

**DEPARTMENT OF CHEMISTRY**

**Curriculum & Syllabus for M.Sc. CHEMISTRY  
 (Four Semesters/ Full Time)  
 CURRICULUM**

<b>SEMESTER I</b>						
<b>S. No.</b>	<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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	0	2	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
		<b>Total credits</b>				<b>23</b>

<b>SEMESTER II</b>						
<b>S. No.</b>	<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
1	GEC6202	Research Methodology	3	0	0	3
2.	CHC6201	Synthetic Organic Chemistry	3	2	0	4
3.	CHC6202	Quantum Chemistry	3	1	0	4
4.	CHC6203	Coordination Chemistry	3	0	0	3
5.		Elective	3	1	0	4
6	CHC6204	Synthetic Organic Chemistry Practical	0	0	4	2

7	CHC6205	Inorganic Chemistry Practical-II	0	0	4	2
8	CHC6206	Physical Chemistry Practical -II	0	0	4	2
		<b>Total Credits</b>				<b>24</b>

<b>SEMESTER III</b>						
<b>S. No.</b>	<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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
4,5,6		Elective				11**
7	CHC7104	Internship (during summer vacation)				1
8	CHC7201	Project Phase -1				2***
		<b>Total Credits</b>				<b>21</b>

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

**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 – I is incorporated in phase -II

## LIST OF ELECTIVES

Course Code	Course Title	L	T	P	C
<b>Basic Chemistry</b>					
CHCY001	Green chemistry	3	0	2	4
CHCY002	Molecular spectroscopy	3	2	0	4
CHCY003	Photophysics and photochemistry	3	0	0	3
CHCY004	Photochemistry	3	0	0	3
<b>Medicinal ,Pharmaceutical and Biological Chemistry</b>					
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
<b>Materials and Technology</b>					
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

<b>Energy ,Water and Environment</b>					
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

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**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-1 STEREOCHEMISTRY I**

**9**

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

**MODULE-2 REACTIVE INTERMEDIATES & REACTION MECHANISM**

**9**

Formation and stability of carbonium ions, norbornyl cation and other non-classical carbocations and classical carbocations, Bredt's 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 – methods of determining mechanism

**MODULE-3 NUCLEOPHILIC SUBSTITUTIONS**

**9**

S<sub>N</sub>1, S<sub>N</sub>2, Neighboring group participation and S<sub>N</sub>i, S<sub>N</sub>Ar mechanisms – effects of substrate, attacking nucleophile, leaving group and solvent – stereochemistry of nucleophilic substitution reactions – substitutions at carbonyl, bridgehead, vinylic and

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allylic carbons, Ambident nucleophiles - O versus C alkylation – activated aromatic nucleophilic substitution

#### **MODULE-4 AROMATICITY AND AROMATIC ELECTROPHILIC SUBSTITUTION REACTIONS** **9**

Aromaticity – concept – Huckel and Craig rules – Aromatic and anti aromatic compounds – benzenoid, non-benzenoid and homo aromatic compounds – anti-aromaticity - Annulenes – Aromaticity in cyclopentadienyl anion, tropolone, ferrocenes, fullerenes, azulenes, fulvenes, azirines, heteroaromatic systems and charged ring systems – NMR and aromaticity - Reactions of aryl diazonium salts – aromatic electrophilic substitution reactions and mechanisms.

#### **MODULE-5 ADDITION AND ELIMINATION REACTIONS** **9**

Addition to carbon-carbon and carbon-hetero multiple bonds – electrophilic, nucleophilic and free radical additions – stereochemistry of addition to carbon-carbon multiple bonds – orientation and reactivity, addition to conjugated systems and orientation – addition to  $\alpha,\beta$ -unsaturated carbonyl groups – E1, E2 and E1<sub>CB</sub> mechanisms – stereochemistry of E2 elimination – competition between elimination and substitution reactions – orientation effects in elimination reactions – effects of substrate structures, attacking base, leaving group and medium on E1 and E2 reactions – pyrolytic eliminations - Chugaev and Cope eliminations – Peterson's and Julia elimination.

**L: 45**

#### **References**

1. Michael B. Smith and Jerry March, Advanced Organic Chemistry, Reactions, Mechanisms and Structure 7<sup>th</sup> Edition, Wiley Intersciences, New York, 2009.
2. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part A – Structure and Mechanisms, 5<sup>th</sup> Edition, Springer, 2007.
3. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5<sup>th</sup> Edition, Springer, 2007.
4. Morrison R.T., Boyd R.N. and Battacharjee S.K., Organic Chemistry, 7<sup>th</sup> 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, 2<sup>nd</sup> 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

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**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 Hoff's 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-1 CHEMICAL THERMODYNAMICS-1 9**

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

**MODULE-2 CHEMICAL THERMODYNAMICS-2 9**

Clausius-Clapeyron equation - determination of partial molar quantities - thermodynamic aspects of extract ion of metals- reduction of oxides and sulphides - Ellingham diagram and its significances - partial molar properties – chemical potential – vant Hoff's equation – Gibbs-Duhem equation.

**MODULE-3 STATISTICAL THERMODYNAMICS 9**

Objectives of statistical thermodynamics – probability – microstates and macrostates for distinguishable and indistinguishable particles – permutation and combinations – Maxwell-Boltzmann statistics – third law of thermodynamics and exception to this law – use of partition function for obtaining thermodynamic functions.

**MODULE-4 NON-EQUILIBRIUM THERMODYNAMICS 9**

Steady state – conservation of energy and mass – entropy production and entropy



flow in open system – fluxes and forces – transformation of properties of rates and affinity – microscopic reversibility and Onsager reciprocal relation – thermokinetic effect – irreversible thermodynamics for non-linear regime.

## **MODULE-5 ELECTROCHEMISTRY**

**9**

Ion-solvent and ion-ion interactions, ion transport in solutions – electrochemical cells electrical double layer – various models – electrocapillary phenomena – electrokinetic phenomena – electro osmosis – streaming potential and electrophoresis – Tiselius apparatus – kinetics of electrode processes – Butler-Volmer equation - Tafel equation.

**L: 45**

### **References**

1. Atkins P., and Paula J.D., Physical Chemistry, 7<sup>th</sup> Edition, Oxford University Press, London, 2002.
2. Alberty P.A. and Silbey R.U., Physical Chemistry, 1<sup>st</sup> Edition, John Wiley and Sons Inc., 1995.
3. Castellan G.W., Physical Chemistry, 3<sup>rd</sup> Edition, Narosa Publishing House, 2004.
4. Kuriacose J.C. and Rajaram J., Thermodynamics for Students of Chemistry, 3<sup>rd</sup> 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 Hoff's 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
- Molecular orbital theory for diatomic and poly atomic 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 – Wave equation – hydrogen atom and poly electron atoms, electronic configuration and term symbols, periodic properties of elements – atomic size, ionization energy, electron affinity, electro negativity, covalent and ionic radii and magnetic properties.

### **MODULE II COVALENT BOND**

**9**

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

### **MODULE III IONIC AND NON-VALENCE FORCES**

**9**

vander waals' forces – hydrogen bond – clathrates, metallic bond – free electron theory of metals, ionic solids – lattice energy – Born-Haber cycle.

### **MODULE IV AQUEOUS AND NON-AQUEOUS CHEMISTRY**

**9**

Acid-base concepts, HSAB theory, super acids, non-aqueous solvents – reactions in liquid ammonia, sulphuric acid, aprotic solvents - molten salts - electrode potentials and applications in inorganic systems.

## MODULE V CRYSTAL STRUCTURE

9

Radius ratio – structures of AX, AX<sub>2</sub>, A<sub>2</sub>X<sub>3</sub>, ABX<sub>3</sub> and A<sub>2</sub>BX<sub>4</sub> type solids – layer structure – cadmium iodide - covalent solids – diamond and graphite - Polymorphism and X-Ray Diffraction.

**L: 45**

### References

1. Cotton F.A., Wilkinson G. and Gaus P.L., Basic Inorganic Chemistry, 3<sup>rd</sup> 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, 4<sup>th</sup> edition, Oxford University Press, 2006.
3. Huheey J.E., Keiter E.A. and Keiter R.L., Inorganic Chemistry, 4<sup>th</sup> Edition, Addison Wesley Publication, London, 1993.
4. Jolly W.L., Modern Inorganic Chemistry, 2<sup>nd</sup> Edition, McGraw – Hill, Inc., 1991.
5. Lee J.D., Concise Inorganic Chemistry, 5<sup>th</sup> Edition, Blackwell Science, 2003.

### Outcome

Students will be able to

- Demonstrate the basic principles of periodicity.
- Demonstrate VSEPR theory.
- Depict the molecular orbital diagram for diatomic and polyatomic systems.
- Recognize the different non valence forces and their influence on the physical & chemical properties
- Demonstrate the basic principles of acid – base chemistry in non aqueous solvents.
- Acquire the knowledge of structure of different types of solids and their diffraction pattern.

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**CHC6104 ANALYTICAL CHEMISTRY**

**L T P C**

**3 0 2 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
- study the principles, instrumentation and applications of spectroscopic methods
- describe the principles, instrumentation and applications of electro analytical techniques
- state the principles and instrumentation of different separation techniques
- describe the different thermal analytical methods and their applications

**MODULE-1 QUANTITATIVE ANALYSIS 9**

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

**MODULE-2 SEPARATION TECHNIQUES 9**

Chromatography – paper, column, TLC, GC, HPLC and GPC techniques – ion exchange techniques – Capillary electrophoresis – principle, instrumentation and applications- gel electrophoresis.

**MODULE-3 INTRODUCTION TO MOLECULAR SPECTROSCOPY 9**

Molecular spectroscopy: Colorimetric analysis- , principle and applications UV, Visible, 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-4 ELECTROANALYTICAL TECHNIQUES 9**

Conductometry and high frequency titrations - potentiometry, pH-metry and ion-selective electrodes - coulometry – voltammetry - polarography, amperometric titrations and anodic stripping voltammetry - principle, practice and applications.

## **MODULE-5 THERMAL METHODS OF ANALYSIS**

**9**

Thermal analytical techniques – TGA, DTA, DSC, DEA (dielectric thermal analysis) TOA (thermo optical analysis) Temperature-programmed Desorption/ Reduction/ Oxidation/ Sulfidation (TPD / TPR / TPO / TPS), – principle, instrumentation and applications

**L: 45**

### **References**

1. Skoog D.A., West D.M., Holler F.J. and Crouch S.R., Fundamentals of Analytical Chemistry, 8<sup>th</sup> 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, 7<sup>th</sup> Edition, CBS Publication, New Delhi Reprint, 2004.
3. Skoog D.A., Holler F.J. and Nieman T.A., Principles of Instrumental Analysis, 5<sup>th</sup> Edition, Harcourt College Publication., Singapore, 1998.
4. Christian G.D., Analytical Chemistry, 6<sup>th</sup> Edition, John Wiley, Singapore, 2003.
5. Fifield F.W. and Kealey D., Principles and Practice of Analytical Chemistry, 5<sup>th</sup> Edition, Blackwell Publication, London, 2000.
6. Settle F. (Editor), Handbook of Instrumental Techniques for Analytical Chemistry, Pearson Education, Singapore, 2004.

### **Outcome**

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 – Purification of solids by recrystallization – Determination of melting point – Determination of boiling point by capillary method.

**L:60**

**References**

1. A.I. Vogel, Vogel's Textbook of Practical Organic Chemistry, 5<sup>th</sup> 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**

### Objective

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 Mohr's method
4. Complexometric titrations: Estimation of  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Mn}^{2+}$  and  $\text{Zn}^{2+}$
5. Spectrophotometric analysis of iron, cobalt, nickel, chromium and manganese

**P: 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; 1<sup>st</sup> Edition, 2012.
3. J. Mendham, R.C. Denney, M.J.K. Thomas David and J. Barnes, Vogel's Quantitative Chemical Analysis, 6<sup>th</sup> Edition, Prentice Hall, 2000.
4. V.V. Ramanujam, Inorganic Semimicro Qualitative Analysis; 3<sup>rd</sup> 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.

**Outcome**

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**

### **Objective**

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 –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**

### **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, 2<sup>nd</sup> Edition, Allied Publishers, Madras, 1991.
5. D.P. Shoemaker and C.W. Garland, Experiments in Physical Chemistry, McGraw Hill, London, 1962.

### **Outcome**

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 –Lambert law
- Determine the molecular weight of a polymer

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**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 Chems sketch. Basics of C and C++ programme – MATLAB – Numerical Methods – Ordinary Differential Equation – Partial Differential Equation – 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 – mean median and mode. Measures of dispersion – 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 – 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 -demonstration

**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

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**CHC6201    SYNTHETIC ORGANIC CHEMISTRY**

**L T P C**

**3 2 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-1 STEREOCHEMISTRY II**

**9**

Conformational analysis and reactivity of cyclic and acyclic systems – topicity – prochirality - enantiotopic and diastereotopic atoms, groups and faces –asymmetric synthesis - stereoselective, stereospecific reactions - enantioselective synthesis - optical purity and enantiomeric excess - Cram's rule – Prelog's rule – Fehn Anns model - methods of resolution – kinetic, dynamic kinetic resolution - Sharpless epoxidation

**MODULE-2 MOLECULAR REARRANGEMENTS**

**9**

General mechanistic considerations, nature of migration, migratory aptitude - nucleophilic, electrophilic and free radical rearrangements – Wagner-Meerwein, Demjanov, Favorskii, Fritsch-Butternberg - Wiechell, Neber, Hofmann, Curtius, Beckmann, Schmidt, Lossen, Wolff, Baeyer – Villiger, Stevens, Wittig, Chapman, Wallach, Orton, Bamberger, Pummerer and Von Richter rearrangements.

**MODULE-3 REAGENTS IN ORGANIC SYNTHESIS**

**9**

Synthesis and application of - Diborane,  $\text{LiAlH}_4$ ,  $\text{NaBH}_4$ , DIBAH,  $\text{Bu}_3\text{SnH}$ ,  $\text{SeO}_2$ , NBS, DCC, PCC, Swern, Dess Martin, DDQ, LDA, Gilman's reagent, phase transfer catalysts, Wittig, Tebbe, Wilkinson's 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-4 MULTISTEP SYNTHESIS**

**9**

Strategies for synthetic analysis and planning – functional group introduction, removal and interconversion - activating groups – 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 – linear and convergent synthesis - control of stereochemistry – reactive umpolung - analysis and synthesis of a few target molecules.

#### **MODULE-5 APPLICATIONS OF ORGANIC SPECTROSCOPY**

**9**

Structure determination of organic compounds - introduction to NMR spectroscopy- interpretation of molecular structure by  $^1\text{H}$ ,  $^{13}\text{C}$  and Mass spectroscopic techniques.

**L: 45**

#### **References**

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



**OBJECTIVES:**

To make the student

- understand the origin of classical mechanics and the background of quantum mechanics
- derive and use of Schrodinger equation to simple systems
- able to construct the molecular orbital for molecules
- gain the basics of quantum statistics and how it is applied to systems of chemical interest
- 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 – 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.

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

Born Oppenheimer approximation; VB and MO theory; Applications to  $H_2^+$  and  $H_2$  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 – 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 – types of groups- group postulates - classification of point groups- Schoenflies symbol –matrix representation of symmetry operations and point groups, representation of point group, reducible and irreducible representations, the great orthogonal theorem – 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.

**Total Hours: 45**

#### **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, 2<sup>nd</sup> Edn, Himalaya Publications, India.2012
10. A. Vincent., Molecular Symmetry and Group theory, A programmed introduction to chemical applications, 2<sup>nd</sup> Edition, Wiley, 2001

### **OUTCOMES:**

The student will gain:

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

### **MODULE II                      THEORIES OF METAL- LIGAND BOND                      9**

Valence bond theory – hybridization - crystal field theory – crystal field splitting, crystal field stabilization energy – thermodynamic and structural implications, Jahn Teller effects, ligand field theory - molecular orbital theory – 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 – Tanabe – Sugano diagrams, selection rules - magnetic properties – Van Vleck equation, magnetic susceptibility – 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.

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## MODULE V COMPARATIVE CHEMISTRY OF OXIDATION STATES OF 9 d AND f BLOCK ELEMENTS

Lanthanides-occurrence, isolation, lanthanide contraction, oxidation states, spectral and magnetic properties, co-ordination complexes, actinides, comparative chemistry with transition metals and lanthanides.

**L: 45**

### References

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

### Outcome

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 – Sugano diagrams.
- interpret the stability of complexes.
- understand the substitution reactions in transition metal complexes.
- demonstrate an understanding of chemistry of 'd' and 'f' block elements.
- analyze and compare the transition metals and lanthanides

## **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**

## **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 – 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, 7<sup>th</sup> Edition, Wiley, 2005.
5. Kemp W., Organic Spectroscopy, 3<sup>rd</sup> 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.

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**CHC6205 INORGANIC CHEMISTRY PRACTICAL-II**

**L T P C**

**0 0 4 2**

**Objective**

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(acetylacetonato)copper(II)
  - (iii) Preparation of tris(acetylacetonato)iron(III)
  - (iv) Preparation of tris(acetylacetonato)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**

**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; 1<sup>st</sup> Edition, 2012.
3. J. Mendham, R.C. Denney, M.J.K. Thomas David and J. Barnes, Vogel's Quantitative Chemical Analysis, 6<sup>th</sup> Edition, Prentice Hall, 2000.

4. V.V. Ramanujam, Inorganic Semimicro Qualitative Analysis; 3<sup>rd</sup> 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.

### **Outcome**

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**

### **Objective**

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**

### **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, 2<sup>nd</sup> Edition, Allied Publishers, Madras,

1991.

5. D.P. Shoemaker and C.W. Garland, Experiments in Physical Chemistry, McGraw Hill, London, 1962.

### **Outcome**

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

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**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-1 CARBOHYDRATES, PROTEINS, NUCLEIC ACIDS 9**

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

**MODULE-2 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-Löffler, Reformatsky, Darzen's, Simmons-Smith, Gattermann-Koch, Mitsunobu reaction, Buchwald and Hartwig.

**MODULE-3 ORGANIC PHOTOCHEMISTRY 9**

Thermal vs photochemical reactions – n-pi\* and pi-pi\* transitions - allowed and forbidden transitions – Jablonski Diagram - fluorescence and phosphorescence – internal conversion and intersystem crossing -- sensitization, quenching and quantum efficiency – photochemical reaction of ketones – 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-4 PERICYCLIC REACTIONS 9**

Definition – electrocyclic, cycloaddition, sigmatropic, chelotropic and ene reactions -

Woodward-Hoffmann rules – Frontier orbital, Mobius-Huckel and orbital symmetry correlation approaches - Stereospecificity and regioselectivity of pericyclic reactions – pericyclic reactions in organic synthesis – Diels-Alder reaction, 1,3-dipolar cycloaddition, Claisen, Cope, Aza cope.

## **MODULE-5 HETEROCYCLES, ALKALOIDS, TERPENOIDS AND STEROIDS 9**

Nomenclature of condensed heterocycles - Synthesis and reactivity of indoles, quinolines, isoquinolines, benzopyran, chromones, coumarins - Alkaloids – classification - synthesis of cocaine and atropine - terpenoids - Classification – isoprene rule – stereochemistry and synthesis of car-3-ene, menthol, zingiberene – Steroids – classification – structure and stereochemistry of cholesterol, synthesis of cortisone, estrone.

**L: 45**

### **References**

1. Jerry March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 4<sup>th</sup> 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, 5<sup>th</sup> Edition, John Wiley and Sons, New York, 1992.
4. Finar I.L., Organic Chemistry, Volume II, 5<sup>th</sup> Edition, ELBS Longman Group Ltd., London, 1975.
5. Sankararaman S., Pericyclic reactions – a Textbook: Reactions, Applications and Theory, Wiley-VCH, 2005.
6. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part A – Structure and Mechanisms, 5<sup>th</sup> Edition, Springer, 2007.
7. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5<sup>th</sup> 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.

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**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-1 KINETICS**

**9**

Methods of determining rate laws – reversible, consecutive and competing reactions – Vant Hoff's rule, Collision theory, Bodenstein's Theory, theory of absolute reaction rates – transmission coefficient – thermodynamic formulation of reaction rates – kinetics – classical treatment – principle of microscopic reversibility - photochemical kinetics, – fast reactions – luminescence and energy transformations –study of kinetics by stopped flow techniques – flash photolysis.

**MODULE-2 MECHANISM OF SOLUTION PHASE REACTION**

**9**

Lindeman's theory – Hinshelwood, Kassel and Slater treatments, reaction rates in solution – effect of dielectric constant and ionic strength – kinetic isotope effect – linear free energy relationships – Hammett equation – Taft equation

**MODULE-3 PHASE EQUILBRIA**

**9**

Two component systems – classification – solid-gas (dehydration and rehydration of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ), solid-liquid systems – benzene-picric acid system, salt-water system fractional distillation – three component systems involving liquid-liquid equilibria.

**MODULE-4 CATALYSIS**

**9**

Acid-base catalysis – general scheme – Arrhenius complex – Vant Hoff's complex – specific and general catalysis – catalytic constants – Bronsted relationship – Hammett acidity functions – mechanism of acid-base catalysed reaction – catalysis by transition metal ions and their complexes – supported transition metal complexes as catalysts – enzyme catalysis – theory and applications.

## **MODULE-5 SURFACE PHENOMENA AND HETEROGENEOUS CATALYSIS 9**

Diffusion – adsorption – surface reaction – various adsorption isotherms – determination of surface area – pore volume and pore size – thermodynamics of interfaces – solid catalysts – metal-metal oxides – geometric factor – electronic factor - zeolites – phase transfer catalysis – colloidal electrolytes – reactions on surfaces – surface characterization techniques – ESCA, AES and SIMS.

**L: 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, 3<sup>rd</sup> 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, 3<sup>rd</sup> Edition, Narosa Publishing House, New Delhi, 1998.
7. Rohatgi, Mukharjii K.K., Fundamentals of Photochemistry- Wiley Eastern

### **Outcome**

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 – preparation, structure and bonding - catalysis by organometallic compounds – hydrogenation, hydroformylation, stereoregular polymerization – Wacker process.

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

Metals and non-metals in biological systems - metal ion transport - oxygen carriers – haemoglobin, myoglobin - metallo-enzymes – carboxypeptidase-A, carbonic anhydrase, vitamin B<sub>12</sub>, 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 – photophysical processes, spontaneous and stimulated emission of radiation, chemical actinometry, solar energy conversion and applications.

**L: 45**

### **References**

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

### **Outcome**

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, Anastas' twelve 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 – advantage of microwave exposure – specific effects of microwave – Neat reactions – solid supports reactions – Functional group transformations – condensations reactions – oxidations – reductions reactions – multi-component reactions.

### **MODULE III Ionic liquids and Phase Transfer catalysis          9**

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

### **MODULE IV Supported catalysts and bio-catalysts for Green chemistry          9**

Introduction – the concept of atom economy – supported metal catalysts – mesoporous silicas –the use of Biocatalysts for green chemistry - modified bio catalysts – fermentations and biotransformations – fine chemicals by microbial

fermentations – vitamins and amino acids – Baker's yeast mediated biotransformations – Bio-catalyst mediated Baeyer-Villiger reactions – Microbial polyester synthesis.

## **MODULE V Alternative synthesis, reagents and reaction conditions 9**

Photochemical alternative to Friedel-Crafts reactions - Dimethyl carbonate as a methylating agent – the design and applications of green oxidants – super critical carbon dioxide for synthetic chemistry.

**L: 45**

### **References**

1. Green Chemistry – Environmentally benign reactions – V. K. Ahluwalia. Ane Books India (Publisher). (2006).
2. Green Chemistry – Designing Chemistry for the Environment – edited by Paul T. Anastas & Tracy C. Williamson. Second Edition, (1998).
3. Green Chemistry – Frontiers in benign chemical synthesis and processes- edited by Paul T. Anastas & Tracy C. Williamson. Oxford University Press, (1998).
4. Green Chemistry – 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 2 0 4**

**OBJECTIVES:**

To make the students

- learn molecular spectroscopy as an important tool to understanding molecular structure and its characteristics.
- acquire a basic idea of different electromagnetic regions and instrumentation of various modern spectrometers
- demonstrate an understanding of the rotational, vibrational and electronic spectroscopy of diatomic and polyatomic molecules
- acquire the skill to determine the functional groups present in unknown molecules using vibrational (IR) spectra and to calculate maximum ( $\lambda_{\text{maximum}}$ ) absorption of molecules in Electronic (UV-Visible) region using Woodward-Fischer rule
- learn 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
- identify the unknown molecular formula of fragmented metastable ions of organic Compounds
- learn hyperfine interactions of nuclei present in a molecule

**MODULE I ELECTROMAGNETIC RADIATION AND ROTATIONAL SPECTROSCOPY**

**9**

Characterization of electromagnetic radiation – regions of the spectrum – basic elements of practical spectroscopy – enhancement of spectra – Applications of group theory – Microwave spectroscopy – rotational spectra of molecules – applications.

**MODULE II INFRA-RED & RAMAN SPECTROSCOPY**

**9**

Infra-red spectroscopy – harmonic and unharmonic vibrations – dissociation energy of diatomics – vibrating rotator – PQR branches in IR spectra – Fermi resonance – Raman spectroscopy – 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 –solvent effects – Woodward-Fischer rule to conjugated dienes.

### **MODULE IV SPIN RESONANCE SPECTROSCOPY**

**9**

Proton magnetic resonance spectroscopy – relaxation processes – chemical shift – coupling –  $^{13}\text{C}$  NMR spectra – Electron spin resonance spectroscopy – hyperfine interactions.

### **MODULE V MASS SPECTROMETRY**

**9**

Reactions of ions in gas phase – effect of isotopes – nitrogen rule –determination of molecular formula – fragmentations and rearrangements –metastable ions – fragmentation of organic compounds. Application of Massspectroscopy with GC.

**Total Hours: 45**

### **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, 3<sup>rd</sup> 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

- gain the theoretical knowledge of the various spectroscopic methods on the basis of the examples from the science and industry.
- become familiar with modern spectrometers and methods, which are applied in industrial and scientific laboratories in the field of synthesis and structural determination.

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**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: 9**

Basic laws, Einstein Laws – absorption, Fundamentals of absorption- absorption coefficients, electronic transitions. Excited state energy relaxations – Jablonski diagram, Radiative and non-radiative relaxations, fluorescence, phosphorescence, Lifetime and quantum yield, Stokes Shift, Kasha's rule.

**Module II: Instrumentation Techniques: 9**

Spectrophotometer, light Sources, photochemical quantum yield and intensity measurements, detectors-PMT, Diode-array. Spectrofluorimeter – Steady state and Time-resolved fluorimeter. Study using time resolved techniques – pump-probe methods and instrumentation: Lasers-nanosecond, picosecond and femtosecond. Measurement of – Triplet quantum yield and Time resolved absorption spectrum. Fluorescence standards – 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 – 1st,2nd, 3rd generation cells - Organic Solar Cells-Single Layer, Double layer, Bulk heterojunction, DSSC, Tandem structured – Fabrication, Key Processes and issues – Materials – Low molecular weight – Polymeric – Donor-acceptor polymeric systems – Devices- Characteristics.

**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

**References:**

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



## Outcomes

The students will acquainted 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.

**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:**

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:**

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:**

Photochemistry of alkene, cis-trans isomerization, photocycloaddition reactions of alkene, photochemical electrocyclic and sigmatropic reactions, di-pi-methane rearrangement, 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-Löffler-Freytag)

#### **Module IV: Reactions in aromatic compounds**

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-Löffler-Freytag)

#### **Module V Applications:**

Fluorescence based sensors – 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.

#### **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 8**

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 8**

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 8**

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 8**

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, carcinogenesis and DNA repair mechanism.

**MODULE V** Biochemistry of proteins **8**

Genetic code and protein synthesis, components of protein synthesis, inhibition of protein synthesis. Regulation of gene expression (Prokaryote and Eukaryote).

**PRACTICAL** **20**

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  $\alpha$  and  $\beta$ -amylase.
8. Effects of temperature on the activity of  $\alpha$ -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.

**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., Philadelphia.
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.

**Outcome**

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





## **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**

### **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.

### **Outcome**

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

- good manufacturing practices
- 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 QC, 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.

## 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.

## Outcome:

The student will be able to demonstrate the

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

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**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 – advantages – types of drug – literature survey for preparation of drugs – characterization and structural elucidation of drugs using different spectral methods.

**MODULE II ANALGESICS, ANTIHISTAMINES AND ANTIMALARIALS 9**

Analgesics – narcotic analgesics – morphine analogues – synthesis of codeine – synthetic narcotic analgesics — antipyretic analgesics – salicylic acid analogues — para amino phenol derivatives – Antihistamines-structure, synthesis, activity promethazine, chlorpheniramine maleate - Antimalarials – classification- structure, synthesis, drug action - quinine-4-amino and 8-amino quinolines – chloroquine.

**MODULE III ANTIBIOTICS AND ANTIBACTERIALS 9**

Synthesis and mode of action -Antibiotics – penicillin, D-penicillamine, semisynthetic penicillin – chloramphenicol streptomycin, tetracyclines, cephalosporins,- Antibacterials – 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 – progesterone, estradiol, (C) Adrenocorticoids – prednisolone, dexamethasone- prostaglandins: misoprostol,

**L: 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 Driver's 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.

### Outcome

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 – classification of polymers: source, structure, processing behavior, composition and structure, mechanism, application – copolymer: types – terpolymer: Definition - nomenclature of polymers - tacticity – crystalline and amorphous polymers - thermal transitions – Molecular weight of polymer – number, weight and viscosity average molecular weights – 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 – Trommsdorff effect – living polymers – Ziegler-Natta catalysts – coordination polymerization – Kinetics of polycondensation reactions – copolymer equation-Reactivity ratio and copolymerization behavior.

## **MODULE III POLYMERISATION TECHNIQUES**

**9**

Polymerisation techniques – homogenous and heterogeneous polymerization – bulk, solution, suspension and emulsion polymerization – merits and demerits – interfacial, and melt polycondensation

## **MODULE IV POLYMER TESTING AND ANALYSIS**

**9**



- 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**

**12**

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 – 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**

**15**

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**

**12**

Structural Characterization: Atomic Force Microscopy (AFM): Contact and Tapping Mode – 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 11**

Current applications - sunscreens and cosmetic, composites, clays, coatings and surfaces, tougher and harder cutting tools. Short-term Applications – 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 – 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 15**

History – Carbon nanotubes, carbon clusters, production methods - arc method, laser method, chemical vapour deposition, purification methods- gas phase, liquid phase, intercalation, - dispersion - functionalization -chopping, oxidation, and “wrapping” 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.

**Total Hours: 60**

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

**MODULE II RESISTIVITY 9**

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

**MODULE III DIELECTRIC BEHAVIOUR 9**

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

**MODULE IV THERMAL PROPERTIES 9**

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

**MODULE V BREAKDOWN TESTING ANALYSIS 9**

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

## 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 Perengins Ltd., London, 1992.

## Outcome

The student will be familiar with the electrical behavior of polymeric materials

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**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 - Crazeing 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 ( $T_g$ ), melt transition ( $T_m$ ), relationship between  $T_g$  and  $T_m$  - other transitions like  $\beta$ -transitions, upper and lower glass transition temperatures - Prediction of  $T_g$  and  $T_m$  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,



10. J. Mort and G. Pfister, (Editor), Electronic Properties of Polymers, Wiley Interscience, New York, 1982.

### **Outcome**

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



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**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 – catalysis by transition metal ions and their complexes – supported transition metal complexes as catalysts – catalysis by enzymes – phase transfer catalysis - photocatalysis – adsorption – 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, AIPOs)  
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 Analysis, Magic Angle Spinning Nuclear Magnetic Resonance (MAS NMR) ( $^{29}\text{Si}$ ,  $^{27}\text{Al}$ ,  $^{31}\text{P}$ ), 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 – 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**

**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, 2<sup>nd</sup> Edition, John Wiley and Sons, 2008.
5. Gadi 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, 2<sup>nd</sup> 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, 2<sup>nd</sup> 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.

**Outcome:**

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

- Distinguish different types of catalyzed and uncatalysed reactions, homogeneous and heterogeneous catalyzed reactions
- Synthesize the catalysts by different methods
- Adopt the suitable characterization techniques and interpret the data
- Carry out reactions with different type of reactors
- Perform different reactions with the prepared catalysts and choose a catalyst for a particular reaction

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

### **MODULE II ELASTOMERS 9**

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

### **MODULE III MOULDING TECHNIQUES 9**

Moulding constituents – functions – moulding techniques – compression – injection – extrusion – blow moulding – thermoforming – Vacuum forming – pultrusion – casting – calendaring – RIM – lamination.

### **MODULE IV CHARACTERISATION AND TESTING 9**

Characterisation of polymers by IR and NMR – Thermal properties by TGA and DSC – Testing tensile strength, Izod impact, Compressive strength, Rockwell hardness, Vicot softening point – Test for electrical resistance, dielectric constant, dissipation factor, arc resistance and dielectric strength – water absorption.

## **MODULE V POLYMER PROPERTIES**

**9**

Effect of structure on mechanical, chemical, thermal, electrical and optical properties.

**L: 45**

### **References**

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

### **Outcome**

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

### **MODULE II HEAVY CHEMICALS 9**

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

### **MODULE III ACIDS AND FERTILIZERS 9**

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

### **MODULE IV SILICATE INDUSTRIES 9**

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

### **MODULE V PRINCIPLES OF METALLURGICAL PROCESSES 9**

Principles of Metallurgical Processes – ore beneficiation- pyrometallurgy, hydrometallurgy, powder metallurgy and electrometallurgy - Explosives and propellants – nuclear materials.

**L: 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), Dryden's 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), Riegel's Industry Chemistry, Asia Publishing House, 1989.

### **Outcome**

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

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

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

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

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

### **MODULE V DYES 9**

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

**L: 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, 2<sup>nd</sup> Edition, Applied Science Publishers Ltd., London, 1979.
3. J.A. Kent, Reigel's Hand Book of Industrial Chemistry, 7<sup>th</sup> Edition, vanNostrand Reinhold Co., New York, 1974.

## Outcome

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**

### References

1. Ullmann's Encyclopedia of Industrial Chemistry, Volume 6, 1986.
2. Krik and Othmer, Encyclopedia of Chemical Technology, 4<sup>th</sup> 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.

### Outcome

The students will be familiar with the

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



hydrogenation – role of the above MODULE processes in such industries as petroleum, drugs, pharmaceuticals and organic synthesis.

**L: 45**

### References

1. Groggins P.H., MODULE Processes in Organic Synthesis, McGraw Hill Book Co., Kogakusha, 5<sup>th</sup> Edition, 2007.
2. McCabe W.L., Smith J.C. and Harriot P., MODULE Operations of Chemical Engineering, 6<sup>th</sup> 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.

### Outcome

The students will be familiar with

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

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

**MODULE II INDUSTRIAL WATER TREATMENT 9**

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

**MODULE III TREATMENT METHODS 9**

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

**MODULE IV WASTEWATER TREATMENT 9**

Wastewater treatment – pre and primary treatment – equalization neutralization –

screening and grid removal – sedimentation – oil separation gas stripping of volatile organics – biological oxidation – lagoons and stabilization basins – aerated lagoons – activated sludge process – trickling filtration – anaerobic decomposition.

## **MODULE V ADSORPTION AND OXIDATION PROCESSES**

**9**

Chemical process – adsorption – theory of adsorption – ion exchange process – chemical oxidation – advanced oxidation process – sludge handling and disposal – miscellaneous treatment processes.

**L: 45**

### **References**

1. W. Wesley Eckenfelder, Jr., Industrial Water Pollution Control, 2<sup>nd</sup> Edition, McGraw Hill Inc., 1989.
2. Metcalf and Eddy, Waste Water Engineering, 3<sup>rd</sup> 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.

### **Outcome**

The student will be familiar with the

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

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

**MODULE II SOLID WASTE COLLECTION AND DISPOSAL**

**9**

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

**MODULE III ENERGY RECOVERY**

**9**

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

**MODULE IV AIR POLLUTION**

**9**

Air pollution – global implication of air pollution – MODULEs of measurement – sources of pollutants – classification of pollutants – meteorology and natural purification processes – influence of meteorological phenomena on air quality – 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 – particulars and gaseous pollutants – methods for monitoring air pollutants – air quality control devices for particulate and gaseous contaminants – major polluting industries – measures to check industrial pollution.

**L: 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.

### **Outcome**

The students will be familiar with the types of

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

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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 – modern technological developments – chlorine cell technologies – mercury and diaphragm cell – membrane – cell.

### MODULE II ELECTROMETALLURGY

9

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

### MODULE III METAL FINISHING

9

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

### MODULE IV ELECTROSYNTHESIS

9

Electrolytic preparation of inorganic compounds – fluorine – peracids and their salts –  $\text{KMnO}_4$  –  $\text{K}_2\text{Cr}_2\text{O}_7$  - Organic electrosynthesis – hydromerisation of acrylonitrile – Monsanto process – manufacture of ethylene glycol – electrolysis of organic compounds with the use of ion – exchange membranes.

## **MODULE V INDUSTRIAL ELECTROCHEMICAL PROCESSES**

**9**

Water treatment and environmental protection – metal ion removal and metal recovery – electro-filtration of particulates from gases – electro-dialysis – desalination – electroflotation.

**L: 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, 1<sup>st</sup> Edition, Tata McGraw Hill, New Delhi, 2000.

### **Outcome**

The student will be familiar with the

- electrowinning,
- electrorefining,
- electrochemical metal finishing,
- electrosynthesis
- electro-dialysis.

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**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 – theories of corrosion – oxidation – direct atmospheric effect – electrochemical corrosion – hydrogen evolution – presence and absence of oxygen – corrosion by gaseous reduction.

**MODULE II FORMS OF CORROSION**

**9**

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

**MODULE III CORROSION TESTING**

**9**

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

**MODULE IV FACTORS INFLUENCING CORROSION**

**9**

Nature of metal – over voltage – areas of anodic/cathodic – purity of metal – physical state of metals – passive nature of metal – solubility – volatility of corrosion products

– corroding environment – influence of pH – ions – formations of cells – polarization of electrodes.

## **MODULE V CORROSION CONTROL**

**9**

Design – selection of materials – pure metals and alloys – annealing – elimination of galvanic action – cathodic protection – sacrificial anodic protection – impressed current cathodic protection – modification of environment – deaeration – dehumidification – inhibitors – protective coatings – preparation of materials for coating – metallic and non-metallic – organic coatings – special paints – varnish, enamel and lacquers.

**L: 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.

### **OUTCOME**

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**

**References**

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

**Outcome**

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**

### **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.

### **Outcome**

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**

### **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.

### **Outcome**

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

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**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) – 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 – hydrogen production : steam reforming, partial oxidation, coal gasification/thermal reforming, fuel cell technology based on bio-mass.

## **MODULE V FUEL CELL APPLICATIONS**

Automotive applications – road map to market – automotive industry and the environment – distributed power generation – grid-connect applications – non-grid connect applications – residential power – portable power – combined heat and power

**L: 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, 2<sup>nd</sup> 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.

### **Outcome:**

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**

**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**

**9**

Advanced Li-ion Batteries: Lithium-ion battery, The Principle carbonaceous anode materials, cathode material Electrolyte, separator.

**MODULE III**

**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**

**9**

Li/polymer Batteries: Polymer cathode for Li battery, Polymer Cathode in SPE, conductivity, ion transport mechanisms, plasticized electrolytes.

**MODULE V**

**9**

Ultra capacitors: Double layer, Metal Oxide, conducting polymers energy and power densities, voltage limitation and self discharge.

**L: 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.

**Outcome:**

The student will have

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

**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<sub>2</sub>S 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**

### **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.

### **Outcome**

The students will be familiar with

- p & n type semiconductors
- luminescence and photovoltaic properties of semiconductors
- application in solar cells.

## CHCY029 ELECTROCHEMICAL ENERGY CONVERSION AND STORAGE

**L T P C**

**3 0 0 3**

### Objectives

To make the student to learn about the

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

### 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**

#### **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.

#### **Outcome**

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 processes
- ❖ 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, Planck's 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 – role of nanostructures and materials – nanomaterials in solar photovoltaic technology- band gap engineering and optical engineering - tandem structures - quantum well and quantum dot solar cells - photo-thermal cells – organic solar cells. Performance and reliability of nanomaterials based solar cells.

## **Module V - MODULE III SOLAR CELLS**

9

Formation of a p-n – 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 – 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)Se<sub>2</sub> 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.

## **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

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