rigidity.

MODULE II	**METAL CARBON PI COMPLEXES**	**9**

Metal-alkene, alkyne and allyl complexes, cyclopentadiene and benzene complexes ï preparation, structure and bonding - catalysis by organometallic compounds ï hydrogenation, hydroformylation, stereoregular polymerization ï Wacker process.

MODULE III	**BIO-INORGANIC CHEMISTRY**	**9**

Metals and non-metals in biological systems - metal ion transport - oxygen carriers ï haemoglobin, myoglobin - metallo-enzymes ï carboxypeptidase-A, carbonic anhydrase, vitamin B_{12}, nitrogenase - electron transfer and redox systems - photosynthesis.

MODULE IV	**BONDING AND MOLECULAR POLYHEDRA IN INORGANIC SOLIDS**	**9**

Boranes, borazines, silicates, phosphorous-nitrogen, sulphur-nitrogen compounds, metal clusters - inert gas compounds.

MODULE V	**INORGANIC SOLID STATE AND PHOTOCHEMISTRY**	**9**

Preparation of non-molecular solids - band theory of solids - defects and non-stoichiometry, electrical and magnetic properties, superconductivity, amorphous solids, nonsolids - photochemistry ï photophysical processes, spontaneous and stimulated emission of radiation, chemical actinometry, solar energy conversion and applications.

			L – 45; Total Hours –45

REFERENCES:

1. Cotton F.A., Wilkinson G. and Gaus P., Basic Inorganic Chemistry, 3rd Edition, John Wiley and Sons, 2003.
2. Shriver D.F., Atkins P.W. and Langford C.H., Inorganic Chemistry, 2nd Edition, Oxford University Press (ELBS), Oxford, 1994.
3. Huheey J.E., Keiter E.A. and Keiter R.L., Inorganic Chemistry, 4th Edition, Addison Wesley Publication, London, 1993.
4. Cotton F.A., Wilkinson G., Murillo C.A., Bochmann M., Advanced Inorganic Chemistry, 6th Edition, John Wiley and Sons, New York, 2003.
5. Jolly W.L., Modern Inorganic Chemistry, 2nd Edition, McGraw-Hill, Inc., 1991.

OUTCOMES:

Students will be able to

- demonstrate basic principles of organometallic compounds.
- illustrate reactivity and stereochemistry of organometallic compounds.
- demonstrate the basic principles of bioinorganic chemistry.
- demonstrate the bonding in inorganic polyhedral solids.
- illustrate the basic principles of inorganic solid state.
- learn the basic principles of photochemistry
- illustrate the basic principles of band theory of solids.

CHCY001	**GREEN CHEMISTRY**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

OBJECTIVES:

To make the students conversant with the

- principle and advantages of green chemistry.
- principle and uses of microwave as a green technology.
- Applications of ionic liquids and phase transfer catalyst
- Application of supported catalysts and bio catalyst for green synthesis various alternative reagents and chemicals for green synthesis.

MODULE I	**INTRODUCTION TO GREEN CHEMISTRY**	**9**

Green chemistry-relevance and goals, Anastasôtwelve principles of green chemistry - Tools of green chemistry: alternative starting materials, reagents, catalysts, solvents and processes with suitable examples.

MODULE II	**MICROWAVE ASSISTED ORGANIC SYNTHESIS (MAOS)**	**9**

Microwave activation ï advantage of microwave exposure ï specific effects of microwave ï Neat reactions ï solid supports reactions _ Functional group transformations ï condensations reactions ï oxidations ï reductions reactions ï multi-component reactions.

MODULE III	**IONIC LIQUIDS AND PHASE TRANSFER CATALYSIS**	**9**

Introduction ï synthesis of ionic liquids ï physical properties ï applications in alkylation ï hydroformylations ï epoxidations ï synthesis of ethers ï Friedel-craft reactions ï Diels-Alder reactions ï Knoevenegal condensations ï Wittig reactions ï Phase transfer catalyst - Synthesis ï applications.

MODULE IV	**SUPPORTED CATALYSTS AND BIO-CATALYSTS FOR GREEN CHEMISTRY**	**9**

Introduction ï the concept of atom economy ï supported metal catalysts ï mesoporous silicas ï the use of Biocatalysts for green chemistry - modified bio

catalysts ï fermentations and biotransformations ï fine chemicals by microbial fermentations ï vitamins and amino acids ï Bakerûs yeast mediated biotransformations ï Bio-catalyst mediated Baeyer-Villiger reactions ï Microbial polyester synthesis.		
MODULE V	**ALTERNATIVE SYNTHESIS, REAGENTS AND REACTION CONDITIONS**	**9**
Photochemical alternative to Friedel-crafts reactions - Dimethyl carbonate as a methylating agent ï the design and applications of green oxidants ï super critical carbon dioxide for synthetic chemistry.		
PRACTICALS		
1. Synthesis of organic compounds by green methods. 2. Synthesis of metal complexes by green methods.		
		L – 45; P – 30; Total Hours –60

REFERENCES:

1. Green Chemistry ï Environmentally benign reactions ï V. K. Ahluwalia. Ane Books India (Publisher). (2006).
2. Green Chemistry ï Designing Chemistry for the Environment ï edited by Paul T. Anastas & Tracy C. Williamson. Second Edition, (1998).
3. Green Chemistry ï Frontiers in benign chemical synthesis and processes- edited by Paul T. Anastas & Tracy C. Williamson. Oxford University Press, (1998).
4. Green Chemistry ï Environment friendly alternatives- edited by Rashmi Sanghi & M. M. Srivastava, Narora Publishing House, (2003).

OUTCOMES:

The students will demonstrate the

- principles and advantages of green chemistry.

- principles and uses of microwave as a green technology.
- Applications of ionic liquids and phase transfer catalyst
- Supported catalysts and bio catalyst for green synthesis
- various alternative reagents and chemicals for green synthesis.

CHYC002	MOLECULAR SPECTROSCOPY	L	T	P	C
		3	1	0	4

OBJECTIVES:

To make the students

- Å learn molecular spectroscopy as an important tool to understanding molecular structure and its characteristics.
- Å acquire a basic idea of different electromagnetic regions and instrumentation of various modern spectrometers
- Å demonstrate an understanding of the rotational, vibrational and electronic spectroscopy of diatomic and polyatomic molecules
- Åacquire the skill to determine the functional groups present in unknown molecules using vibrational (IR) spectra and to calculate maximum (ə-maximum) absorption of molecules in Electronic (UV-Visible) region using Woodward-Fischer rule
- Ålearn the magnetic properties of electrons and nucleus of atoms and free radicals, using spin angular momentum with the help of nuclear magnetic resonance and electron spin resonance spectra
- Åidentify the unknown molecular formula of fragmented metastable ions of organic Compounds
- Ålearn hyperfine interactions of nuclei present in a molecule

MODULE I	ELECTROMAGNETIC RADIATION AND ROTATIONAL SPECTROSCOPY	9

Characterization of electromagnetic radiation ï regions of the spectrum ï basic

elements of practical spectroscopy ï enhancement of spectra ï Applications of group theory ï Microwave spectroscopy ï rotational spectra of molecules ï applications.		
MODULE II	**INFRA-RED & RAMAN SPECTROSCOPY**	**9**
Infra-red spectroscopy ï harmonic and unharmonic vibrations ï dissociation energy of diatomics ï vibrating rotator ï PQR branches in IR spectra ï Fermi resonance ï Raman spectroscopy ï mutual exclusion principle.		
MODULE III	**ELECTRONIC SPECTROSCOPY**	**9**
Electronic spectra of diatomic molecules: Born Oppenheimer approximation,Franck-Condon principle, selection rules, intensity of electronic transition, vibronic coupling, types of electronic transition - UV-Visible spectroscopy ï solvent effects ï Woodward-Fischer rule to conjugated dienes.		
MODULE IV	**SPIN RESONANCE SPECTROSCOPY**	**9**
Proton magnetic resonance spectroscopy ï relaxation processes ï chemical shift ï coupling ï ^{13}C NMR spectra ï Electron spin resonance spectroscopy ï hyperfine interactions.		
MODULE V	**MASS SPECTROMETRY**	**9**
Reactions of ions in gas phase ï effect of isotopes ï nitrogen rule ï determination of molecular formula ï fragmentations and rearrangements ï metastable ions ï fragmentation of organic compounds. Application of Mass spectroscopy with GC.		
		L – 45; T – 15; Total Hours –60

REFERENCES:

1. Banwell C.N. and McCash E.M., Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw Hill, New Delhi, 1995.
2. Kemp W., Organic Spectroscopy, 3rd Edition, ELBS, McMillan, London, 1991.
3. Drago R., Physical Methods for Chemists, Saunders, Philadelphia, 1992.

4. Williams D.H. and Fleming I., Spectroscopic Methods in Organic Chemistry, 4th Edition, McGraw Hill, New York, 1989.
5. Pasto D., Johnson C. and Miller M., Experiments and Techniques in Organic Chemistry Prentice-Hall Inc., New Jersey, 1992.
6. Pavia D.L., Lampman G.M. and Kriz G.S., Introduction to Spectroscopy, 3rd Edition, Brooks/Cole Publication, Singapore, 2001.
7. Robert M. Silverstein, Francis X. Webster, David Kiemle, Spectrometric Identification of Organic Compounds, 7th Edition, Wiley, 2005.

OUTCOMES:

The students will be able to

Ågain the theoretical knowledge of the various spectroscopic methods on the basis of the examples from the science and industry.

Åbecome familiar with modern spectrometers and methods, which are applied in industrial and scientific laboratories in the field of synthesis and structural determination.

CHCY003	PHOTOPHYSICS AND PHOTOCHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the students conversant with the

- basic laws of photophysics and photochemistry.
- principle and instrumentation of different types of spectrofluorimeter.
- Basics of fluorescence spectroscopy
- Different types of photochemical reactions
- Applications of solar energy materials.

MODULE I	BASICS OF PHOTOPHYSICS AND PHOTOCHEMISTRY	
Basic laws, Einstein Laws ï absorption, Fundamentals of absorption- absorption coefficients, electronic transitions. Excited state energy relaxations ï Jablonski diagram, Radiative and non-radiative relaxations, fluorescence, phosphorescence, Lifetime and quantum yield, Stokes Shift, Kashaûs rule.		
MODULE II	**INSTRUMENTATION TECHNIQUES**	**9**
Spectrophotometer, light Sources, photochemical quauntum yield and intensity measurements, detectors-PMT, Diode-array. Spectrofluorimeter ï Steady state and Time-resolved fluorimeter. Study using time resolved techniques ï pump-probe methods and instrumentation: Lasers-nanosecond, picosecond and femtosecond. Measurement of ï Triplet quantum yield and Time resolved absorption spectrum. Fluorescence standards ï lifetime and quantum yield.		
MODULE III	**FLUORESCENCE SPECTROSCOPY**	**9**
Quenching of fluorescence, fluorescence lifetime, fluorescence quantum yield-method of determination, Rotation diffusion, Time resolved anisotropy, environmental influence on fluorescence properties and photo-bleaching. Solvent effect-Lippert equation, excited state acidity constants, Fluorescence analysis of excited state reactions. Ultrafast solvation dynamics.		
MODULE IV	**PHOTOCHEMICAL REACTIONS**	**9**
Norrish type reactions. Paterno-Büchi Reaction. Quenching by excitation transfer (Förster and Dexter), electron transfer, excited state complex formation, heavy atoms and paramagnetic effects, Proton transfer, addition reactions, elimination reactions, photoisomerisation, photosensitisation, Distance dependence of electron transfer (superexchange). Electron transfer to metals and semiconductors.		
MODULE V	**APPLICATIONS: SOLAR ENERGY MATERIALS**	**9**
Photovoltaic cells ï 1st,2nd, 3rd generation cells - Organic Solar Cells-Single Layer, Double layer, Bulk heterojunction, DSSC, Tandem structured ï Fabrication, Key		

Processes and issues ï Materials ï Low molecular weight ï Polymeric ï Donor-acceptor polymeric systems ï Devices- Characteristics.			
			L – 45; Total Hours –45

REFERENCES:

1. Principles of Fluorescence Spectroscopy by Joesph R. Lakowicz
2. Fundamentals of photochemistry by k. k. Rohatgi-Mukherjee
3. Modern molecular Photochemistry of Organic molecules by N. J. Turro

OUTCOMES:

After completing the course the student should be able to

- describe and explain common photochemical and photophysical processes and mechanisms with suitable theoretical models, and apply established experimental methods for the investigation of these processes
- describe the interaction of excited states with their surroundings and analyse photoinduced electron transfer and excitation energy transfer with quantitative models
- describe the structure and function of photosynthetic reaction centres, and explain the function of photosynthetic antenna systems
- describe photoinduced processes in semiconductors and at molecule-semiconductor interfaces, and explain how these can be used for photophysical energy conversion and in photocatalysis
- describe and explain the impact and applications of photochemistry

CHCY004	**PHOTOCHEMISTRY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To make the students conversant with the

- Principles and concepts of photochemistry.
- Measurement of fluorescence and phosphorescence
- Different types of photochemical reactions
- Different types of photochemical reactions
- Applications of solar energy materials.

MODULE I	PRINCIPLES AND CONCEPTS	9

An overview of: Laws of photochemistry, Beer-Lambert law, electronic energy levels, atomic and molecular term symbols, singlet-triplet state, intensity and strength of electronic transition, selection rules for electronic transition, Jablonski diagram and photophysical processes, Franck-Condon principle.

Excited state lifetime, steady state and time resolved emission, factors affecting excited state energy: solvent effect, TICT.

Excited state kinetics, quantum yield expressions, excimer and exciplex, kinetics of luminescence quenching: static and dynamic, Stern-Volmer analysis, deviation from Stern-Volmer kinetics. Photoinduced electron transfer rates, free energy dependence of electron transfer on rate, Photoinduced energy transfer, FRET, rate and efficiency calculation of FRET.

MODULE II	METHODS	9

Measurement of fluorescence and phosphorescence and lifetimes. Introduction to time-resolved techniques for absorption and emission measurements, detection and kinetics of reactive intermediates. Examples of low temperature matrix isolation of reactive intermediates.

MODULE III	REACTIONS	9

Photochemistry of alkene, cis-trans isomerization, photocycloaddition reactions of alkene, photochemical electrocyclic and sigmatropic reactions, di-pi-methane rearrangment, electron transfer mediated reactions of alkene. Photochemistry of carbonyl compounds, Norrish type I and type II reactions, enone and dienone cycloadditions. Photochemistry of aromatic systems, electron transfer and nucleophilic substitution reactions. Photochemistry of nitro, azo and diazo compounds. Photochemistry involving molecular oxygen, generation and reactions of singlet oxygen. Photo-fragmentation reactions (Barton, Hofmann-Loffler-Freytag)

MODULE IV	**REACTIONS IN AROMATIC COMPOUNDS**	**9**

Photochemistry of aromatic systems, electron transfer and nucleophilic substitution reactions. Photochemistry of nitro, azo and diazo compounds. Photochemistry involving molecular oxygen, generation and reactions of singlet oxygen. Photo-fragmentation reactions (Barton, Hofmann-Loffler-Freytag)

MODULE V	**APPLICATIONS**	**9**

Fluorescence based sensors ï examples of molecular and supramolecular systems. Conversion of solar energy to chemical and other forms of energies, solar photovoltaic cell, basic principle and design of the cell.

			L – 45; Total Hours –45

REFERENCES:

1. Fundamental of Photochemistry, K. K. Rohatgi-Mukherjee, New Age International (P) Ltd., New Delhi, 1986.
2. Principles of Fluorescence Spectroscopy, 3rd Ed., J. R. Lakowicz, Springer, New York, 2006.
3. Fundamentals of Photoinduced Electron Transfer, G. J. Kavarnos, VCH publishers Inc., New York, 1993.
4. Molecular Fluorescence: Principles and Applications, B. Valeur, Wiley-VCH Verlag GmbH, Weinheim, 2002.

5. Modern Molecular Photochemistry of Organic Molecules, N. J. Turro, V. Ramamurthy, J. C. Scaiano, University Science, Books, CA, 2010.
6. Photochemical Synthesis, I. Ninomiya, T. Naito, Academic Press, New York, 1989.

OUTCOMES:

To make the students acquainted with the

- Principles and concepts of photochemistry.
- Measurement of fluorescence and phosphorescence
- Different types of photochemical reactions
- Different types of photochemical reactions
- Applications of solar energy materials.

CHCY005	BIOCHEMISTRY	L	T	P	C
		3	0	2	4

OBJECTIVES:

The student are trained about

- Mechanism of enzymes and coenzymes.
- Carbohydrate metabolism
- Lipid metabolism and biological oxidation.
- Biochemistry of amino acids
- Biochemistry of proteins

MODULE I	ENZYMES AND COENZYMES	9

Enzymes: Nomenclature, enzymes-kinetics and mechanism of action, mechanism of inhibition of enzymes and isoenzymes in chemical diagnosis. Co-enzymes: Vitamins

as co-enzymes and their significance - Metals as co-enzymes and their significance.		
MODULE II	**CARBOHYDRATE METABOLISM**	**9**
Glycolysis, gluconeogenesis and glycogenolysis - metabolism of galactose and galactosemia - role of sugar nucleotides in biosynthesis and pentose phosphate pathway - citric acid cycle, significance, reactions and energetics of the cycle.		
MODULE III	**LIPID METABOLISM AND BIOLOGICAL OXIDATION**	**9**
Oxidation of fatty acids-oxidation and energetics, biosynthesis of ketone bodies and their utilization, biosynthesis of saturated and unsaturated fatty acids, regulation of lipid metabolism, essential fatty acids. The respiratory chain, its role in energy capture and control, energetics of oxidative phosphorylation, mechanism of oxidative phosphorylation.		
MODULE IV	**BIOCHEMISTRY OF AMINOACIDS**	**9**
Biosynthesis of amino acids, catabolism of amino acids and conversion of amino acids to specialized products, biosynthesis of purine and pyrimidine - formation of deoxyribonucleotides. Biosynthesis of RNA, DNA replication, carcinogensis and DNA repair mechanism.		
MODULE V	**BIOCHEMISTRY OF PROTEINS**	**9**
Genetic code and protein synthesis, components of protein synthesis, inhibition of protein synthesis. Regulation of gene expression (Prokaryote and Eukaryote).		
PRACTICALS		
1. Preparation of standard buffers (citrate, phosphate and carbonate) and measurement of pH. 2. Titration curve for amino acids. 3. Separation of amino acids by chromatography. 4. The separation of lipids by TLC. 5. Quantitative estimation of amino acids.		

6. The determination of glucose by means of the enzyme glucose oxidase. 7. Enzymatic hydrolysis of glycogen by Ŭand ɓ-amylase. 8. Effects of temperature on the activity of Ŭ- amylase. 9. Estimation of cholesterol in Blood. 10. Estimation of Glucose in blood and urine. 11. Estimation of Urea in blood. 12. Estimation of ketone bodies in blood. 13. Qualitative analysis of inorganic as well as organic constituents of Urine.			
			L – 45; P-30;Total Hours –75

REFERENCES:

1. Conn E.E. and Stumph P.K., Outline of Biochemistry, John Wiley and Sons, New York.
2. Nelson D.L. and Cox M.M., Lehninger Principles of Biochemistry, Macmillan Worth Publishers.
3. Stryer L., Biochemistry, W.H., Freeman and Company, San Francisco.
4. Harrow B. and Mazur A., Text book of Biochemistry, W.B. Saunders Co., Philadephia.
5. Harpers Review of Biochemistry, Lange Medical Publication.
6. Jayaraman J., Laboratory Manual in Biochemistry, Wiley Eastern Limited.
7. Plummer David J., An Introduction to Practical Biochemistry, McGraw Hill, New Delhi.
8. Singh S.P., Practical Manual to Biochemistry, CBS Publisher, New Delhi.

OUTCOMES:

The students are acquainted with the

- Mechanism of enzymes and coenzymes.
- Carbohydrate metabolism
- Lipid metabolism and biological oxidation.

- Biochemistry of amino acids
- Biochemistry of proteins
- Different types of textile mat

CHCY006	PHARMACEUTICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student learn about the

- pre formulation studies
- additives used in formulations
- evaluation of drug and packaging
- cosmetic preparations

MODULE I	PRE-FORMULATION STUDIES	9

Study of physical properties of drug like physical form, particle size, shape, density, wetting, dielectric constant, solubility, dissolution and organoleptic properties and their effect on formulation, stability and bioavailability ï Drug delivery types and methods including nano-delivery system.

MODULE II	LIQUID DOSAGE FORMS	9

Introduction, types of additives used in formulations, vehicles, stabilizers, preservatives, suspending agents, emulsifying agents, solubilizers, colors, flavours and others, manufacturing packaging and evaluation of clear liquids, suspensions and emulsions.

MODULE III	SEMISOLID DOSAGE FORMS	9

Definitions, types, mechanisms of drug penetration, factors influencing penetration,

semisolid bases and their selection, general formulation of semisolids, clear gels and manufacturing procedure, evaluation and packaging.		
MODULE IV	**SUPPOSITORIES**	**9**
Ideal requirements, bases, manufacturing procedure, packaging and evaluation. Pharmaceutical Aerosols: Definition, propellants, general formulation, manufacturing and packaging methods, pharmaceutical applications.		
MODULE V	**COSMETOLOGY AND COSMETIC PREPARATIONS**	**9**
Structure of skin, formulation of cold cream, vanishing cream, cleansing cream, all purpose cream, protective cream, antiperspirants, deodorant, face powder - Hair structure, Shampoos, Conditioner, Shaving and after shaving products, Dentrifice and Mouthwash, Lipstick, Nail lacquer.		
		L – 45; Total Hours –45

REFERENCES:

1. Remington's Pharmaceutical Sciences, Volume I and Volume II, Mack Publishing Co., USA.
2. Cooper J.W., and Gunn G., Tutorial Pharmacy, Petman Books Ltd., London.
3. Lachman L., Lieberman H.A, Kanig J.L, Theory and Practice of Industrial Pharmacy, Lea and Febiger, Philadelphia, USA.
4. Ansel H.C., Introduction to Pharmaceutical Dosage Forms, Lea and Febiger, Philadelphia, USA.
5. R.L. Juliano, Drug Delivery Systems, Oxford University Press, Oxford.
6. Harrys Cosmetology.
7. Balsam and Sagarin, Cosmetics: Science and Technology.
8. Thomssen E.G., Modern Cosmetics, Universal Publishing Corporation.
9. Mittal B.M. and Saha R.N., A Handbook of Cosmetics, Vallabh Prakashan.

OUTCOMES:
The students will be familiar with the • pre formulation studies • additives used in formulations • evaluation of drug and packaging preparations of cosmetic

CHCY007	**GMP, QUALITY ASSURANCE and VALIDATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To make the student learn about the

- Å good manufacturing practices
- Å documentation, quality management and control
- Validation methods
- IPQC problems
- Sampling and operating characteristics curves

MODULE I	**GOOD MANUFACTURING PRACTICE**	**9**

Requirements of GMP, CGMP1, GLP, USFDA, WHO guidelines and ISO 9000 series.

MODULE II	**DOCUMENTATION AND MAINTENANCE**	**9**

Documentation - Protocols, Forms and maintenance of records in Pharmaceutical industry - Preparation of documents for new drug approval and export registration.

MODULE III	**QUALITY ASSURANCE**	**9**

Basic concept of C, Quality assurance systems, Sources and control of quality

variation - raw materials, containers, closures, personnel, environment etc.		
MODULE IV	**VALIDATION**	**9**
Concepts in validation, validation of manufacturing and analytical equipment, Process validation in manufacturing dosage formulations, applications of process validation.		
MODULE V	**QUALITY CONTROL**	**9**
In process quality control tests, IPQC problems in pharmaceutical industries - Sampling plans, Sampling and operating characteristics curves.		
		L – 45; Total Hours –45

REFERENCES:

1. Willing, Tuckerman and Hitchings, Good Manufacturing Practices for Pharmaceuticals.
2. OPPI, Quality Assurance.
3. Loftus and Nash, Pharmaceutical Process Validation.
4. Florey, Analytical Profile of Drugs (All volumes).
5. Indian Pharmacopoeia.
6. MODULEed States Pharmacopoeia.
7. British Pharmacopoeia.
8. Garfield, Quality Assurance Principles for Analytical Laboratories.

OUTCOMES:

The student will be able to demonstrate the

- Å good manufacturing practices
- Å documentation, quality management and control
- Validation methods
- IPQC problems
- Sampling and operating characteristics curves

CHCY008	MEDICINAL AND PHARMACEUTICAL CHEMISTRY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student to learn

- The basic factors governing drug design
- The synthesis and drug action of anti-malarial, anti-bacterial and anti-tuberculosis drugs, etc.

MODULE I	INTRODUCTION TO DRUG DESIGN	9

Factors governing drug design ï advantages ï types of drug ï literature survey for preparation of drugs ï characterization and structural elucidation of drugs using different spectral methods.

MODULE II	ANALGESICS, ANTIHISTAMINES AND ANTIMALARIALS	9

Analgesics ï narcotic analgesics ï morphine analogues ï synthesis of codeine ï synthetic narcotic analgesics ï ï antipyretic analgeics ï salicyclic acid analogues ï ï para amino phenol derivatives ï Antihistamines-structure, synthesis, activity promethazine, chlorpheneraminemaleate - Antimalerials ï classification- structure, synthesis, drug action - quinine-4-amino and 8-amino quinolines ï chloroquine.

MODULE III	ANTIBIOTICS AND ANTIBACTERIALS	9

Synthesis and mode of action -Antibiotics ï pencillin, D-pencillamine, semisythetic pencillin ï chloramphenicol streptomycin, tetracyclines, cephalosporins,-Antibacterials ï norfloxacin, ciprofloxacin, clotrimazole,

MODULE IV	ANTIHYPERTENSIVE, ANTI-INFECTIVES AND ANTIVIRALS	9

Synthesis and drug action - Antihypertensive drugs-methyldopa - antiseptics and disinfectants: benzalkonium chloride - anthelmintics: mebendazole - antivirals: amantadine, acyclovir.		
MODULE V	**STEROIDS AND RELATED DRUGS**	**9**
Introduction, classification, nomenclature and stereochemistry - (A) Androgens - testosterone (B) Estrogens and progestational agents ï progesterone, estradiol, (C) Adrenocorticoids ï prednisolone, dexamethasone- prostaglandins: misoprostol.		
		L – 45; Total Hours –45

REFERENCES:

1. J. B. Stenlake, Medicinal and Pharmaceutical Chemistry, Volume 1, Viva /b S Publication, 1979.
2. A. Berger, Medicinal Chemistry, Wiley Interscience, New York, Volume 1 and 2, 1990.
3. Bentely and Driverôs Textbook of Pharmaceutical Chemistry, Oxford University Press, 1985.
4. David A. Williams, David A. Williams A, William O. Foye, Thomas L. Lemke, Foye's Principles of Medicinal Chemistry, Wolter Kluwer, 2008.
5. J. B. Stenlake, The Chemical Basis of Drug Action Volume 2, Viva /b S Publication, 1979.

OUTCOMES:

The student will be familiar with

- The drug design,
- The functions of various drugs
- the drug action and uses

CHCY009	POLYMER CHEMISTRY	L	T	P	C
		3	0	2	4

OBJECTIVES:

To make the student conversant with the

- basic concepts of polymers, molecular weight and its distribution
- kinetics and mechanism of Addition, Coordination and Condensation polymerization
- various polymerization techniques
- various testing methods for mechanical, thermal and electrical properties
- preparation, properties and applications of polymeric materials.

MODULE I	BASIC CONCEPTS OF POLYMERS	9

Basic concepts of polymers ï classification of polymers: source, structure, processing behavior, composition and structure, mechanism, application ï copolymer: types ï terpolymer: Definition - nomenclature of polymers - tacticity ï crystalline and amorphous polymers - thermal transitions ï Molecular weight of polymer ï number, weight and viscosity average molecular weights ï molecular weight distribution (problems)

MODULE II	KINETICS AND MECHANISM OF POLYMERISATION REACTIONS	9

Kinetics and mechanism of addition polymerization: free radical, cationic and anionic polymerizations ï Trommsdroff effect ï living polymers ï Ziegler-Natta catalysts ï coordination polymerization ï Kinetics of polycondensation reactions ï copolymer equation-Reactivity ratio and copolymerization behavior.

MODULE III	POLYMERISATION TECHNIQUES	9

Polymerisation techniques ï homogenous and heterogeneous polymerization ï bulk,

solution, suspension and emulsion polymerization ï merits and demerits ï interfacial, and melt polycondensation.		
MODULE IV	**POLYMER TESTING AND ANALYSIS**	**9**
Mechanical properties : tensile strength, Flexural strength, Compressive strength, Izod impact, Rockwell hardness ï thermal properties : TGA and DSC - electrical properties: dielectric constant, dissipation factor, and dielectric strength ï molecular weight: determination by GPC and viscometry.		
MODULE V	**POLYMERIC MATERIALS**	**9**
Preparation, properties and applications ï thermoplastics : LDPE, HDPE, PVC, PTFE, PET and Nylons ï thermosets : phenolic resins, epoxy resins, unsaturated polyesters and polyurethanes ï polymer blends and alloys ï reinforced plastics.		
PRACTICALS		
1. Synthesis of thermoplastics 2. Synthesis of thermosetting plastics 3. Determination of molecular weight of polymers 4. Demonstration of DTA, TGA, DSC etc. 5. Determination of electric properties of polymers		
		L – 45; P – 30; Total Hours –75

REFERENCES:

1. Billmeyer F.N., Text Book of Polymer Science, 3rd Edition, John Wiley and Sons, New York, 1994.
2. George Odian, Principles of Polymerisation, 3rd Edition, McGraw Hill Book Company, New York, 1991.
3. Young R.S., Introduction to Polymers, Chapman and Hall Ltd., London, 1981.
4. P. J. Flory., Principles of Polymer Chemistry, Cornell Press (recent edition).
5. Vishu shah., Handbook of plastics testing and failure analysis, John Wiley and Sons, New Jersey, 2007.

6. I.M. Ward and D.W. Hadley, An Introduction to the Mechanical Properties of Solid Polymers, John Wiley and Sons, Chichester, England, 1993.
7. C.C. Ku and R. Liepins, Electrical Properties of Polymers, Hanser Publications, Munich, 1987.
8. Jacqueline I., Kroschwitz, Concise Encyclopedia of Polymer Science and Engineering, John Wiley and Sons, New York, 1998.
9. Michael L. Berins, Plastics Engineering Hand Book, 5th Edition, Chapman and Hall, New York, 1991.
10. Gowarikar V.R., Viswanathan N.V and Jayadev Sreedhar, Polymer Science, Wiley Eastern Limited, Madras, 1981.

OUTCOMES:

The student will be able to

1) classify various polymers, calculate molecular weight of polymers, explain the theory of crystallinity and thermal transitions.
2) derive the rate equations and explain the mechanism of polymerization reactions
3) compare and contrast the various polymerization techniques with its merits and demerits.
4) analyze and test the polymers for the mechanical, thermal and electrical properties
5) summarize the preparation, properties and applications of different polymeric materials

CHCY010	NANOTECHNOLOGY	L	T	P	C
		3	0	2	4

OBJECTIVES:

To make the students conversant with the

- definition and significance of nanoscale materials and their properties
- different methods of preparation of nanomaterials
- various tools for characterizing nanomaterials

applications and impacts of nanotechnology

MODULE I	INTRODUCTION OF NANOMATERIALS	9

Definition of nano - significance of the nanoscale - nanomaterials - Classification - nanoscale in one dimension -thin films, layers and surfaces - nanoscale in two dimensions - carbon nanotubes- inorganic nanotubes, nanowires, biopolymers- nanoscale in three dimensions ï nanoparticles, fullerenes, carbon 60, dendrimers, quantum dots; Nanomachines and Devices. Properties of nanomaterials: Size and shape dependent optical (quantum confinement in semiconductors), electronic, emission, transport, photonic, refractive index, dielectric, mechanical, magnetic, catalytic and photocatalytic, non-linear optical properties.

MODULE II	PREPARATION OF NANOMATERIALS	9

Methods of preparation of nanomaterials, top-down approach and bottom-up: Mechanical milling, laser ablation, electrodeposition, sputtering and microwave plasma synthesis, inert gas condensation - Chemical reduction and oxidation, hydrothermal, micelles, sol-gel processes, photolysis, radiolysis and metallo-organic chemical vapour deposition.

MODULE III	CHARACTERIZATION TECHNIQUES	9

Structural Characterization: Atomic Force Microscopy (AFM): Contact and Tapping Mode ï Scanning Electron microscopy (SEM), Transmission electron microscopy (TEM), and Powder XRD. Chemical Characterization: Optical spectroscopy, X-ray Photoelectron spectroscopy (XPS). Physical properties: Melting point, Lattice constant. Electrical and magnetic characterization: Mechanical properties- Nanoindentation and nanotribology.

Introduction to advanced Scanning Probe Microscopy - Electrostatic Force Microscopy (EFM) - Magnetic Force Microscopy (MFM) - Scanning Thermal Microscopy (SThM), Scanning Tunnelling Mode (STM), Piezoelectric force

microscopy (PFM), Scanning Capacitance Microscopy (SCM).

MODULE IV	APPLICATIONS AND ENVIRONMENTAL IMPACTS	9

Current applications - sunscreens and cosmetic, composites, clays, coatings and surfaces, tougher and harder cutting tools. Short-term Applications ï Paints, remediation, fuel cells, displays, batteries, fuel additives, catalysts. Long - term Applications - lubricants, magnetic materials, medical implants machinable ceramics, water purification, military battle suits. Biomedical applications ï Photodynamic therapy in targeted drugs, biosensors, quantum dot technology in cancer treatment, nanoparticles as a drug carrier.

Environmental Impacts: toxicological health effects, relevant parameters in nanoparticle toxicology, integrated concept of risk assessment of nanoparticles

MODULE V	CARBON NANOSTRUCTURES	9

History ï Carbon nanotubes, carbon clusters, production methods - arc method, laser method, chemical vapour deposition, purification methods- gas phase, liquid phase, intercalation, - dispersion - fuctionalization -chopping, oxidation, and ñwrappingò of CNTs. Properties of carbon nanotubes: Electrical conductivity, strength and elasticity, thermal conductivity and expansion, field emission, high aspect ratio, highly absorbent.

Applications of carbon nanostructures - field emission, conductive or reinforced plastics, energy storage, conductive adhesives and connectors, molecular electronics, thermal materials, structural composites, fibers and fabrics, catalyst support, CNT ceramics, biomedical applications, air, water and gas filtration.

PRACTICALS

1. Synthesis and characterization of

a) Copper oxides	b) Titanium oxides	c) Zinc oxides
d) Cerium oxides	e) Molybdenum oxides	f) Nickel oxides
g) Graphene oxides	h) Carbon nanotubes oxides	i) Tin oxides

2. Demonstration of analysis of nanoparticles by a) XEM b)TEM c)XRD d)XPS e) AFM			
			L – 45; P – 30; Total Hours –75

REFERENCES:

1.Pradeep T., Nano: The Essentials Understanding Nanoscience and Nanotechnology,
Tata McGraw-Hill, New Delhi, 2007.

2. Mark Ratner and Daniel Ratner, Nano Technology, Pearson Education, New Delhi, 2003.

3. Tlusty J, Machining Processes and Equipment, 2nd Edition, Prentice Hall, 2000.
Viswanathan B., Nano Materials

4. Nanobiotechnology by Subbiah balagi, MJP Publishers, India (2010)

OUTCOMES:

The students will be able to

- differentiate the nanomaterials based on their dimensions
- acquire knowledge of various synthetic methods and characterization techniques
- select the appropriate nanomaterials for specific applications

CHCY011	**ELECTRICAL PROPERTIES OF POLYMERIC MATERIALS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To make the student to learn

- The blend morphology

- Effect of structural features
- Resistivity, thermal behavior and electrical behavior of polymeric materials

MODULE I	**POLYMER BLENDS**	**9**

Introduction ï equilibrium phase ï polymer behaviour ï effect of polymer structure, polymer ï polymer interaction ï special structural effects ï blend morphology ï chemical reactions ï properties ï miscible blends ï immiscible blends ï toughened polymers - Commercial blends ï applications.

MODULE II	**RESISTIVITY**	**9**

General features ï polymer as wide band gap insulators ï theories ï trapping ï carrier injection ï effects of structural features ï effects of additives.

MODULE III	**DIELECTRIC BEHAVIOUR**	**9**

Mechanism of laws ï relaxation ï non-polar polymers ï amorphous dipolar polymers ï crystalline dipolar polymers ï effects of structures, additives and impurities ï testing of degradation in polymers.

MODULE IV	**THERMAL PROPERTIES**	**9**

Specification of thermal evaluation and classification of electrical insulation ï determination of resistivity ï relating resistance of solid insulating materials ï relating resistance of insulating materials to breakdown by surface discharges ï artificial pollution tests of HV insulator ï AC, DC.

MODULE V	**BREAKDOWN TESTING ANALYSIS**	**9**

Breakdown test methods ï statistical analysis ï graphical techniques ï numerical techniques.

			L – 45; Total Hours –45

REFERENCES:

1. J. Kreschurity, concise Encyclopedia of polymer Science and Engineering, John Wiley and Sons, New York, 1990.
2. M.E. Balrd, Electrical Properties of Polymeric Materials, The Plastic Institute, London.
3. A. Bradwell (Editor), Electrical Insulation, Peter Peregrinus Ltd., 1983.
4. Tiller Shugg W., A Handbook of Electrical and Electronic Materials, Van Nostrand Reinhold, New York, 1986.
5. L.A. Dissado and J.C. Fothergil, Electrical Degradation and Breakdown in Polymers, Peter Perenguins Ltd., London, 1992.

OUTCOMES:

The student will be able to

- mention the properties and applications of polymer blends
- discuss the resistivity and dielectric behaviour of polymeric materials
- discuss the thermal properties and breakdown testing analysis of polymers.

CHCY012	POLYMER STRUCTURE AND PROPERTY RELATIONSHIP	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student to learn the

- structure of polymers
- various properties of polymers

MODULE I	STRUCTURE OF POLYMERS	9

Linear, branched, cross linked, and network polymers - homochain and hetero atomic chain polymers - Copolymers - Linear and cyclic arrangement - Prediction of polymer properties, group contribution techniques, topological techniques - Volumetric properties - molar volume, density, vanderWaals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

MODULE II	**MECHANICAL PROPERTIES**	**9**

Stress-strain properties of polymers - Effect of polymer structure on modulus of elasticity, tensile strength, flexural strength, impact strength, yield strength, fracture toughness - Crazing in glassy polymers - Ductile brittle transition - Effect of additives on mechanical properties of polymers - Creep, stress relaxation and fatigue

MODULE III	**THERMODYNAMIC AND TRANSITION PROPERTIES**	**9**

Transition temperature in polymers, glass transition (Tg), melt transition (Tm), relationship between Tg and Tm - other transitions like β-transitions, upper and lower glass transition temperatures - Prediction of Tg and Tm of polymers by group contributions. Calorimetric properties - Heat capacity, specific heat, latent heat of crystallization and fusion, enthalpy and entropy - Calculation of heat capacities of polymers.

MODULE IV	**ELECTRICAL AND OPTICAL PROPERTIES**	**9**

Effect of polymer structure on dielectric constant, power factor, dissipation factor, and loss factor - effect of frequency of voltage and temperature on dielectric properties - Prediction of molar polarization and effective dipole moment - Effect of é additives on electrical properties of polymers - Optical properties - Effect of polymer structure on optical properties - clarity, transparency, haze, transmittance, reflectance, and gloss - Prediction of refractive indices of polymers by group contributions.

MODULE V	**CHEMICAL PROPERTIES**	**9**

Cohesive energy, cohesive energy density, solubility parameter, determination of solubility parameter of polymers - Prediction of solubility parameter - Effect of polymer

structure on solubility in solvents and oils - Influence of structure in prediction of flame retardancy, water repellency - Chemical resistance of polymers - Polymer toxicity.

			L – 45; Total Hours –45

REFERENCES:

1. D.W. vanKrevelen and P.J. Hoftyzen, Properties of Polymer, 3rd Edition, Elsevier Scientific Publishing Company Amsterdam, Oxford New York, 1990.
2. J.E. Mark (Editor), AIP, Physical Properties of Polymers Hand Book, Williston, 1996.
3. D.A. Seanor, (Editor), Electrical Properties of Polymers, Academic press, New York, 1982.
4. Jozef Bicerano, Prediction of Polymer Properties, 2nd Edition, Marcel Dekker Inc. New York, 1995.
5. J.M. Margolis (Editor), Engineering Thermoplastics Properties and Applications, Marcel Dekker, New York 1985.
6. R.J. Samuels, Structured Polymer Properties, John Wiley and Sons, New York, 1974.
7. I.M. Ward and D.W. Hadley, An Introduction to the Mechanical Properties of Solid Polymers, John Wiley and Sons, Chichester, England, 1993.
8. C.C. Ku and R. Liepins, Electrical Properties of Polymers, Hanser Publications, Munich, 1987.
9. F. Bueche, Physical Properties of Polymers, Wiley, New York, 1962.
10. J. Mort and G. Pfister, (Editor), Electronic Properties of Polymers, Wiley Interscience, New York, 1982.

OUTCOMES:

At the end of the course, the students will be familiar with the

- structure of polymers
- effect of polymer structure on the properties such as mechanical, electrical and optical properties

CHCY013	CONCEPTS AND TECHNIQUES IN CATALYSIS	L	T	P	C
		3	0	0	3

OBJECTIVES:

The objectives of this course is to

- impart the basic concepts involved in catalytic processes.
- learn the different preparation methods of catalysts such as by precipitation, impregnation, mixing method, ion-exchange, etc.
- develop a knowledge in the physic-chemical and spectral characterization methods for catalytic materials.
- evaluate the catalysts using different catalytic reactors
- use different types catalysts for various organic reactions in detail.

MODULE I	CONCEPTS OF CATALYSIS	9

acid-base catalysis ï catalysis by transition metal ions and their complexes ï supported transition metal complexes as catalysts ï catalysis by enzymes ï phase transfer catalysis - photocatalysis ï adsorption ï chemisorption on metals, metal oxides and semiconductors - kinetics of unimolecular and bimolecular surface reactions - Contact time - WHSV - time on stream - Catalyst deactivation and regeneration

MODULE II	HETEROGENEOUS CATALYSTS AND THEIR SYNTHESIS	9

Metals, metal oxides, mixed metal oxides, supported metals, spinels, perovskites, super acids, hydrotalcites, zeolites and zeotypes (small, medium, large), shape selective catalysts, mesoporous materials (SBA, MCM, KIT, AlPOs)

Hydrothermal synthesis, sol-gel process, impregnation method, ion-exchange method

- MODULE operations in catalyst manufacture - drying, calcination, spray drying		
MODULE III	**CATALYSTS CHARACTERIZATION**	**9**
Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFT), Diffuse Reflectance UV-Visible Spectroscopy (DRSUV), X-ray Powder Diffraction (XRD), Brunauer-Emmett-Teller (BET) Surface Area Analysis, Barrett-Joyner-Halenda (BJH) Pore Size and Volume AnalysisMagic Angle Spinning Nuclear Magnetic Resonance (MAS NMR) (^{29}Si, ^{27}Al, ^{31}P), Auger Electron Spectroscopy (AES), Scanning Electron Microscopy and Energy Dispersive Spectroscopy (SEM/EDAX), Electron Probe Micro-Analyzer (EPMA), Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), X-ray Photoelectron Spectroscopy (XPS), Extended X-ray Absorption Fine Structure Spectroscopy (EXAFS), Transmission Electron Microscopy (TEM), Electron Spin Resonance Spectroscopy (ESR).		
MODULE IV	**CATALYTIC REACTORS**	**9**
Integral and fixed bed reactors - differential reactors - stirred flow reactors - microcatalytic reactors of pulse type - static reactors ï high pressure reactors - reaction monitoring by GC and GC-MS.		
MODULE V	**CATALYTIC REACTIONS**	**9**
Catalytic asymmetric synthesis - C-C, C-H bond formation, oxidation - acid catalysed isomerisation - heterogeneous hydrogenation, dehydrogenation, cyclo dehydrogenation, oxidation - Homogeneous catalysis by transition metal complexes - metathesis of olefins - synthetic fuels.		
		L – 45; Total Hours –45

REFERENCES:

1. J. Rajaram and J.C. Kuriacose, Kinetics and Mechanisms of Chemical Transformations, Macmillan Publishers India Limited, 2000.
2. John Meurig Thomas and W. John Thomas, Principles and Practice of

Heterogeneous Catalysis, Wiley, 1997.

3. Herman Pines, The Chemistry of Catalytic Hydrocarbon Conversions, Academic Press, 1981.
4. J.W. Niemantsverdriet, Spectroscopy in Catalysis, 2nd Edition, John Wiley and Sons, 2008.
5. 2Gadi Rothenberg, Catalysis: Concepts and Green Applications, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2008.
6. B. Viswanathan, S. Sivasanker and A.V. Ramaswamy (Editors), Catalysis: Principles and Applications, Narosa Publishing House, 2002.
7. Julian R.H. Ross, Heterogeneous Catalysis: Fundamentals and Applications, Elsevier, 2011.
8. Gerhard Ertl, Handbook of Heterogeneous Catalysis, 2nd Edition, Volume 6, Wiley-VCH-Verlag, 2008.
9. Charles N. Satterfield, Heterogeneous Catalysis in Practice, McGraw-Hill, 1980.
10. Jens Hagen, Industrial Catalysis: A Practical Approach, 2nd Edition, Wiley, 2006.
11. Jens Weitkamp, Lothar Puppe (Editors), Catalysis and Zeolites: Fundamentals and Applications, Springer, 1999.
12. R.A. Sheldon and Herman van Bekkum (Editors), Fine Chemicals through Heterogeneous Catalysis, John Wiley and Sons, 2008.
13. Michel Che and Jacques C. Védrine (Editors), Characterization of Solid Materials and Heterogeneous Catalysts: From Structure to Surface Reactivity, John Wiley and Sons, 2012.

OUTCOMES:

To make the student to learn about

- Classification of polymeric materials.
- the process of elastomers
- different types of moulding
- characterization of polymers
- effect of structure on polymer properties

CHCY014	POLYMER TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student to learn about

- Classification of polymeric materials.
- the process of elastomers
- different types of moulding
- characterization of polymers
- effect of structure on polymer properties

MODULE I	POLYMERIC MATERIALS	9

Introduction ï classification ï thermoplastics ï cellulose derivatives ï LDPE, HDPE, PVC, PMMA, PTFE, PET and Nylons ï thermosetting resins ï phenolic resins, epoxy resins, silicones and polyurethanes ï polymer blends and alloys ï reinforced plastics.

MODULE II	ELASTOMERS	9

Natural rubber ï processing ï vulcanization ï synthetic rubber ï SBR, neoprene, butyl and thiocol rubbers ï thermoplastic elastomers ï high performance polymers ï polythers ï PEEK, polysulphones and polyimides.

MODULE III	MOULDING TECHNIQUES	9

Moulding constituents ï functions ï moulding techniques ï compression ï injection ï extrusion ï blow moulding ï thermoforming ï Vacuum forming ï pultrusion ï casting ï

calendaring ï RIM ï lamination.		
MODULE IV	**CHARACTERISATION AND TESTING**	**9**
Characterisation of polymers by IR and NMR ï Thermal properties by TGA and DSC ï Testing tensile strength, Izod impact, Compressive strength, Rockwell hardness, Vicot softening point ï Test for electrical resistance, dielectric constant, dissipation factor, arc resistance and dielectric strength ï water absorption.		
MODULE V	**POLYMER PROPERTIES**	**9**
Effect of structure on mechanical, chemical, thermal, electrical and optical properties.		
		L – 45; Total Hours –45

REFERENCES:

1. Michael L. Berins, Plastics Engineering Hand Book, 5th Edition, Chapman and Hall, New York, 1991.
2. Jacqueline I., Kroschwitz, Concise Encyclopedia of Polymer Science and Engineering, John Wiley and Sons, New York, 1998.
3. Iyson R.W., Specialty Polymers, Blackie Academic and Professional, London, 1992.
4. Maurice Morton, Rubber Technology, van Nostrand, Reinhold, New York, 1987.

OUTCOMES:

The students will be familiar with the

- classification of polymeric materials.
- the process of elastomers
- different types of moulding
- characterization of polymers
- effect of structure on polymer properties

CHCY015	INORGANIC CHEMICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student to learn about the

- fuel and industrial gases
- chemicals used in fertilizers and glass industries
- principles of metallurgic processes

MODULE I	FUEL AND INDUSTRIAL GASES	9

Fuel and industrial gases ï production and uses of producer gas, water gas, coke oven gas, acetylene, natural gas and LPG: Liquefaction of gases ï noble gases, carbon dioxide, hydrogen, oxygen, nitrogen.

MODULE II	HEAVY CHEMICALS	9

Chloralkali industry ï soda ash, caustic soda and chlorine. Chemicals from sea ï sodium chrloride, magnesium chloride and bromine.

MODULE III	ACIDS AND FERTILIZERS	9

Sulphur and sulphuric acid ï nitric acid ï ammonia ï nitrogenous fertilizers ï phosphorous ï phosphoric acid ï phosphatic fertilizers ï potassic fertilizers.

MODULE IV	SILICATE INDUSTRIES	9

Silicate industries ï refractories ï abrasives ï ceramics ï glass ï cement, lime and gypsum.

MODULE V	PRINCIPLES OF METALLURGICAL PROCESSES	9

Principles of Metallurgical Processes ï ore benefication- pyrometallurgy,

hydrometallurgy, powder metallurgy and electrometallurgy - Explosives and propellants ï nuclear materials.

			L – 45; Total Hours –45

REFERENCES:

1. B. Norris Shreve and Joseph A. Brink, Chemical Process Industries, McGraw Hill, Kogakusha Ltd., 1991.
2. M. Gopala Rao and Marshall Sitty (Editors), Drydenôs Outlines of Chemical Technology, Affiliated East West Press Pvt. Ltd., 1992.
3. B.K. Sharma, Industrial Chemistry, GOEL Publishing House, 1991.
4. James A. Kent (Editors), Riegelôs Industry Chemistry, Asia Publishing House, 1989.

OUTCOMES:

The student will be familiar with the

- use of caustic soda, sodium chloride
- N,P and K fertilizers
- Ceramics, glass, etc.
- Powder and extractive metallurgy

CHCY016	**ORGANIC CHEMICAL TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To make the student to learn about the

- industrial organic synthesis

- pharmaceuticals, pesticides and dyes

MODULE I	**BASIC PRINCIPLES OF CHEMICAL TECHNOLOGY**	**9**

Classification of chemical technological processes ï chemical equilibrium in technological processes ï rates of technological processes ï designing and modeling chemical technological processes and reactors.

MODULE II	**INDUSTRIAL ORGANIC SYNTHESIS**	**9**

Raw materials ï manufacture of methyl alcohol, ethyl alcohol, ethylene, 1,3-butadiene, acetylene, ethyl benzene, cumene, linear alkyl benzenes and alkyl phenols.

MODULE III	**SYNTHETIC ORGANIC CHEMICALS**	**9**

Chemicals derived from ethylene ï polyethylene, ethylene oxide, ethylene dichloride chlorinated hydrocarbons ï chemicals derived from propylene ï isopropyl alcohol, polypropylene, acrylontrile, propylene oxide ï oxidation of butane ï esters ï maleic anhydride ï acetone ï ethyl methyl ketone ï disphenol ï DDT ï aniline.

MODULE IV	**PHARMACEUTICALS AND PESTICIDES**	**9**

Introduction ï manufacture ï aspirin, Phenobarbital, penicillin, malathion, parathion and naled.

MODULE V	**DYES**	**9**

Classification ï raw materials ï intermediates ï manufacture ï azodyes ï triphenylmethane dyes ï xanthene dyes. Indigoid and thioindigoid dyes, sulphur dyes, phthalcoanines ï optical brighteners.

			L – 45; Total Hours –45

REFERENCES:

1. P.H. Groggins, MODULE Processes in Organic Synthesis, McGraw Hill Book

Co., Kogakusha, 1984.
2. Peter Wiseman, An Introduction to Industrial Organic Chemistry, 2nd Edition, Applied Science Publishers Ltd., London, 1979.
3. J.A. Kent, Reigelôs Hand Book of Industrial Chemistry, 7th Edition, vanNostrand Reinhold Co., New York, 1974.

OUTCOMES:

The student will be familiar with the

- industrial organic processes with enes, alcohols, esters, ketones, etc.
- Manufacture of aspirin, penicillin xanthenes dyes, etc.

CHCY017	CHLOR-ALKALI TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student to learn about the

- Electrode materials
- Membrane cells
- Process control and instrumentation

MODULE I	ELECTODES	9

Anodes, cathodes and separators for chlor-alkali production: graphite, metal anodes, steel cathodes, coated cathodes, asbestos diaphragms, Improved diaphragms, cation exchange membranes - different types - preparation-characteristics.

MODULE II	DIAPHRAGM CELL PROCESS	9

Diaphragm cell process, different cell designs, deposition of diaphragm, mercury cell process - different cell designs, reasons for hydrogen evolution in the primary cells,

denuder vertical and horizontal types, design aspects.		
MODULE III	**MEMBRANE CELL PROCESS**	**9**
Membrane cell process, different designs of membrane cell, monopolar and bipolar cells - conversion of mercury and diaphragm cells to membrane cells - factors affecting the performance of the membrane cells.		
MODULE IV	**MODULE OPERATIONS**	**9**
MODULE operations in chlor-alkali industry, salt washing, saturation - brine dechlorination - primary brine purification - secondary brine purification, caustic concentration - separation of salt from diaphragm cell liquor, handling of hydrogen, chlorine and caustic, chlorine liquefaction.		
MODULE V	**ENERGY CONSERVATION IN CHLOR-ALKALI INDUSTRY**	**9**
Energy conservation in chlor-alkali industry, chlorine utilization - materials of construction - electrode protection devices - environmental pollution and its control - analytical techniques - process control and instrumentation - safety aspects.		
		L – 45; Total Hours –45

REFERENCES:

1. Ullmann's Encyclopedia of Industrial Chemistry, Volume 6, 1986.
2. Krik and Othmer, Encyclopedia of Chemical Technology, 4th Edition, 1991.
3. N.M. Prout and J.S. Moorhouse, Modern Chlor-Alkali Technology, Volume IV, Elsevier Applied Science, London, 1990.
4. T. Wellington, Modern Chlor-Alkali Technology, Volume V, Elsevier Science, Essex, 1992.

OUTCOMES:

The students will be familiar with the

- anode, cathode and membrane cells
- MODULE operations in chlor-alakli industry and instrumentation

CHCY018	MODULE OPERATIONS AND MODULE PROCESSES	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student conversant with

- Chemical engineering concepts
- Fouriers law and HETP concepts
- Laws of crushing and types of Crushers

MODULE I	BASIC CONCEPTS	9

Stoichiometric principle ï material and energy balances - Combustion, Theoretical air for combustion, Flue gas analysis - water treatment - environmental protection.

MODULE II	HEAT AND MASS TRANSFER	9

Modes of Heat Transfer - Fourierôs law ï simple numerical problems on conduction ï natural and forced convection ï heat transfer equipment ï Drying, Distillation ï vapour-liquid equilibria ï distillation methods ï continuous rectification of binary systems.

MODULE III	MASS TRANSFER OPERATIONS	9

Adsorption and adsorption principle ï equilibrium relationships ï methods of calculation ï various types of equipment - Extraction and Leaching ï liquid extraction ï ternary diagram ï selection of solvent and equipment ï method of calculation of co-

current and counter-current extraction operations - Crystallization ï types of crystallization equipment ï material and energy balances.		
MODULE IV	**MECHANICAL OPERATIONS**	**9**
Laws of crushing ï closed and open circuit grinding ï various types of crushers and grinders ï settling, floatation and filtration concepts.		
MODULE V	**MODULE PROCESSES**	**9**
Nitration, sulphonation, halogenation, esterification, amination, saponification and hydrogenation ï role of the above MODULE processes in such industries as petroleum, drugs, pharmaceuticals and organic synthesis.		
		L – 45; Total Hours –45

REFERENCES:

1. Groggins P.H., MODULE Processes in Organic Synthesis, McGraw Hill Book Co., Kogakusha, 5th Edition, 2007.
2. McCabe W.L., Smith J.C. and Harriot P., MODULE Operations of Chemical Engineering, 6th Edition, McGraw Hill Book Co. 2001.
3. Perry J.H., Handbook of Chemical Engineers, McGraw Hill Book Co., 2006.
4. Badger W.I. and Banchero I.T., Introduction to Chemical Engineering, McGraw Hill Book Co. Inc., Kogakusha, 1988.

OUTCOMES:

The students will be familiar with

- Bernoullis equation & its applications and
- demonstrate the role of MODULE processes in various industries.

CHCY019	WATER AND WASTEWATER TREATMENT	L	T	P	C

		3	**0**	**0**	**3**

OBJECTIVES:

To make the student to learn about the

- Quality standard for drinking water
- Industrial water treatment methods
- Waste Water analysis and treatment
- Adsorption and oxidation process

MODULE I	**REQUIREMENTS OF WATER AND PRELIMINARY TREATMENT**	**9**

Requirements of water ï quality standards for drinking water ï object of water treatment ï conventional treatment ï turbidity removal ï cause of turbidity ï coagulation ï common coagulants ï theory of coagulation ï mixing basins ï flocculation ï principle and design of flocculators ï sedimentation ï settling tanks ï settling velocity ï surface loading rate ï efficiency of settling tanks ï sludge removal mechanism.

MODULE II	**INDUSTRIAL WATER TREATMENT**	**9**

Filtration ï size and shape characteristics of filtering media ï sand filters ï hydraulics of filtration ï design considerations ï radial, upflow, high rate and multimedia filters ï pressure filter - Water softening ï lime soda, zeolite and demineralization processes ï industrial water treatment for boilers.

MODULE III	**TREATMENT METHODS**	**9**

Taste and odour control ï absorption ï activated carbon treatment ï removal of colour ï iron and manganese removal ï aeration, oxidation, ion exchange and other methods ï effects of fluorides ï fluoridation and defluoridation ï desalination ï corrosion prevention and control ï factors influencing corrosion ï Langelier index ï corrosion control measures.

MODULE IV	WASTEWATER TREATMENT	9
Wastewater treatment ï pre and primary treatment ï equalization neutralization ï screening and grid removal ï sedimentation ï oil separation gas stripping of volatile organics ï biological oxidation ï lagoons and stabilization basins ï aerated lagoons ï activated sludge process ï trickling filtration ï anaerobic decomposition.		
MODULE V	**ADSORPTION AND OXIDATION PROCESSES**	**9**
Chemical process ï adsorption ï theory of adsorption ï ion exchange process ï chemical oxidation ï advanced oxidation process ï sludge handling and disposal ï miscellaneous treatment processes.		
		L – 45; Total Hours –45

REFERENCES:

1. W. Wesley Eckenfelder, Jr., Industrial Water Pollution Control, 2nd Edition, McGraw Hill Inc., 1989.
2. Metcalf and Eddy, Waste Water Engineering, 3rd Edition, McGraw Hill Inc., 1991.
3. C.S. Rao, Environmental Pollution Control Engineering, Wiley Eastern Ltd., 1994.
4. S.P. Mahajan, Pollution Control in Process Industries, Tata McGraw Hill Publishing Company Ltd., 1994.
5. Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, Environmental Engineering, McGraw Hill Inc., 1985.

OUTCOMES:

The student will be familiar with the

- quality requirement of water,
- analysis and treatment methods.

CHCY020	SOLID WASTE MANAGEMENT AND AIR POLLUTION	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student to learn about the

- Solid waste collection and disposal
- Air quality and air pollution control
- Energy recovery

MODULE I	SOLID WASTE	9

Solid waste ï definition ï characteristics ï perspectives ï types of solid waste ï sources ï properties of solid waste ï physical and chemical composition ï changes in composition ï solid waste management ï materials flow ï reduction in raw materials usages and solid waste quantities ï reuse of solid waste materials.

MODULE II	SOLID WASTE COLLECTION AND DISPOSAL	9

Solid waste generation ï on-site handling, storage and processing ï collection of solid waste ï transfer and transport ï processing techniques ï ultimate disposal.

MODULE III	ENERGY RECOVERY	9

Energy recovery ï processing techniques ï materials recovery systems ï recovery of biological conversion products and thermal conversion products ï materials and energy recovery system.

MODULE IV	AIR POLLUTION	9

Air pollution ï global implication of air pollution ï MODULEs of measurement ï sources of pollutants ï classification of pollutants ï meteorology and natural purification processes ï influence of meteorological phenomena on air quality ï effects on man and vegetation - Effects of pollutants on human beings, animals,

vegetation, buildings and materials.		
MODULE V	**ANALYSIS AND CONTROL DEVICES**	**9**
Sampling and analysis ï particulars and gaseous pollutants ï methods for monitoring air pollutants ï air quality control devices for particulate and gaseous contaminants ï major polluting industries ï measures to check industrial pollution.		
		L – 45; Total Hours –45

REFERENCES:

1. Howard S. Revay, Donald R. Rowe and George Technobanoglous, Environmental Engineering, McGraw Hill Inc., 1985.
2. Gilbut M. Masters, Introduction to Environmental Engineering and Science, Prentice-Hall of India Pvt. Ltd., 1991.
3. S.K. Garg, Sewage Disposal and Air Pollution Engineering, Khanna Publishers, 1990.
4. V.P. Kudesia, Air Pollution, Pragati Prakashan Publishers, 1992.
5. M.N. Rao and H.V.N. Rao, Air Pollution, Tata McGraw Hill Publishing Company Ltd., 1994.

OUTCOMES:

The students will be familiar with the types of

- solid waste, collection and disposal
- air pollutants and control measures

CHCY021	**INDUSTRIAL ELECTROCHEMISTRY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To make the student to learn about the

- basics of electrolysis
- electrometallurgy
- metal refining
- electrosynthesis
- industrial electrochemical process

MODULE I	**CHLORALKALI INDUSTRY**	**9**

General concepts of brine electrolysis ï modern technological developments ï chlorine cell technologies ï mercury and diaphragm cell ï membrane ï cell.

MODULE II	**ELECTROMETALLURGY**	**9**

Metal extraction and refining ï electrowinning ï aluminium extraction ï manufacture of sodium, lithium and magnesium ï hydrometallurgical processes ï electrorefining ï aqueous and molten salt electrorefining.

MODULE III	**METAL FINISHING**	**9**

Pretreatment ï conversion coatings ï phosphating ï types, methods, properties and influencing factors ï evaluation and testing ï applications ï anodizing ï principle and applications - electroplating ï objectives, theory and method ï electroplating of nickel ï electroless plating ï galvanizing ï tinning.

MODULE IV	**ELECTROSYNTHESIS**	**9**

Electrolytic preparation of inorganic compounds ï fluorine ï peracids and their salts ï $KMnO_4$ ï $K_2Cr_2O_7$ - Organic electrosynthesis ï hydromerisation of acrylonitrile ï Monsanto process ï manufacture of ethylene glycol ï electrolysis of organic compounds with the use of ion ï exchange membranes.

MODULE V	**INDUSTRIAL ELECTROCHEMICAL PROCESSES**	**9**

Water treatment and environmental protection ï metal ion removal and metal

recovery ï electro-filtration of particulates from gases ï electrodialysis ï desalination ï electroflotation.			
			L – 45; Total Hours –45

REFERENCES:

1. P.H. Rieger, Electrochemistry, Prentice Hall, Inc., New York, 1987.
2. D. Fletcher, Industrial Electrochemistry, Chapman and Hall, London, 1982.
3. J. Bockris and A.K.M. Reddy, Modern Electrochemistry, Volume II, Mac Donold, London, 1970.
4. C. Rajagopal and K. Vasu, Conversion Coatings, 1st Edition, Tata McGraw Hill, New Delhi, 2000.

OUTCOMES:

The student will be familiar with the

- electrowinning,
- electrorefining,
- electrochemical metal finishing,
- electrosynthesis
- electrodialysis.

CHCY022	CORROSION AND CORROSION CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student conversant with the

- Causes and theories of corrosion
- Different types of corrosion

- Basic concepts to prevent corrosion and testing of corrosion by various diagrams.
- Factors influencing corrosion
- Control of corrosion using various methods.

MODULE I	**CORROSION**	**9**

Causes and effects of corrosion ï theories of corrosion ï oxidation ï direct atmospheric effect ï electrochemical corrosion ï hydrogen evolution ï presence and absence of oxygen ï corrosion by gaseous reduction.

MODULE II	**FORMS OF CORROSION**	**9**

Galvanic bimetal corrosion ï differential aeration corrosion ï concentration cell corrosion ï erosion corrosion ï pitting corrosion ï underground soil corrosion ï intergranular corrosion ï stress corrosion ï seasonal cracking of alloys ï caustic embrittlement ï corrosion fatigue.

MODULE III	**CORROSION TESTING**	**9**

Rate of corrosion ï calculation of qpG and other related thermodynamic parameters ï potential measurement ï electrochemical series ï redox reactions ï EMF measurement and corrosion current ï anodic and cathodic behaviour of metals ï passivity ï testing of virgin metals ï alloy ï Pourbaix and Evans diagrams.

MODULE IV	**FACTORS INFLUENCING CORROSION**	**9**

Nature of metal ï over voltage ï areas of anodic/cathodic ï purity of metal ï physical state of metals ï passive nature of metal ï solubility ï volatility of corrosion products ï corroding environment ï influence of pH ï ions ï formations of cells ï polarization of electrodes.

MODULE V	**CORROSION CONTROL**	**9**

Design ï selection of materials ï pure metals and alloys ï annealing ï elimination of galvanic action ï cathodic protection ï sacrificial anodic protection ï impressed

current cathodic protection ï modification of environment ï deaeration ï dehumidification ï inhibitors ï protective coatings ï preparation of materials for coating ï metallic and non-metallic ï organic coatings ï special paints ï varnish, enamel and lacquers.

			L – 45; Total Hours –45

REFERENCES:

1. M.G. Fontana and N.G. Green, Corrosion Engineering, McGraw Hill Book Company, New York, 1984.
2. J.H. Brophy, R.M. Rose and J. Walf, The Structure and Properties of Materials, Wiley Inter Science Inc., New York, 1984.
3. B.T. Kelly, Irradiation Diamagneto Solids, Pergamon Press, New York, 1992.
4. D.R. Cross, Principles and Applications of Electrochemistry, Chapman and Hall, UK, 1988.

OUTCOMES:

Students will become familiar with the

- basic concepts of corrosion,
- factors which influence the corrosion
- mechanism of corrosion
- control of corrosion in real situation.

CHCY023	**ELECTROCHEMICAL PROTECTION SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To make the student to learn about the

- cathodic protection
- Sacrificial anode system
- Impressed current cathodic protection
- Design of Anodic and cathodic protection

MODULE I	CATHODIC PROTECTION	9

Fundamental aspects, Definition of cathodic protection using Evans diagram and Pourbaix diagram, Derivation of protective potential for steel protective potentials of different metals. Criteria for cathodic protection, half cells used in cathodic protection potential measuring devices, rectifiers, zero current ammeter, automatic control MODULEs, holiday detectors.

MODULE II	SACRIFICIAL ANODE SYSTEM	9

Principle of sacrificial anodes, required properties of galvanic anodes, anode life, current output. Advantages and limitations of sacrificial anodes-shape - and size of anodes, inserts, back-fills: Magnesium anode-electrochemical properties, current density, anode consumption, composition field of application. Aluminium anode - electrochemical properties, composition, field of application - Zinc alloy anodes - electrochemical properties, composition, field of application.

MODULE III	IMPRESSED CURRENT CATHODIC PROTECTION	9

Principle of impressed current system - DC power sources, cables, advantages and limitation, required properties of impressed current anode. Consumable anodes, Scrap steel, Aluminum -properties consumption - field of application. Permanent anodes, Graphite, High Silicon Iron, magnetite, platinum and platinum alloys platinised titanium, platinised Niobium, platinised tantalum, Metal oxide anodes lead alloy anode, properties, composition, consumption, field of application. Back fills for impressed current anodes.

MODULE IV	DESIGN OF CATHODIC PROTECTION	9

Cathodic protection to buried structures - Field data, soil resistivity, pH determination redox potential measurement, potential measurement, long line current survey,

coating resistance, current drainage survey - Designing of sacrificial anode system, designing of impressed current system - Designing of CP to buried pipe line, ship hull and storage tank.		
MODULE V	**Design of Anodic protection**	**9**
Anodic protection: Principles of anodic protection-description of electrochemical passivity, characteristics of anodic polarisation curves, the passive metal layer and mechanism of iron passivity, passivity breakdown. Equipments for anodic protection-characteristics of cathodes, platinum clad cathode, Hastelloy - cathodes, stainless steel cathode. Reference electrodes-calomel half cell, silver/silver chloride half cell, mercury/mercury sulphate half cell, metal oxide and metals as reference electrodes. Design, operation and maintenance of anodic protection system. Establishing electrochemical parameters, operation and maintenance applications.		
		L – 45; Total Hours –45

REFERENCES:

1. John H. Morgan, Cathodic Protection, New Age International, 2nd Edition, 1987.
2. Glen, L. Riggs, Anodic Protection, Kluwer Academic Publication, 1981.

OUTCOMES:

The students will be familiar with the

- cathodic protection
- Sacrificial anode system
- Impressed current cathodic protection
- Design of Anodic and cathodic protection

CHCY024	**METAL COATING TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To make the student to know about

- the different surface coating methods to preserve the metal surface
- different methods of coating
- electron beam coating

MODULE I	**SURFACE CHEMISTRY OF ALLOYS**	**9**

Basic physical chemistry, surface chemistry, pretreatment principle - technology and control of electro deposition systems such as alloy plating, electrolysis, composites and non aqueous.

MODULE II	**METHODS OF COATING I**	**9**

Hot dip coatings - principle, surface preparation, methods, applications, Diffusion coatings - Principle - Cementation - Cladding - case hardening - structures.

MODULE III	**Methods of coating II**	**9**

Chemical vapor deposition - classification-techniques, metal organic type, plasma assisted, layer assisted, applications.

MODULE IV	**METHODS OF COATING III**	**9**

Sputtering techniques, methods, applications, plasma treatments, nitriding, carbonizing, boriding, titanizing methods and applications.

MODULE V	**LASER ALLOY AND ELECTRON BEAM COATING**	**9**

Laser alloying - sources, variables, methods, applications, Electron beam coating - evaporation materials, methods, applications.

			L – 45; Total Hours –45

REFERENCES:

1. T.S. Sudarsan, Surface Modification Technologies, Marcel Dekker Inc., 1989

2. D.R. Gabe, Principles of Metal Surfaces Treatment and Protection, Pergmon Press 1972.

OUTCOMES:

The student will be familiar with the

- pretreatment methods before coating
- Galvanizing and tinning and cladding
- Chemical vapour deposition
- Sputtering and laser alloying methods to preserve the metal surface.

CHCY025	PROTECTIVE COATINGS	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student to learn the

- organic and inorganic coatings to protect the surface.
- Electroplating
- Evaluation of paints
- Special paints
- Inorganic coating materials

MODULE I	PIGMENTS AND RESINS	9

Pigments and additives used in paints - properties and functions - Inorganic, organic and metallic pigments - Extenders - Driers. Natural resins - chemistry and properties -

shellac Rosin, rubber oils used for surface coatings - preparation and properties of synthetic resins - alkyds - phenolic - vinyls - amino resins - acrylics - epoxies - urethanes - silicones. Formulation of paints and rheological characteristics - Importance of pigment volume concentration, volume solids etc., water based paints, composition and properties - factors affecting water solubility.

MODULE II	**ELECTROPLATING**	**9**

Surface preparation for paint applications, methods of surface preparation - methods of application of paints brushing - roller coating - compressed air spraying - airless spraying - electrostatic spraying - Electrodeposition of Paints and Electropolymerization Electrokinetic phenomena involved in electrodeposition fundamental principle, formulation of bath - anodic and cathodic deposition - advantages over conventional methods.

MODULE III	**TESTING AND EVALUATION OF PAINTS**	**9**

Testing and evaluation of liquid paints and coatings - specific gravity - viscosity - time of grind - thickness - hardness, abrasion - flexibility - electrochemical and accelerated tests - field exposure tests - paint film defects - identification and remedial measures.

MODULE IV	**PAINTS FOR FUNCTIONAL APPLICATIONS**	**9**

Paints for automobiles - aircrafts - marine paints (ships) chemical resistant coatings - Paints for pipe line, paints for various substrates other than metals - paints for concrete - wood - plastic - powder coatings - basic and application principle.

MODULE V	**INORGANIC COATINGS**	**9**

Conversion coatings - phosphating, chromating of ferrous and non-ferrous metals - ceramic coatings.

			L – 45; Total Hours –45

REFERENCES:

1. John Williams, Organic Coating Technology Payne, Volume I and II, Henry Fleming Sons Inc., New York London, 1961.
2. Gosta Wranglen, An Introduction to Corrosion and Protection Of Metals, Institute for Metals Kgdd, Stockholm, 1972.
3. Charles G. Munger, Corrosion Prevention by Organic Coating, NACE 1984.
4. H.W. Chatfield, (Editor)s, The Science of Surface Coating, Published: Ernest Benn Limited London, 1962.
5. Willibald Machu, Hand Book of Electropainting Technology, Electrochemical Publication Limited 1978.

OUTCOMES:

The students will be familiar with the

- Surface preparation methods
- Different types of paints, their constituents and fictions
- Constituents and functions of paints
- Inorganic coating methods

CHCY026	FUEL CELLS AND APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

The primary objective of the course is make the student conversant with

- classification and types of fuel cell
- outline components of fuel cells
- performance for fuel cells
- hydrogen storage and production
- the applications of fuel cells

MODULE I	**INTRODUCTION AND TYPES OF FUEL CELLS**	**9**
Introduction - definition - history - difference between batteries and fuel cells - chemistry of fuel cells - classification of fuel cell (based on temperature and electrolyte) ï types of fuel cell: polymer electrolyte membrane or proton exchange membrane fuel cell (PEMFC), direct methanol fuel cell (DMFC), alkaline fuel cell (AFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC) and solid oxide fuel cells (SOFC)		
MODULE II	**FUEL CELL COMPONENTS**	**9**
Membrane electrode assembly components : membranes and ionomers , fuel cell electrodes and gas diffusion layer, fuel cell electrocatalysts - bi-polar plates, humidifiers and cooling plates - fuel cell stack		
MODULE III	**FUEL CELLS PERFORMANCE AND APPLICATIONS**	**9**
Thermodynamics of fuel cells - electrochemical kinetics of fuel cells - Fuel cell efficiency - performance characteristics:, voltage efficiency - effect of voltage with current density for low and high temperature fuel cells- causes for voltage losses- introduction to fuel cycle analysis		
MODULE IV	**PRODUCTION AND STORAGE OF HYDROGEN FUEL**	**9**
Hydrogen as energy source -its merit as a fuel - hydrogen storage: compressed hydrogen, liquid hydrogen, metal hydrides, carbon fibers ï hydrogen production : steam reforming, partial oxidation, coal gasification/thermal reforming, fuel cell technology based on bio-mass		
MODULE V	**FUEL CELL APPLICATIONS**	**9**
Automotive applications ï road map to market ï automotive industry and the environment ï distributed power generation ï grid-connect applications ï non-grid connect applications ï residential power ï portable power ï combined heat and power		
		L – 45; Total Hours –45

REFERENCES:

1. R.H. Thring (Editor), Fuel Cells for Automotive Applications, Professional Engineering Publishing UK, 2004.
2. Gregor Hoogers (Editor), Fuel Cell Technology Handbook, SAE International, CRC Press, 2003.
3. Vladimir S. Bagotsky, Fuel Cells: Problems and Solutions, 2nd Edition, John Wiley and Sons, 2012.
4. B. Viswanathan and M. Aulice Scibioh, Fuel Cells: Principles and Applications, Taylor and Francis Group, 2007.
5. Supramaniam Srinivasan, From Fundamentals to Applications, Springer, 2006.
6. Prospects for Hydrogen and Fuel Cells, International Energy Agency, OECD Publishing, 2005.

OUTCOMES:

The student will be able to

1) classify fuel cells and elaborate the different types of fuel cells.
2) explain the various components of the fuel cells
3) calculate the open circuit voltage, efficiency and voltage losses, explain fuel cycle analysis and prove the laws of thermodynamics for fuel cell.
4) describe the various methods for production and storage of hydrogen.
5) list out the applications of fuel cells.

CHCY027	ADVANCED BATTERIES AND SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

The students will be trained about the

- different types of batteries
- design and operation of different types of batteries

MODULE I	**Ni-MH BATTERIES**	**9**
Advanced Ni-MH Batteries: Introduction to Ni-MH batteries, overview of Ni MH, Improvement in hydrogen storage alloys, improvement in Cathode materials, improvement in separator and cell design.		
MODULE II	**Li- ion BATTERIES**	**9**
Advanced Li-ion Batteries: Lithium-ion battery, The Principle carbonaceous anode materials, cathode material Electrolyte, separator.		
MODULE III	**PERFORMANCE OF LITHIUM BATTERIES**	**9**
Advanced Cathode materials for Lithium Batteries: The intercalative reactions, relationships between performance requirements and materials characteristics D stability, capacity, voltage, energy, power, cycle life, shelf life.		
MODULE IV	**Li/POLYMER BATTERIES**	**9**
Li/polymer Batteries: Polymer cathode for Li battery, Polymer Cathode in SPE, conductivity, ion transport mechanisms, plasticized electrolytes.		
MODULE V	**ULTRA CAPACITORS**	**9**
Ultra capacitors: Double layer, Metal Oxide, conducting polymers energy and power densities, voltage limitation and self discharge.		

L – 45; Total Hours –45

REFERENCES:

1. Energy Storage Systems for Electronics Edited by Tetsuya Osaka, Department of Applied Chemistry, Wasuda University, Tokyo, Japan and Madhav Dutta, Intel Corporation, Hillsboro, USA.

2. M. Barak, Electrochemical Power Sources, IEEE Series, Peter Peregrinus Ltd.
3. Lindar D., Handbook on Batteries and Fuel Cells, McGraw Book Co., New York, 1955.

OUTCOMES:

The student will have

- A thorough understanding about batteries and their components
- Understand the working up of the batteries

CHCY028	ELECTROCHEMICAL MATERIAL SCIENCE	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student to learn about the

- Different types of semiconductors
- Preparation and properties of the semiconductors
- Application in photovoltaic cells

MODULE I	SEMICONDUCTORS	9

Semiconductors, n-type and p-type semiconductors, conductivity of semiconductors, applications, of semiconductors, Photo conductivity, Photo conducting materials, electronic transitions in photoconductors, trapping and recombination, general mechanism of photoconductivity, life-time of majority carriers, preparation of CdS photoconductors by the sintering technique, ohmic contacts, fabrication of photo conductive cells and their applications.

MODULE II	METHODS OF PREPARATION	9

Thin films of semiconductors, methods of preparation: vacuum evaporation,

sputtering, molecular beam epitaxy, hot wall epitaxy, chemical bath deposition, spray pyrolysis, electrodeposition, liquid phase epitaxy, chemical vapor deposition, structural, electrical and optical characterization, mechanical properties of thin films, effect of grain boundaries.

MODULE III	**LUMINESCENCE**	**9**

Luminescence, various types of luminescence (definitions only) model of luminescence in sulphide phosphors, applications, basic aspects of superconductivity, super conducting materials, high temperature, super conducting materials, method of preparation and applications.

MODULE IV	**PHOTOVOLTAICS**	**9**

Basic of photovoltaics, homo and heterojunctions, preparation of single crystals and polycrystalline silicon solar cells, Metal-Insulator-Metal and semiconductors - Insulator-semiconductors solar cells, photovoltaic measurements - I-V characteristics, spectral response and capacitance measurements.

MODULE V	**SOLAR CELLS AND PEC CELLS**	**9**

Preparation of CdS/CU_2S solar cells by screen printing technique and their characteristics, amorphous Si solar cells GaAs solar cells, Semiconductors electrolyte interface. Photoelectrochemical (PEC) cells for conversion of light energy to electrical energy, PEC cells based on CdSe Si and GaAs and their output characteristics, Estimation of flat band potential from Mott-Schottky plots.

			L – 45; Total Hours –45

REFERENCES:

1. B.S. Saxena, R.C. Gupta and P.N. Saxena, Fundamentals of Solid State Physics, Pragati Prakashan Educational Publishers, Meerut, 2001.
2. K.L. Chopra and I. Kaur, Thin Film Devices and their Applications, Plenum Press, New York, 1983.

3. A.C. Rose D. Innes and E.H. Rhoderick, Introduction to Superconductivity, Robert Maxwell Publishers, 1988.
4. Photoelectrochemical Solar Cell, Edited By K.S.V. Santhanam and M. Sharon, Elsevier Science Publishers, BV New York 1988.
5. C. Hu and R.M. White, Solar Cells, McGraw Hill Book Company, New Delhi, 1983
6. R.K. Kotnala and N.P. Singh, Essentials of Solar Cells, Allied Publishers Pvt. Ltd., Chennai, 1992
7. A.F. Fahrenbruch and R.H. Bube, Fundamentals of Solar Cells, Academic Press, London 1983.
8. W.E. Hatified and J.H. Miller (Editors), High Temperature Superconducting Materials, Marcel Dekker, New York 1988.

OUTCOMES:

To make the student to learn about the

- electrochemical cells and their types
- factors affecting battery performance
- application of batteries
- testing in fuel cells

CHCY029	ELECTROCHEMICAL ENERGY CONVERSION AND STORAGE	L	T	P	C
		3	0	0	3

OBJECTIVES:

MODULE I	FUNDAMENTALS	9

EMF, Reversible cells, Reversible electrodes, relationship between electrical energy

and energy content of a cell, force energy changes and EMF in cells, relationship between the energy changes accompanying a cell reaction and concentration of the reactants, effect of sulphuric acid concentration on EMF in the lead acid battery, effect of cell temperature in lead acid battery, derivation of number of electrons involved in a cell reactions, thermodynamic calculation of the capacity of a battery, calculation of the capacity of a battery, calculation of operating parameters for a lead acid battery from calorimetric measurements, calculations of energy density of cells, heating effects in batteries, spontaneous reaction in electrochemical cells, pressure development in sealed batteries.

MODULE II	**FACTORS AFFECTING BATTERY PERFORMANCE**	**9**

Factors affecting battery capacity, voltage level current drain of discharge, types of discharge continuous, intermittent, constant current, constant load, constant power, temperature of battery during discharge, service life, voltage regulation, changing voltage, effect of all design, battery age and storage condition, effect of battery design.

MODULE III	**SELECTION AND APPLICATION OF BATTERIES**	**9**

Major consideration in selecting a battery, battery applications, comparative features and performance characteristics, characteristics of batteries for portable equipment, cost effectiveness, other comparison of performance criteria for battery selection D probable equipment.

MODULE IV	**TESTING AND EVALUATION**	**9**

Evaluation of active masses, Porosity - mercury porosity meter, liquid absorption method, Surface area measurement - BET method (nitrogen absorption), internal resistance of cells - D.C. methods, polarization elimination method - I.E. polarization and flash current method A.C. methods, A.C. impedance method, testing of storage batteries - capacity test for retention of charge, vibration test, life test, efficiency test, leakage test for sealed cells, testing of separators, HRD at normal and low temperature.

MODULE V	FUEL CELLS AND SUPER CAPACITOR		9
Introduction, Types of Fuel cells, figure of merit, electro catalysts for hydrogen oxidation and oxygen reduction, electrochemical double layer capacitors, ruthenium oxide as capacitor electrode, manual capacitors with proton conducting solid polymer electrolytes.			
			L – 45; Total Hours –45

REFERENCES:

1. Barak, Electrochemical Power sources, IEEE Series, Peter Peregrinus Ltd., Steverage, UK 1980, 1997.
2. N. Corey Cahoon and George W. Heise, Primary Battery (Volume I and II), John Wiley New York, 1971 and 1976 London.
3. Linden D. Hand Book on Batteries and Fuel Cell, McGraw Hill Book Co., New York 1955.
4. J.P. Gabano, Lithium Batteries, Academic Press, London, 1983
5. T.R. Crompton, Batteries Reference Book, Batterworths, London.
6. G.W. Vinal, Storage Batteries, John Wiley, New York 1955.

OUTCOMES:

The students will be familiar with

- electrochemical cells and their types
- factors affecting battery performance
- application of batteries
- testing in fuel cells

CHCY030	SOLAR ENERGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

The students will be conversant with the

- Sustainable energy conversion proceses
- Fundamentals of solar cells
- Solar electrical energy conversion
- Nanomaterials as photovoltaics
- Different types of solar cells

MODULE I	INTRODUCTIONS TO SUSTAINABLE ENERGY CONVERSION PROCESSES	9

Photovoltaic, Photothermal, Photoelectrochemical, Biofuel, Wind Power, and Geothermal Systems. Insolation vs. world energy demand, Current energy consumption from different sources, Renewable Energy Resources; Utilization, Storage, and Economic limitations Solar energy: Thermonuclear energy source, Planckôs Law, Thermal radiation fundamentals, Solar Radiation Table: extraterrestrial and terrestrial radiations; Solar constant, Air Mass, Spectral Irradiance, Mean annual irradiance on horizontal surface across the world, Radiation on an inclined surface: direct, reflected, and diffused radiations, Global solar radiation data.

MODULE II	SOLAR CELL FUNDAMENTALS	9

Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure.

MODULE III	SOLAR ELECTRICAL ENERGY CONVERSION	9

Solar photovoltaic energy conversion - Principles - Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I-V characteristics, effect of variation of solar insolation and temperature, losses. Solar PV power plants.

MODULE IV	NANOMATERIALS FOR PHOTOVOLTAICS	9

Photochemical solar cells, PV panels with nanostructures. Phase compositions on nanoscale microstructures ï role of nanostructures and materials ï nanomaterials in solar photovoltaic technology- band gap engineering and optical engineering - tandem structures - quantum well and quantum dot solar cells - photo-thermal cells ï organic solar cells. Performance and reliability of nanomaterials based solar cells.

MODULE V	SOLAR CELLS	9

Formation of a pn ï junction - Space charge and internal field - Quasi - Fermi levels - The Shockley diode equation - Structure of a solar cell - The solar cell equation - Fill factor and maximum power - Various electron - hole-pair recombination mechanisms - Crystalline silicon solar cells - Thin film solar cells: CIGS, Cite and a ï silicon - Tandem solar cells - Dye - sensitized solar cells - Organic solar cells. Thin film solar cells, Amorphous silicon (a-Si) solar cells, Cadmium Telluride (Cd-Te) Solar cells, Cu(InGa)Se2 solar cells, Dye-sensitized solar cells, Organic and polymer solar cells. Photoelectrochemical hydrogen production, photoelectrochemical cells, solar-to-hydrogen efficiency; Hydrogen storage, hydrogen economy, Electrochemical Storage of energy, Current developments in energy storage.

L – 45; Total Hours –45

REFERENCES:

1. Photoelectrochemical Solar Cell, Edited By K.S.V. Santhanam and M. Sharon, Elsevier Science Publishers, BV New York 1988.
2. C. Hu and R.M. White, Solar Cells, McGraw Hill Book Company, New Delhi, 1983
3. R.K. Kotnala and N.P. Singh, Essentials of Solar Cells, Allied Publishers Pvt. Ltd., Chennai, 1992
4. A.F. Fahrenbruch and R.H. Bube, Fundamentals of Solar Cells, Academic Press, London 1983.

OUTCOMES:
The students will be acquainted with the • Sustainable energy conversion processes • Fundamentals of solar cells • Solar electrical energy conversion • Nanomaterials as photovoltaics • Different types of solar cells

CHCY031	CHEMISTRY OF CARBOHYDRATES	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student conversant with

- The basic concepts in carbohydrates
- Structural and spectroscopic analysis of sugars
- Various synthetic methodologies of carbohydrates
- Carbohydrates as chiral synthons
- Basics on glycans and glycoconjugates

MODULE I	CLASSIFICATION OF SUGARS	9

Definition and classification of sugars, nomenclature, aldoses and ketoses, configuration of (+)- glucose: the Fischer proof, ring structures and conformation, mutarotation, anomericity, Naturally occurring monosaccharides, oligosaccharides and polysaccharides, three-dimensional structure of macromolecular carbohydrates.

MODULE II	STRUCTURAL AND SPECTROSCOPIC ANALYSIS OF CARBOHYDRATES	8

Methods for isolation, purification and structural analysis, complete and partial hydrolysis, methylation analysis, Smith degradation, chromatographic and electrophoretic techniques, advanced spectroscopic techniques.

MODULE III	CHEMICAL REACTIONS OF CARBOHYDRATES	10

Chemical reactions of carbohydrates: oxidation, reduction, formation of derivatives, glycosides, ethers, esters and cyclic acetals, modern chemical transformations, methods for the formation and cleavage of O-glycosidic bond, Ferrier rearrangement.

MODULE IV	CARBOHYDRATES AS SYNTHONS	10
Use of protecting groups, chemical and enzymatic synthesis of oligosaccharides, carbohydrates as chiral synthons for natural products synthesis.		
MODULE V	**GLYCANS AND GLYCOCONJUGATES**	**8**
Carbohydrate biopolymers, animal glycoproteins, blood-group substances, plant and algal glycoproteins, proteoglycans and glycosaminoglycans, glycolipids, biological functions of glycan chains in glycoconjugates, carbohydrates and carbohydrate components of nucleic acids and antibiotics.		
		L – 45; Total Hours –45

REFERENCES:

1. J.F. Kennedy and C.A. White, Bioactive Carbohydrates, Ellis Horwood, New York, 1983
2. R.W. Binkley, Moden Carbohydrate Chemistry, Marcell and Dekker, New York., 1988
3. J.F. Kennedy (Ed.) Carbohydrate Chemistry, Oxford University Press, Oxford, 1988.
4. E.A. Davidson, Carbohydrate Chemistry, Holt, Rinehart & Winston Inc., Mew York, 1967.
5. A.F.Bochkov and G.E. Zaikov, Chemistry of the O-Glycosidic Bond Formation and Cleavage, Pergamon, Oxford, 1979.
6. S.Hanessian, Total Synthesis of Natural Products: The Chiron Approach, Pergamon, Oxford. 1983.

OUTCOMES:

The students will be able to

- Recognize the different types of carbohydrates
- Acquire knowledge about the structural and spectroscopic analysis of carbohydrates
- Recognize and depict the mechanism of carbohydrate based chemical reactions
- Identify chiral based carbohydrates as synthons
- Understand the basics of glycans, glycoproteins and glycoconjugates.

CHCY032	ADVANCED CONCEPTS IN ORGANIC SYNTHESIS	L	T	P	C
		3	0	0	3

OBJECTIVES:

To make the student conversant with

- Different organometallic reactions in organic synthesis
- Various types of coupling reactions
- Transition metal based chemical reactions
- Oxidation and reduction reactions
- Few named reactions

MODULE I	ORGANOMETALLIC REACTIONS	9

Organometallic reagents of Al, Cu, Ti, Zr, Cr, Zn, Cd, Hg and Ce metals. Nucleophilic addition to imines, imine derivatives and carboxylic acid derivates; Carbanions stabilized by N, B, S, Si and Se, containing groups; epoxidation; transition metal enolates, metalloenamines, asymmetric synthesis with enol ethers; Eschenmoser coupling reactions; Passserini and Ugi reaction.

MODULE II	COUPLING REACTIONS	9

Alkylation of enols, enolates; stabilized and non-stabilized carbanions; cyclization reactions; coupling reactions and rearrangements; additions to and substitution at carbon-carbon bonds; organocuprates and conjugate reactions; nucleophiles with cationic pentadienyl- metal complexes; organopalladium reagents; carbometallation.

MODULE III	TRANSITION METAL MEDIATED REACTIONS	9

Synthesis of sulphides, sulphoxides, phosphonium ylides and related compounds,; protecting groups; reductive elimination; vicinal deoxygenation and vicinal desilylation, Ene reactions; photoisomerisation, transition metal mediated cycloadditions; charge-

transfer accelerated cyclization.

MODULE IV	OXIDATION AND REDUCTION REACTIONS	9

Oxidation by remote functionalisation, epoxidation and asymmetric epoxidation; glycol formation; electrochemical oxidation; oxidative rearrangements; solid-support oxidants and electron transfer reactions.

Reduction by metal hydrides; asymmetric hydrogenation; enzymatic reduction; hydrozirconation, hydroboration, hydroalumination and hydrosilylation reaction.

MODULE V	NAMED REACTIONS	9

Birch-Pearson, Dotz, Heck-Stille, Buchwald, Jacobsens, Hegedus, Mcmurray, Noyori, Pauson-Khand, Sharpless, Tebbe-Grubbs, Ritter type reaction, Nef reaction, Vollhardt reactions; Diels-Alder reactions and Nazarov cationic cyclization.

L – 45; Total Hours –45

REFERENCES:

1. B.M. Trost (ed.) Comprehensive Organic Synthesis: Selectivity, Strategy and Efficiency in Modern Organic Chemistry, Pergamon Press, Oxford, Vols 1-9, 1991.
2. E.J. Corey and X..-M.Cheng, The Logic of Chemical Synthesis, Wiley, New York, 1989.
3. J.D. Morrison (Series Ed.) Asymmetric Synthesis Academic Press, New York.
4. J.P. Collman, L.S. Hegedus, J.R. Norton and R.G. Finke, Principles and Applications of Organotransition Metal Chemistry. University Science Books, Mill Valley, California, 1987.

OUTCOMES:

The students will be able to

- Gain understanding on the various metals in organic reactions
- Depict the mechanism of organometallic reactions.
- Illustrate organic chemical reactions using transition metals.
- Understand the metal mediated oxidation and reduction of organic compounds
- Recognise the organometallic based named reactions.