



# BIRLA INSTITUTE OF TECHNOLOGY

A Deemed University u/s 3 of UGC Act , 1956

MESRA- 835215 ( RANCHI) INDIA

Phone : 0651-2275444/2275896,2276002/2276006

Fax: 0651-227501/2275868

website: [www.bitmesra.ac.in](http://www.bitmesra.ac.in)

1.1.3 Average percentage of courses having focus on employability/ entrepreneurship/ skill development during the last five years (10)

1.2.1 Percentage of new courses introduced of the total number of courses across all programmes offered during the last five years (30)

Name of the Course	Course Code	Year of introduction	Activities/Content with direct bearing on Employability/ Entrepreneurship/ Skill development	Link to the relevant document
Advanced Physical Chemistry	SAC 1001	2009	Employability	
Organic Reaction Mechanisms	SAC 1003	2009	Employability	
Metal Chemistry	SAC 1005	2009	Employability	
Modern Spectroscopy	SAC 1007	2009	Employability	
Environmental Chemistry	SAC 1009	2009	Employability	
Theoretical Chemistry	SAC 2001	2009	Employability	
Synthetic Organic Chemistry	SAC 2003	2009	Employability	
Advanced Analytical Techniques	SAC 2005	2009	Employability	
Applications of Spectroscopy	SAC 2007	2009	Employability	
Environmental Monitoring & control	SAC 2009	2009	Employability	
Bioinorganic & organometallic Chemistry	SAC 3001	2009	Employability	
Industrial Chemistry	SAC 3003	2009	Employability	
Advanced Organic Chemistry	SAC 3005	2009	Employability	
Polymer chemistry	SAC 3007	2009	Employability	




Physical Chemistry-VI Lab	CH406	2018	Skill development	
Organic Chemistry-VI Lab	CH407	2018	Skill development	
Advanced Inorganic Chemistry	CH408	2018	Employability	
Quantum Chemistry & Group Theory	CH409	2018	Employability	
Modern Organic Chemistry	CH410	2018	Employability	
Equilibrium, Non-Equilibrium & Statistical Thermodynamics	CH411	2018	Employability	
Analytical Chemistry	CH412	2018	Employability	
Inorganic Chemistry-V Lab	CH413	2018	Skill development	
Theoretical & Computational Chemistry Lab	CH 414	2018	Skill development	

P.K. Srinivasan *[Signature]*  
Head of Department 6/2/2020



# Table of Contents

Sr. No.	Description of evidences (BOS minutes, Name of the Course)	Course Code	Year of introduction	Page No
i	BOS Minutes			6-7
1	Advanced Physical Chemistry	SAC 1001	2009	374
2	Organic Reaction Mechanisms	SAC 1003	2009	375
3	Metal Chemistry	SAC 1005	2009	376
4	Modern Spectroscopy	SAC 1007	2009	392
5	Environmental Chemistry	SAC 1009	2009	377
6	Theoretical Chemistry	SAC 2001	2009	380
7	Synthetic Organic Chemistry	SAC 2003	2009	381
8	Advanced Analytical Techniques	SAC 2005	2009	382
9	Applications of Spectroscopy	SAC 2007	2009	
10	Environmental Monitoring & control	SAC 2009	2009	284
11	Bioinorganic & organometallic Chemistry	SAC 3001	2009	388
12	Industrial Chemistry	SAC 3003	2009	371
13	Advanced Organic Chemistry	SAC 3005	2009	389
14	Polymer chemistry	SAC 3007	2009	393
15	Medicinal Chemistry	SAC 3009	2009	394
16	Chemistry of Environmental Pollutants	SAC 3015	2009	398
17	Aquatic Chemistry	SAC 3017	2009	400
18	Env. Impact Assessment	SAC 3021	2009	401

 [Click here to go to page](#)



19	Inorganic Chemistry-I; Atomic Structure & Chemical Bonding-I	CH103	2018	10
20	Physical Chemistry-I; States of Matter & Ionic Equilibrium	CH 104	2018	14
21	Inorganic Chemistry-I Lab	CH 105	2018	18
22	Physical Chemistry-I Lab	CH 106	2018	19
23	Physical Chemistry-II; Chemical Thermodynamics & its Applications	CH107	2018	20
24	Organic Chemistry-I	CH108	2018	24
25	Physical Chemistry-II Lab	CH109	2018	28
26	Organic Chemistry-I Lab	CH110	2018	29
27				
28	Basic Inorganic Chemistry	CH401	2018	115
29	Chemical Kinetics & Surface Chemistry	CH402	2018	119
30	Reactions Mechanism in Organic Chemistry	CH403	2018	123
31	Organometallic Chemistry	CH404	2018	127
32	Principles of Organic Synthesis	CH405	2018	130
33	Physical Chemistry-VI Lab	CH406	2018	134
34	Organic Chemistry-VI Lab	CH407	2018	136
35	Advanced Inorganic Chemistry	CH408	2018	137
36	Quantum Chemistry & Group Theory	CH409	2018	141
37	Modern Organic Chemistry	CH410	2018	145
38	Equilibrium, Non-Equilibrium & Statistical Thermodynamics	CH411	2018	149
39	Analytical Chemistry	CH412	2018	153



40	Inorganic Chemistry-V Lab	CH413	2018	157
41	Theoretical & Computational Chemistry Lab	CH 414	2018	158




DEPARTMENT OF CHEMISTRY  
BIRLA INSTITUTE OF TECHNOLOGY  
MESRA RANCHI


Date: 17.04.2018

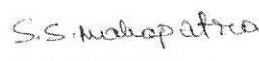
Minutes of the Board of Studies committee (BOS) held on 17.04.2018 at 11.00 AM  
for CBCS Syllabus

A meeting of the Board of Studies (BOS) was held in the seminar hall of the department on April 17<sup>th</sup> 2018 at 11:00 AM, for the approval of CBCS proposed syllabus of IMSC, MSC & BE. The syllabus was discussed and scrutinized by the committee members following conclusion was taken.


1. The content and volume of the syllabus are adequate and of respective standard level
2. The BOS members recommends the proposed syllabus for the further processing

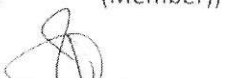
  
Dr. J. Dhar,  
(Invited Member)


  
Dr. G. Sen  
(Member)


  
Dr. S. S. Mahapatra  
(Member)


  
Dr. S. Mishra  
(Member)


  
Dr. S. Naskar  
(Member)

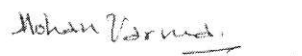
  
Dr. A. Sharon  
(Member)


  
Dr. B. Verma  
(Invited Member)


  
Dr. J. P. Pandey 17.4.18  
(Member)

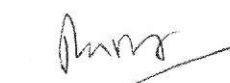
  
Dr. Usha Jha  
(Member)

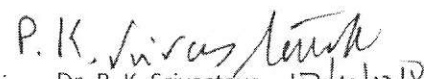
  
Dr. R. P. Sharma  
(Invited Member)

  
Dr. Mohan Varma 17.4.18  
(Invited Member)

  
Dr. R. N. Gupta  
(Member)

  
Dr. D. Tiwary  
(External Member)

  
Dr. R. K. Dey  
(External Member)


  
Dr. P. K. Srivastava 17/4/2018  
Chairman (Ex-Officio)

**BIRLA INSTITUTE OF TECHNOLOGY**  
**MESRA : RANCHI**

**DEPARTMENT OF CHEMISTRY**

Based on the meeting of Board of Studies conducted on April 17 2018, the following Courses are being prepared for revision/ implementation after the consideration from reviews done by the subject experts:

Program Code	Course Code	Course Name	Remarks
MS0204	CH103	Inorganic Chemistry-I; Atomic Structure & Chemical Bonding-I	New Course
MS0204	CH 104	Physical Chemistry-I; States of Matter & Ionic Equilibrium	New Course
MS0204	CH 105	Inorganic Chemistry-I Lab	New Course
MS0204	CH 106	Physical Chemistry-I Lab	New Course
MS0204	CH107	Physical Chemistry-II; Chemical Thermodynamics & its Applications	New Course
MS0204	CH108	Organic Chemistry-I	New Course
MS0204	CH109	Physical Chemistry-II Lab	New Course
MS0204	CH110	Organic Chemistry-I Lab	New Course
			New Course
MS0104	CH401	Basic Inorganic Chemistry	New Course
MS0104	CH402	Chemical Kinetics & Surface Chemistry	New Course
MS0104	CH403	Reactions Mechanism in Organic Chemistry	New Course
MS0104	CH404	Organometallic Chemistry	New Course
MS0104	CH405	Principles of Organic Synthesis	New Course
MS0104	CH406	Physical Chemistry-VI Lab	New Course
MS0104	CH407	Organic Chemistry-VI Lab	New Course
MS0104	CH408	Advanced Inorganic Chemistry	New Course
MS0104	CH409	Quantum Chemistry & Group Theory	New Course
MS0104	CH410	Modern Organic Chemistry	New Course
MS0104	CH411	Equilibrium, Non-Equilibrium & Statistical Thermodynamics	New Course
MS0104	CH412	Analytical Chemistry	New Course
MS0104	CH413	Inorganic Chemistry-V Lab	New Course
MS0104	CH 414	Theoretical & Computational Chemistry Lab	New Course

  
(Dr. P. K. Srivastava)  
Professor & Head  
Chairman, Board of Studies

**New Course Structure- To be effective from academic session 2018-2019**  
**Based on CBCS System & OBE Model**

**For**

**Integrated M. Sc. Programme in Chemistry**



**DEPARTMENT OF CHEMISTRY**  
**BIRLA INSTITUTE OF TECHNOLOGY**  
**MESRA, RANCHI - 835215**

**98A, Academic Council, 2<sup>nd</sup> May, 2018**



## **CBCS Based Syllabus for Integrated M. Sc. Programme in Chemistry**

### **Important notes:**

- The basic criteria of UGC have been followed in preparing the course structure of this programme.
- **The Exit option with B.Sc. (Chemistry Honours) can be offered to them who want to get it after successful completion of 6<sup>th</sup> semester.**
- On the other hand, a parallel entry is allowed in 7<sup>th</sup> semester in the form of M.Sc. programme.

### **Department Vision**

To become a recognized centre of excellence for teaching and research in Chemical Sciences through producing excellent academicians, professionals, entrepreneur and innovators

### **Department Mission**

Inoculate fundamental concepts of Chemical Sciences to students & scholars through our state of art laboratory, teaching and research facilities. Building a scientific environment and motivation towards innovation with quality research in chemical sciences and allied area.

### **Program Educational Objectives of Integrated M.Sc. Programme in Chemistry**

1. To impart high quality education and research to develop future academicians, scientists and technocrats.
2. To develop a vibrant and motivational work environment by availability of high end research exposure at UG, PG and research levels.
3. To instill values like work commitment, honesty, integrity, empathy as fundamental basis for serving humanity through chemical education and research.

### **Program Outcomes of Integrated M.Sc. Programme in Chemistry**

1. The students will be trained personnel resource in Chemical Sciences who will get through national and international level tests and be an asset to the nation.
2. They will have knowledge of basic fundamentals of chemical sciences and allied areas and will be able to compete national level tests such as JAM, UGC-CSIR NET, GATE, etc., successfully.
3. They will have an exposure to high end modern facilities used in research at par with global standards.
4. They will implement their educational and research skills with basic human values, integrity, empathy and ultimate objective of serving humanity.

# COURSE INFORMATION SHEET

**Course code:** CH 103

**Course title:** Inorganic Chemistry-I: Atomic Structure & Chemical Bonding-I

**Pre-requisite(s):** Intermediate level Chemistry

**Co- requisite(s):**

**Credits:** 4      L: 3      T: 1      P: 0

**Class schedule per week:** 04

**Class:** I. M. Sc.

**Semester / Level:** I. M. Sc. I

**Branch:** Chemistry

**Name of Teacher:**

## Course Objectives

This course enables the students:

A.	To understand the structure of atom at electronic level
B.	To develop knowledge on the physical and chemical properties of the atoms
C.	To create concept of interaction of atomic orbitals
D.	To know the process of electron transfer

## Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the properties of the atoms quantum mechanically and calculate the atomic parameters
2.	Able to predict the chemical reactivity
3.	Able to explain the interaction between atoms
4.	Able to predict and analyse the redox reactions

## Syllabus

### Module- I: Atomic Structure

(10 Lectures)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of  $\psi$  and  $\psi^2$ . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

### Module- II: Periodicity of Elements

(9 Lectures)

*s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffe's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.



**Module- III: Chemical Bonding I****(9 Lectures)**

(i) *Ionic bond*: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) *Metallic Bond*: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

(iii) *Weak Chemical Forces*: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

**Module- IV: Chemical Bonding II****(10 Lectures)**

*Covalent bond*: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules  $N_2$ ,  $O_2$ ,  $C_2$ ,  $B_2$ ,  $F_2$ ,  $CO$ ,  $NO$ , and their ions;  $HCl$ ,  $BeF_2$ ,  $CO_2$ , (idea of  $s-p$  mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding ( $\sigma$  and  $\pi$  bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

**Module- V: Oxidation-Reduction (7 Lectures)**

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class.

**Text books:**

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B. E. and McDaniel, D. H. Concepts & Models of Inorganic Chemistry Oxford, 1970.

**Reference books:**

1. Atkins, P. W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
2. Day, M. C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
3. Rodger, G. E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

<u>Course Outcome #</u>	<u>Program Outcomes</u>			
	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>
<u>CO1</u>	H	H	L	<u>L</u>
<u>CO2</u>	M	H	H	L
<u>CO3</u>	H	H	M	L
<u>CO4</u>	H	H	M	M



### Mapping between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-10	1	Atomic Structure	T1, R2,R3	1, 2	PPT Digi Class/Chock-Board
4-6	L 11-19	2	Periodicity of elements	T1, R2,R3	1, 2	-do-
7-9	L20-28	3	Chemical Bonding I	T1, R2,R3	1, 2	-do-
10-13	L29-38	4	Chemical Bonding II	T1, R2,R3	1, 2	-do-
14-15	L39-45	5	Oxidation reduction	T1, R1,R3	1, 2	-do-

**Course code: CH 104**

**Course title: Physical Chemistry-I: States of Matter & Ionic Equilibrium**

**Pre-requisite(s): Intermediate Level Chemistry**

**Co- requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: I. M. Sc.**

**Semester / Level: I. M. Sc. I**

**Branch: Chemistry**

**Name of Teacher:**

### **Course Objectives**

This course enables the students:

A.	To differentiate the states of matter based on molecular level interactions
B.	To understand the concept of ideal and real gases from the molecular level energetic
C.	To familiarize with different physical properties of liquids and solids
D.	To understand the theories of equilibrium in ionic medium

### **Course Outcomes**

After the completion of this course, students will be:

1.	Able to derive the Van der Waals equation of state and explain the deviation of real gases from ideal gases
2.	Able to analyse surface tension and viscosity coefficient of liquids
3.	Able to use Bragg's law to index cubic powder XRD pattern, determine unit cell parameter
4.	Able to calculate pH/pKa, degree of ionization, dissociation constant, solubility product of electrolytes

## **Syllabus**

### **Module I: Gaseous state: *Kinetic molecular model of a gas***

**(9 Lectures)**

Postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of  $\sigma$  from  $\eta$ ; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

### **Module II: Gaseous state: *Behaviour of real gases***

**(9 Lectures)**

Deviations from ideal gas behaviour, compressibility factor,  $Z$ , and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

### **Module III: Liquid state**

**(8 Lectures)**

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

### **Module IV: Solid state**

**(8 Lectures)**



Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl.

#### **Module V: Ionic Equilibria**

**(11 Lectures)**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids (exact treatment). Salt hydrolysis—calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer action; buffer capacity derivation of Henderson equation and its applications; applications of buffers in analytical chemistry and biochemical processes. Solubility and solubility product of sparingly soluble salts—applications. Qualitative treatment of acid–base titration curves. Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

#### **Text books:**

1. Kapoor, K. L. A Textbook of Physical Chemistry, Volume 1, Macmillan Publishers India Ltd, 2004
2. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University Press (2014).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).

#### **Reference books:**

1. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
2. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
3. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson (2013).

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Teacher's Assessment</b>	<b>5</b>
<b>Mid Sem</b>	<b>25</b>
<b>Two Quizzes</b>	<b>10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√	√	
Quiz –I	√	√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	H	H	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2,3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book /References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Gaseous state: Kinetic molecular model of a gas	<b>T1, R1,R3</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-6</b>	<b>L10-L18</b>	<b>2</b>	Behaviour of real gases	<b>T1,T2 R1,R3</b>	<b>1</b>	<b>-do-</b>
<b>7-9</b>	<b>L19-L26</b>	<b>3</b>	Viscosity and Surface Tension	<b>T1, R2,R3</b>	<b>2</b>	<b>-do-</b>
<b>9-12</b>	<b>L27-L34</b>	<b>4</b>	Solid state	<b>T1</b>	<b>3</b>	<b>-do-</b>
<b>12-15</b>	<b>L35-L45</b>	<b>5</b>	Ionic equilibria	<b>T1</b>	<b>4</b>	<b>-do-</b>



**Course code:** CH 105  
**Course title:** INORGANIC CHEMISTRY- I LAB  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. I  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

### (A) Titrimetric Analysis

- (i) Calibration and use of apparatus
- (ii) Preparation of solutions of different Molarity/Normality of titrants

### (B) Acid-Base Titrations

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

### (C) Oxidation-Reduction Titrimetry

- (i) Estimation of Fe(II) and oxalic acid using standardized  $\text{KMnO}_4$  solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iii) Estimation of Fe(II) with  $\text{K}_2\text{Cr}_2\text{O}_7$  using internal (diphenylamine, anthranilic acid) and external indicator.

### Reference book:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 106  
**Course title:** Physical Chemistry-I Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. I  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

### 1. Surface tension measurements.

- Determine the surface tension by (i) drop number (ii) drop weight method.
- Study the variation of surface tension of detergent solutions with concentration.

### 2. Viscosity measurement using Ostwald's viscometer.

- Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
- Study the variation of viscosity of sucrose solution with the concentration of solute.

### 3. Indexing of a given powder diffraction pattern of a cubic crystalline system.

### 4. pH metry

- Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
- Preparation of buffer solutions of different pH
  - Sodium acetate-acetic acid
  - Ammonium chloride-ammonium hydroxide
- pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
- Determination of dissociation constant of a weak acid.

*Any other experiment carried out in the class.*

### Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code: CH 107**

**Course title: Physical Chemistry-II: Chemical Thermodynamics & its Applications**

**Pre-requisite(s): Intermediate level Chemistry**

**Co- requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: I. M. Sc.**

**Semester / Level: I. M. Sc. II**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basic principles of thermodynamics
B.	To analyze the thermodynamic parameters in systems with variable compositions
C.	To develop the concept of equilibrium in chemical reactions using rate constant
D.	To familiarize the concept of colligative properties of solutions

### Course Outcomes

After the completion of this course, students will be:

1.	Able to calculate different thermodynamic parameters of reversible and irreversible systems using First, Second and Third Law of thermodynamics
2.	Able to measure the equilibrium constants of chemical reactions
3.	Able to determine the decrease in vapour pressure, increase in boiling point, depression of freezing point and osmotic pressure of solutions

## Syllabus

### Module I: Basic Thermodynamics I

**(9 lectures)**

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

*First law:* Concept of heat,  $q$ , work,  $w$ , internal energy,  $U$ , and statement of first law; enthalpy,  $H$ , relation between heat capacities, calculations of  $q$ ,  $w$ ,  $U$  and  $H$  for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

*Thermochemistry:* Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

### Module II: Basic Thermodynamics II

**(10 lectures)**

*Second Law:* Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

*Third Law:* Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

*Free Energy Functions:* Gibbs and Helmholtz energy; variation of  $S$ ,  $G$ ,  $A$  with  $T$ ,  $V$ ,  $P$ ; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.



**Module III: Systems of Variable Composition****(7 lectures)**

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

**Module IV: Chemical Equilibrium****(10 lectures)**

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants  $K_p$ ,  $K_c$  and  $K_x$ . Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

**Module V: Solutions and Colligative Properties****(9 lectures)**

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.

Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

**Text books:**

1. Kapoor, K. L. A Textbook of Physical Chemistry, Volume 2, Mcmillan Publishers India Ltd, 2004.
2. Peter, A. & Paula, J. de. Physical Chemistry 10th Ed., Oxford University Press (2014).
3. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).

**Reference books:**

1. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
2. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
3. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
4. Levine, I. N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
5. Metz, C. R. 2000 solved problems in chemistry, Schaum Series (2006).

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Mid Sem	√	√	
Quiz I	√		
Quiz II	√	√	
End Sem Examination Marks	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	M	L
CO3	H	H	H	2

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3	CD1
CD2	Tutorials/Assignments	CO1, 2, 3	CD1,CD2
CD3	Seminars	CO 2,3	CD3
CD4	Mini projects/Projects	CO 2,3	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5

CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3	CD6
CD7	Simulation	CO 2	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-4</b>	<b>L1-L10</b>	<b>1</b>	Thermodynamics and its Laws	<b>T1,T2,T3,R2</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-7</b>	<b>L11-L20</b>	<b>2</b>	Thermodynamic Energy Functions	<b>T2,T3 R2,R3</b>	<b>1</b>	<b>-do-</b>
<b>7-9</b>	<b>L21-L26</b>	<b>3</b>	Systems of Variable Compositions	<b>T2, T3,R2</b>	<b>1</b>	<b>-do-</b>
<b>8-12</b>	<b>L27-L36</b>	<b>4</b>	Chemical Equilibrium	<b>T1,R4</b>	<b>2</b>	<b>-do-</b>
<b>12-15</b>	<b>L37-L45</b>	<b>5</b>	Colligative Properties	<b>T1,T2</b>	<b>3</b>	<b>-do-</b>



**Course code:** CH 108  
**Course title:** Organic Chemistry-I  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. II  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basics of organic chemistry including stereochemistry perspectives
B.	To grow knowledge on the hybridization, bonding and structural properties of the molecules
C.	To create concept of molecular orbital, arrow in mechanism, with 3D structural understanding.
D.	To know the process of reaction driven by nucleophiles and electrophiles

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the organic reaction mechanism
2.	Able to predict the resonance structure and aromaticity
3.	Able to explain the interaction between reaction intermediates
4.	Able to predict and analyses the configuration and conformation of molecules

## Syllabus

### Module I: Basics of Organic Chemistry

(9 Lectures)

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

### Module II: Stereochemistry

(9 Lectures)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: *cis-trans* and, *syn-anti* isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

### Module III: Chemistry of Aliphatic Hydrocarbons

(9 Lectures)

A. Carbon-Carbon sigma bonds, Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction

(catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

#### **Module IV: Cycloalkanes and Conformational Analysis (9 Lectures)**

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

#### **Module V: Aromatic Hydrocarbons (9 Lectures)**

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

#### **Text books:**

1. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

#### **Reference books:**

1. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
2. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
3. McMurry, J. E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Mid Sem</b>	<b>25</b>
<b>Assignment</b>	<b>05</b>
<b>Two Quizzes</b>	<b>20</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7



**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Tentative Date</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L5</b>			Organic Compounds: Structure, Bonding, Electronics	<b>T1, T3, R3</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-5</b>	<b>L5-L12</b>			Reactivity & Mechanism	<b>T1, T3, R3</b>	<b>1</b>	<b>-do-</b>
<b>5-7</b>	<b>L13-L20</b>			Isomerism and Projection Formula	<b>T3, R1,R2</b>	<b>2</b>	<b>-do-</b>
<b>7-9</b>	<b>L21-L27</b>			Optical Isomerism, Configuration Nomenclature	<b>T3, R1,R2</b>	<b>3</b>	<b>-do-</b>
<b>9-10</b>	<b>L28-L33</b>			Sigma Bond and Pi Bond Reactivity in Organic Reactions	<b>T1, R3</b>	<b>4</b>	<b>-do-</b>
<b>10-11</b>	<b>L34-L39</b>			Cycloalkanes and Conformation	<b>T3, R1,R2</b>	<b>4</b>	<b>do</b>
<b>11-12</b>	<b>L40-L45</b>			Aromaticity and Electrophilic Substitution Reaction	<b>T3, R3</b>	<b>4</b>	<b>do</b>

**Course code:** CH 109  
**Course title:** Physical Chemistry-II Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. II  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

### Thermochemistry

- Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
  - Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
  - Calculation of the enthalpy of ionization of ethanoic acid.
  - Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
  - Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
  - Determination of enthalpy of hydration of copper sulphate.
  - Study of the solubility of benzoic acid in water and determination of  $\Delta H$ .
- Any other experiment carried out in the class.

### Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 110  
**Course title:** Organic Chemistry-I Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. II  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
  - a. Water
  - b. Alcohol
  - c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
  - a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
  - b. Separation of a mixture of two sugars by ascending paper chromatography
  - c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

## Reference Books:

1. Mann, F. G. & Saunders, B. C. Practical Organic Chemistry, Pearson Education (2009).
2. Furniss, B. S.; Hannaford, A. J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 201  
**Course title:** Inorganic Chemistry-II  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. III  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the principle and techniques of metallurgy
B.	To grow knowledge on the acid- base properties of molecules
C.	To know about inorganic polymers
D.	To know about the reactivity of s, p block elements

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain metallurgical processes
2.	Able to interpret and explain the acidic/basic properties of molecules
3.	Able to explain the applications of Inorganic Polymers
4.	Able to interpret and explain the chemical reactions of s, p block elements

### Syllabus

#### Module I: General Principles of Metallurgy (9 Lectures)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

#### Module II: Acids and Bases (9 Lectures)

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

#### Module III: Chemistry of s and p Block Elements (9 Lectures)

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

#### Module IV: Noble Gases (9 Lectures)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF<sub>2</sub>, XeF<sub>4</sub> and XeF<sub>6</sub>; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF<sub>2</sub>). Molecular shapes of noble gas compounds (VSEPR theory).



**Module V: Inorganic Polymers****(9 Lectures)**

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

**Text books:**

1. Lee, J. D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E; Mac Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
3. Greenwood, N. N. & Earnshaw, E. A. Chemistry of the Elements, Butterworth-Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.

**Reference books:**

1. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
2. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.19
3. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

<u>Course Outcome #</u>	<u>Program Outcomes</u>			
	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>
<u>CO1</u>	H	H	M	<u>L</u>
<u>CO2</u>	M	H	H	L
<u>CO3</u>	H	H	M	L
<u>CO4</u>	M	H	M	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / Refere nces	COs mapped	Methodology used
1-3	L1-9	1	Metallurgy	T1, R2,R3	1, 2	PPT Digi Class/Chock -Board
3-5	L 10-18	2	Acids & Bases	T1, R2,R3	1, 2	-do-
5-8	L19-27	3	Chemistry of <i>s</i> and <i>p</i> Block Elements	T1, R2,R3	1, 2	-do-
8-10	L28-36	4	Noble gases	T1, R2,R3	1, 2	-do-
10-12	L37-45	5	Inorganic polymers	T1, R1,R3	1, 2	-do-

**Course code:** CH 202

**Course title:** Physical Chemistry-III: Phase Equilibria & Chemical Kinetics

**Pre-requisite(s):** Intermediate level chemistry

**Co- requisite(s):**

**Credits:** 4      L: 3      T: 1      P: 0

**Class schedule per week:** 04

**Class:** I. M. Sc.

**Semester / Level:** I. M. Sc. III

**Branch:** Chemistry

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To develop the concepts of phase equilibrium in multi-component systems
B.	To understand the principles of reaction rates and mechanism and apply those ideas in elementary to complex reactions
C.	To grow the basic understanding about catalysis and its role on reaction mechanism

### Course Outcomes

After the completion of this course, students will be:

1.	Able to calculate the number of degrees of freedom in a system using phase rule
2.	Able to draw phase diagram in multi-component systems
3.	Able to derive rate equations of chemical reactions
4.	Able to solve problems on rate constants for (i) unimolecular (ii) bimolecular and (iii) complex reactions and adsorption kinetics

## Syllabus

### Module I: Phase Equilibria I

**(15 lectures)**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for non-reactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots.

### Module II: Phase Equilibria II

**(15 lectures)**

*Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

### Module III: Chemical Kinetics

**(15 lectures)**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

### Module IV: Catalysis

**(10 lectures)**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

**Module V: Surface chemistry****(5 lectures)**

Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

**Text books:**

1. Kapoor, K. L. A Textbook of Physical Chemistry, Volume 3, Macmillan Publishers India Ltd, 2004
2. Kapoor, K. L. A Textbook of Physical Chemistry, Volume 5, Macmillan Publishers India Ltd, 2004
3. Atkins, P. & Paula, J. D. Physical Chemistry 10th Ed., Oxford University Press (2014).
4. Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
5. McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).

**Reference books:**

1. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
2. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
3. Zundhal, S. S. Chemistry concepts and applications Cengage India (2011).
4. Ball, D. W. Physical Chemistry Cengage India (2012).
5. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
6. Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
7. Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	M	H	M	L

### **Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2,3	CD3
CD4	Mini projects/Projects	CO 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD8	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD9	Simulation	CO 3	CD7



**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-4</b>	L1-L09	<b>1</b>	Basics of Phase Equilibria	<b>T1, T2 R1,R4</b>	<b>1,2</b>	<b>PPT Digi Class/Chock-Board</b>
<b>5-8</b>	L10-L18	<b>2</b>	Phase Equilibria in Binary Systems	<b>T1,T2 R1,R3</b>	<b>1,2</b>	<b>-do-</b>
<b>9-12</b>	L19-L27	<b>3</b>	Chemical Kinetics	<b>T1, R2,R3</b>	<b>3</b>	<b>-do-</b>
<b>12-14</b>	L28-L36	<b>4</b>	Chemical and Enzyme Catalysis	<b>T2, T3</b>	<b>3, 4</b>	<b>-do-</b>
<b>15</b>	L37-L45	<b>5</b>	Surface Chemistry	<b>T2</b>	<b>4</b>	<b>-do-</b>

**Course code:** CH 203  
**Course title:** Organic Chemistry-II  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. III  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basics of Halogenated Hydrocarbons, Alcohols, Phenols, Ethers and Epoxides, Carboxylic Acids and their Derivatives
B.	To have detailed idea of synthesis and physical properties.
C.	To study Nucleophilic additions, Nucleophilic addition-elimination reactions involving carbonyl compounds
D.	To know the process of reaction driven by nucleophiles and electrophiles

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the organic reaction mechanisms
2.	Able to draw stepwise mechanisms involved various organic synthesis
3.	Able to explain the interaction between reaction intermediates
4.	Able to predict and analyses the configuration and conformation of molecules

## Syllabus

### Module I: Chemistry of Halogenated Hydrocarbons (9 Lectures)

Alkyl halides: Methods of preparation, nucleophilic substitution reactions –  $S_N1$ ,  $S_N2$  and  $S_Ni$  mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution;  $S_NAr$ , Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

### Module II: Alcohols, Phenols, Ethers and Epoxides (9 Lectures)

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and  $LiAlH_4$ .

### Module III: Carbonyl Compounds (10 Lectures)

Structure, reactivity and preparation;

Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements,

haloform reaction and Baeyer Villiger oxidation,  $\alpha$ -substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner,  $\text{LiAlH}_4$ ,  $\text{NaBH}_4$ , MPV, PDC and PGC);

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

#### **Module IV: Carboxylic Acids and their Derivatives (10 Lectures)**

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement.

#### **Module V: Sulphur containing compounds (7 Lectures)**

Preparation and reactions of thiols, thioethers and sulphonic acids.

##### **Text books:**

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

##### **Reference books:**

1. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Teacher's Assessment</b>	<b>5</b>
<b>Mid Sem</b>	<b>25</b>
<b>Two Quizzes</b>	<b>10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz -1	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

#### Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

#### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	H	L	M

#### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Chemistry of Halogenated Hydrocarbons	<b>T1, T2, R1,R2</b>	<b>4</b>	<b>PPT Digi Class/Chock -Board</b>
<b>3-5</b>	<b>L10-L18</b>	<b>2</b>	Alcohols, Phenols, Ethers and Epoxides	<b>T1, R1,R2</b>	<b>4</b>	<b>-do-</b>
<b>5-8</b>	<b>L19-L27</b>	<b>3</b>	Carbonyl Compounds	<b>T1, R1,R2</b>	<b>3</b>	<b>-do-</b>
<b>8-10</b>	<b>L28-L37</b>	<b>4</b>	Carboxylic Acids and their Derivatives	<b>T1, T2, R2</b>	<b>3</b>	<b>-do-</b>
<b>10-12</b>	<b>L38-L45</b>	<b>5</b>	Sulphur containing compounds	<b>T1, T2, R1</b>	<b>2</b>	<b>-do-</b>

**Course code:** CH 204  
**Course title:** Inorganic Chemistry-II Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M.Sc.  
**Semester / Level:** I. M. Sc. III  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

### (A) Iodo / Iodimetric Titrations

- (i) Estimation of Cu(II) and  $K_2Cr_2O_7$  using sodium thiosulphate solution (Iodimetrically).
- (ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
- (iii) Estimation of available chlorine in bleaching powder iodometrically.

### (B) Inorganic preparations

- (i) Cuprous Chloride,  $Cu_2Cl_2$
- (ii) Preparation of Manganese(III) phosphate,  $MnPO_4 \cdot H_2O$
- (iii) Preparation of Aluminium potassium sulphate  $KAl(SO_4)_2 \cdot 12H_2O$  (Potash alum) or Chrome alum.

### Reference Books:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)



**Course code:** CH 205  
**Course title:** Physical Chemistry-III Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. III  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

- I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
- II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
  - a. simple eutectic and
  - b. congruently melting systems.
- III. Distribution of acetic/ benzoic acid between water and cyclohexane.
- IV. Study the equilibrium of at least one of the following reactions by the distribution method:
  - (i)  $\text{I}_2(\text{aq}) + \text{I}^- \rightarrow \text{I}_3^-(\text{aq})$
  - (ii)  $\text{Cu}^{2+}(\text{aq}) + n\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_n]^{2+}$
- V. Study the kinetics of the following reactions.
  1. Initial rate method: Iodide-persulphate reaction
  2. Integrated rate method:
    - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
    - b. Saponification of ethyl acetate.
  3. Compare the strengths of HCl and  $\text{H}_2\text{SO}_4$  by studying kinetics of hydrolysis of methyl acetate.
- VI. Adsorption
  - I. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

## Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 206

**Course title:** Organic Chemistry-II Lab

**Pre-requisite(s):** Intermediate level chemistry

**Co- requisite(s):**

**Credits:** 1.5    L: 0    T: 0    P:3

**Class schedule per week:** 03

**Class:** I. M. Sc.

**Semester / Level:** I. M. Sc. III

**Branch:** Chemistry

**Name of Teacher:**

## Syllabus

1 Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

2 Organic preparations:

i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols ( $\beta$ -naphthol, vanillin, salicylic acid) by any one method:

a. Using conventional method.

b. Using green approach

ii. Benzoylation of one of the following amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols ( $\beta$ -naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination of any one of the following:

a. Acetanilide by conventional methods

b. Acetanilide using green approach (Bromate-bromide method)

v. Nitration of any one of the following:

a. Acetanilide/nitrobenzene by conventional method

b. Salicylic acid by green approach (using ceric ammonium nitrate).

vi. Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline.

vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

viii. Hydrolysis of amides and esters.

ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.

x. S-Benzylisothiuronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

xi. Aldol condensation using either conventional or green method.

xii. Benzil-Benzilic acid rearrangement.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

## Reference Books:

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012).
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 207  
**Course title:** Inorganic Chemistry-III  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. IV  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To learn the theory and application of coordination chemistry
B.	To learn the electronic structure and reactivity of transition elements
C.	To study the chemistry of Lanthanoids and Actinides
D.	To grow the basic concept of bio-inorganic chemistry

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the principle and application of coordination chemistry
2.	Able to predict the reactivity of transition elements
3.	Able to predict the reactivity of Lanthanides and Actinides
4.	Able to explain the basic features of bioinorganic chemistry

### Syllabus

#### Module-I: Coordination Chemistry I (9 Lectures)

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of  $10 Dq$  ( $\Delta_o$ ), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of  $10 Dq$  ( $\Delta_o$ ,  $\Delta_t$ ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry.

#### Module-II: Coordination Chemistry II (9 Lectures)

Qualitative aspect of Ligand field and MO Theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.

#### Module-III: Transition Elements (10 Lectures)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy).

#### Module-IV: Lanthanoids and Actinoids (7 Lectures)

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

#### Module-V: Bioinorganic Chemistry (10 Lectures)

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium/K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

#### Text books:

1. Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth-Heinemann, 1997.
2. Huheey, J. E., Inorganic Chemistry, Prentice Hall, 1993.
3. Lippard, S. J. & Berg, J. M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
4. Cotton, F. A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999

**Reference books:**

1. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
2. Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Teacher's Assessment</b>	<b>5</b>
<b>Mid Sem</b>	<b>25</b>
<b>Two Quizzes</b>	<b>10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>
<b>Mid Sem</b>	√	√		
<b>Quiz –I</b>	√			
<b>Quiz II</b>			√	
<b>End Sem Examination Marks</b>	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	M	M	L
CO3	H	H	H	M
CO4	M	H	H	M

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L9	1	Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory	T1, T2, R1,R2	4	PPT Digi Class/Chock-Board
3-5	L10-L18	2	Qualitative aspect of Ligand field and MO Theory	T1, R1,R2	4	-do-
5-8	L19-L28	3	Transition Elements	T1, R1,R2	3	-do-
8-10	L29-L35	4	Lanthanoids and Actinoids	T1, T2, R2	3	-do-
10-12	L36-L45	5	Bioinorganic Chemistry	T1, T2, R1	2	-do-

**Course code: CH 208**

**Course title: Physical Chemistry-IV: Electrochemistry**

**Pre-requisite(s): Intermediate level chemistry**

**Co- requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: I. M. Sc.**

**Semester / Level: I. M. Sc. IV**

**Branch: Chemistry**

**Name of Teacher:**

### **Course Objectives**

This course enables the students:

A.	To understand the basic concept of conductivity and related phenomenon in electrolytic medium
B.	To learn the applicability of conductance measurement to determine different physical properties
C.	To gain the knowledge about electromotive forces in galvanic cells and its relation with various thermodynamic parameters
D.	To develop the concept on electrical and magnetic properties of matter

### **Course Outcomes**

After the completion of this course, students will be:

1.	Able to calculate equivalent conductivity, ionic mobility, transference numbers of electrolyte
2.	Able to determine dissociation constant, ionic product, solubility product, hydrolysis constant using conductometric measurement
3.	Able to measure the cell potential in a galvanic cell with half cell equations
4.	Able to determine equilibrium constants, pH/pKa, thermodynamic parameters with the help of EMF measurement
5.	Able to explain electrical and magnetic phenomenon in matter with molecular level interpretations

### **Syllabus**

#### **Module I: Conductance: Theory**

**(15 lectures)**

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods.

#### **Module II: Conductance: Applications**

**(10 lectures)**

Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

#### **Module III: Electromotive Force of Galvanic Cells: Theory**

**(10 lectures)**

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells.



**Module IV: Electromotive Force of Galvanic Cells: Applications (15 lectures)**

Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and  $\text{SbO/Sb}_2\text{O}_3$  electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

**Module V: Electrical & Magnetic Properties of Atoms and Molecules (10 lectures)**

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mossotti equation, Lorentz-Lorentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

**Text books:**

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Kapoor, K. L. A Textbook of Physical Chemistry, Volume 3, Macmillan Publishers India Ltd, 2004
4. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).

**Reference books:**

1. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
2. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
3. Rogers, D. W. Concise Physical Chemistry Wiley (2010).
4. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

### Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

#### Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem	√	√	√		
Quiz –I	√	√			
Quiz II				√	
End Sem Examination Marks	√	√	√	√	√

#### Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

#### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	M	L
CO3	H	H	H	L
CO4	M	H	M	L
CO5	M	H	H	L

### Mapping between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4, 5	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2,3,5	CD3
CD4	Mini projects/Projects	CO 3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4, 5	CD6
CD7	Simulation	CO 5	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-4	L1-L09	1	Basic concepts in Electrolytic Conductivity	T1, T2 T3,R4	1,2	PPT Digi Class/Chock-Board
5-6	L10-L18	2	Applications of Conductance Measurement	T1,T3 R1,R3	1,2	-do-
7-9	L19-L27	3	Galvanic Cells	T1,T2,R2	3,4	-do-
9-13	L28-L36	4	Application of Galvanostatic Measurement	T2, T3	3, 4	-do-
13-15	L37-L45	5	Electrical and Magnetic Properties	T1, R4	5	-do-

**Course code:** CH 209  
**Course title:** Organic Chemistry-III  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. IV  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand heterocyclic chemistry
B.	To read Nitrogen Containing Functional Groups.
C.	To study few natural compounds such as alkaloids and terpenoids
D.	To know structure elucidation of alkaloids

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the organic reaction mechanisms
2.	Able to discuss effect of substituent and role of solvent in organic synthesis
3.	Able to explain the interaction between reaction intermediates
4.	Able to explain Structure elucidation of natural products

## Syllabus

### Module I: Nitrogen Containing Functional Groups (9 Lectures)

Preparation and important reactions of nitro and compounds, nitriles and isonitriles

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications.

### Module II: Polynuclear Hydrocarbons (8 Lectures)

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

### Module III: Heterocyclic Compounds (10 Lectures)

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction

Derivatives of furan: Furfural and furoic acid.

### Module IV: Alkaloids (9 Lectures)

Natural occurrence, General structural features, Isolation and their physiological action

Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

**Module V: Terpenes****(9 Lectures)**

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and  $\alpha$ -terpineol.

**Text books:**

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Willy & Sons (1976).
5. Singh, J.; Ali, S.M.; Singh, J. Natural Product Chemistry, Pragati Prakashan (2010).

**Reference books:**

1. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
4. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz -1	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

#### Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

#### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	H	L	M

#### Mapping between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7



**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L01-L09</b>	<b>1</b>	Nitrogen Containing Functional Groups	<b>T1, T2, R1, R2, R4</b>	<b>4</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-5</b>	<b>L10-L17</b>	<b>2</b>	Polynuclear Hydrocarbons	<b>T1, T4, R1</b>	<b>4</b>	<b>-do-</b>
<b>5-8</b>	<b>L18-L27</b>	<b>3</b>	Heterocyclic Compounds	<b>T1, T4, R1, R2, R3</b>	<b>3</b>	<b>-do-</b>
<b>8-10</b>	<b>L28-L36</b>	<b>4</b>	Alkaloids	<b>T3, T5, R3</b>	<b>3</b>	<b>-do-</b>
<b>10-12</b>	<b>L37-L45</b>	<b>5</b>	Terpenes	<b>T3, T5, R3</b>	<b>2</b>	<b>-do-</b>

**Course code:** CH 210  
**Course title:** Inorganic Chemistry-III Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. IV  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

### Gravimetric Analysis:

- i. Estimation of nickel(II) using Dimethylglyoxime (DMG).
- ii. Estimation of copper as CuSCN
- iii. Estimation of iron as  $\text{Fe}_2\text{O}_3$  by precipitating iron as  $\text{Fe}(\text{OH})_3$ .
- iv. Estimation of Al(III) by precipitating with oxine and weighing as  $\text{Al}(\text{oxine})_3$  (aluminium oxinate).

### Inorganic Preparations:

- i. Tetraamminecopper(II) sulphate,  $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- ii. *Cis* and *trans*  $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2 \cdot (\text{H}_2\text{O})_2]$  Potassium dioxalatodiaquachromate(III)
- iii. Tetraamminecarbonatocobalt(III) ion
- iv. Potassium tris(oxalate)ferrate(III)

### Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

- i. Ni (II) and Co (II)
- ii. Fe (III) and Al (III)

### Reference Book:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

**Course code:** CH 211  
**Course title:** Physical Chemistry-IV Lab  
**Pre-requisite(s):** Intermediate level Chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. IV  
**Branch:** Chemistry  
**Name of Teacher:**

## **Syllabus**

### **Conductometry**

- I. Determination of cell constant
- II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- III. Perform the following conductometric titrations:
  - i. Strong acid vs. strong base
  - ii. Weak acid vs. strong base
  - iii. Mixture of strong acid and weak acid vs. strong base
  - iv. Strong acid vs. weak base

### **Potentiometry**

- I. Perform the following potentiometric titrations:
  - i. Strong acid vs. strong base
  - ii. Weak acid vs. strong base
  - iii. Dibasic acid vs. strong base
  - iv. Potassium dichromate vs. Mohr's salt

### **Reference Books:**

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

**Course code:** CH 212  
**Course title:** Organic Chemistry-III Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. IV  
**Branch:** Chemistry  
**Name of Teacher:**

## **Syllabus**

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

## **Reference Books:**

1. Mann, F. G. & Saunders, B. C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B. S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
3. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Ahluwalia, V. K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

**Course code: CH 301**

**Course title: Physical Chemistry-V: Quantum Chemistry & Spectroscopy**

**Pre-requisite(s): Intermediate level chemistry**

**Co- requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: I. M. Sc.**

**Semester / Level: I. M. Sc. V**

**Branch: Chemistry**

**Name of Teacher:**

### **Course Objectives**

This course enables the students:

A.	To acquire knowledge of the quantum chemical description of chemical bonding, reactivity and their applications in molecular spectroscopy and derive essential mathematical relationships in quantum mechanics and spectroscopy.
B.	To acquire knowledge of electromagnetic radiation, laws and principles of photochemistry, their applications in biochemical processes.

### **Course Outcomes**

After the completion of this course, students will be:

1.	Able to interpret (and normalize) a wavefunction, calculate a probability using a wavefunction, calculate and interpret an expectation value, utilize and interpret the Heisenberg Uncertainty Principle and solve Schrodinger equation for a particle in a box.
2.	Able to apply the essential mathematical relationships to understand quantum mechanical models such as Particle in a Box, Harmonic Oscillator, and Rigid Rotor.
3.	Able to employ quantum mechanical principles and models to interpret topics in the hydrogen atom, polyelectronic atoms, and chemical bonding.
4.	Able to interpret microwave, infrared-vibration-rotation Raman and infrared spectroscopy for chemical analysis and electronic spectroscopy of different elements and simple molecules.
5.	Able to analyse organic compounds by nuclear magnetic and electron spin resonance spectroscopy.
6.	Able to apply the knowledge of photochemistry in spectrophotometry and derive rate equation for photochemical reactions and photosensitised reactions.

## **Syllabus**

### **Module I: Quantum Chemistry**

**(10 lectures)**

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

### **Module II: Chemical Bonding**

**(9 lectures)**

Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of  $H_2^+$ . Bonding and antibonding orbitals. Qualitative extension to  $H_2$ . Comparison of LCAO-MO and VB treatments of  $H_2$  (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic ( $BeH_2$ ,  $H_2O$ ) molecules. Qualitative MO theory and its application to  $AH_2$  type molecules.

### **Module III: Molecular Spectroscopy I**

**(9 lectures)**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

*Rotation spectroscopy:* Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

*Vibrational spectroscopy:* Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

*Vibration-rotation spectroscopy:* diatomic vibrating rotator, P, Q, R branches.

*Raman spectroscopy:* Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

*Electronic spectroscopy:* Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

### **Module IV: Molecular Spectroscopy II**

**(8 lectures)**

*Nuclear Magnetic Resonance (NMR) spectroscopy:* Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

*Electron Spin Resonance (ESR) spectroscopy:* Its principle, hyperfine structure, ESR of simple radicals.

### **Module V: Photochemistry**

**(9 lectures)**

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

### **Text books:**

1. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
2. Atkins, P.W. and Friedman, R.S. Molecular Quantum Mechanics, 4<sup>th</sup> edition, Oxford University Press. Oxford, 2005.
3. Kapoor, K. L. A Textbook of Physical Chemistry, Volume 4, Macmillan Publishers India Ltd, 2004
4. Prasad, R.K. Quantum Chemistry, 3<sup>rd</sup> edition, New Age International, 2006.
5. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
6. Rohatgi-Mukherjee, K. K. Fundamentals of Photochemistry, New Age International Pvt. Ltd.; 3rd edition, New Delhi, 2014.

**Reference books:**

1. House, J. E. Fundamentals of Quantum Chemistry 2<sup>nd</sup> Ed. Elsevier: USA (2004).
2. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
3. Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015).

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem	√	√	√			
Quiz –I	√	√				
Quiz II				√		
End Sem Examination Marks	√	√	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	H	L
CO3	H	H	M	L
CO4	M	M	H	L
CO5	M	H	H	L
CO6	H	H	H	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4, 5, 6	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4, 6	CD1,CD2
CD3	Seminars	CO 2,3,5	CD3
CD4	Mini projects/Projects	CO 2,3,4	CD4
CD5	Laboratory experiments/teaching aids	CO 4, 5	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4, 5	CD6
CD7	Simulation	CO 2,3,4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-5	L1-L09	1	Introduction to Quantum Chemistry	T1, T2 T4,R1	1,2	PPT Digi Class/Chock -Board
6-8	L10-L18	2	Chemical Bonding	T2, R1	2	-do-
8-12	L19-L27	3	Rotational, Vibrational and Electronic Spectroscopy	T3,T5,R3	4	-do-
12-13	L28-L36	4	NMR and EPR Spectroscopy	T3,T5	5	-do-
13-15	L37-L45	5	Introductory Photochemistry	T6	6	-do-



**Course code:** CH 302  
**Course title:** Organic Chemistry-IV  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand about the different organic molecules working as building blocks for the bio-macromolecules
B.	To understand the structure-activity relationship of these organic macromolecule in biological process as metabolites
C.	To learn the classification, structure and therapeutic utility of different types of pharmaceutically important organic molecules

### Course Outcomes

After the completion of this course, students will be:

1.	To learn about the organic molecules as building blocks of the living organisms and their pharmacological effects
2.	To understand the structure of assembly of building blocks in the structure of biomacromolecules such as nucleic acid, peptides and proteins and enzymes
3.	To understand the sources of energy in the biological systems and energetic of the biological processes
4.	To understand the structure-property-activity relationship of the pharmaceuticals on biological systems

### Syllabus

#### Module I: Nucleic Acids

(9 Lectures)

Components of nucleic acids, Nucleosides and nucleotides;

Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

#### Module II: Amino Acids, Peptides and Proteins

(9 Lectures)

Amino acids, Peptides and their classification.

$\alpha$ -Amino Acids - Synthesis, ionic properties and reactions. Zwitterions,  $pK_a$  values, isoelectric point and electrophoresis;

Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups- Solid-phase synthesis

#### Module III: Enzymes & Lipids

(9 Lectures)

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

#### **Module IV: Concept of Energy in Biosystems (9 Lectures)**

Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD<sup>+</sup>, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle. Overview of catabolic pathways of fat and protein. Interrelationship in the metabolic pathways of protein, fat and carbohydrate. Caloric value of food, standard caloric content of food types.

#### **Module V: Pharmaceutical Compounds: Structure and Importance (9 Lectures)**

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

#### **Text books:**

1. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

#### **Reference books:**

1. Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry. 6th Ed. W.H. Freeman and Co. (2006).
2. Nelson, D. L., Cox, M. M. & Lehninger, A.L. Principles of Biochemistry. IV Edition. W.H. Freeman and Co. (2009).
3. Murray, R. K., Granner, D. K., Mayes, P. A. & Rodwell, V. W. Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill. (2009).

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Teacher's Assessment</b>	<b>5</b>
<b>Mid Sem</b>	<b>25</b>
<b>Two Quizzes</b>	<b>10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Quiz -1	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	H	L
CO3	H	H	M	L
CO4	M	M	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L09</b>	<b>11</b>	Nucleic Acids	<b>T1, T2 R3,R1</b>	<b>1,2</b>	<b>PPT Digi Class/Chock -Board</b>
<b>3-7</b>	<b>L10-L18</b>	<b>13</b>	Amino Acids, Peptides and Proteins	<b>T1,T2, R2</b>	<b>2</b>	<b>-do-</b>
<b>7-11</b>	<b>L19-L27</b>	<b>3</b>	Enzymes & Lipids	<b>T1,T2R3</b>	<b>4</b>	<b>-do-</b>
<b>11-13</b>	<b>L28-L36</b>	<b>4</b>	Concept of Energy in Biosystems	<b>T1,T2</b>	<b>5</b>	<b>-do-</b>
<b>13-15</b>	<b>L37-L45</b>	<b>5</b>	Pharmaceutical Compounds: Structure and Importance	<b>T1,R2</b>	<b>6</b>	<b>-do-</b>

**Course code:** CH 303  
**Course title:** Analytical Methods in Chemistry  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

## Course Objectives

This course enables the students:

A.	To understand qualitative and quantitative aspects of chemical analysis
B.	To understand the optical methods of analysis
C.	To learn the thermal and electrochemical methods of analysis
D.	To understand the separation processes

## Course Outcomes

After the completion of this course, students will be:

1.	Able to calculate the error analysis
2.	Able to explain different optical methods of analysis
3.	Able to explain different thermal and electrochemical methods
4.	Able to separate a component from mixture

## Syllabus

### Module I: Qualitative and quantitative aspects of analysis: (7 Lectures)

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

### Module II: Optical methods of analysis: (11 Lectures)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

*UV-Visible Spectrometry:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;

*Basic principles of quantitative analysis:* estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

*Infrared Spectrometry:* Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, Effect and importance of isotope substitution.

*Flame Atomic Absorption and Emission Spectrometry:* Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

### Module III: Thermal methods of analysis: (7 Lectures)

Theory of thermogravimetry (TG), basic principle of instrumentation.

Techniques for quantitative estimation of Ca and Mg from their mixture.

**Module IV: Electroanalytical methods:****(10 Lectures)**

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.

Techniques used for the determination of pK<sub>a</sub> values.

**Module V: Separation techniques:****(10 Lectures)**

Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation.

Technique of extraction: batch, continuous and counter current extractions.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Role of computers in instrumental methods of analysis.

**Reference Books:**

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
7. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	M	M	L
CO3	H	H	H	M
CO4	M	H	H	M

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
	L1-L6	1	Qualitative and quantitative aspects of analysis	T1, T2 R3,R1	1	PPT Digi Class/Chock-Board
	L7-L17	2	Optical methods of analysis	T1,T2, R2	2	-do-
	L18-L26	3	Thermal methods of analysis	T1,T2, R3	3	-do-
	L26-L35	4	Electroanalytical methods	T1,T2	3	-do-
	L36-L45	5	Separation Techniques	T1,R2	4	-do-



**Course code:** CH 304  
**Course title:** Industrial Chemicals and Environment  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

## Course Objectives

This course enables the students:

A.	To understand the concepts and applications of Inorganic Chemicals & Environment
B.	To strengthen the fundamental concepts of chemistry and then builds an interface with their industrial applications.
C.	To apply basic chemistry/science skills, conduct experiments in teams, analyze the results, and communicate these results, in a safe, professional and ethical manner

## Course Outcomes

After the completion of this course, students will be:

1.	Able to understand Industrial chemicals and environment.
2.	Able to classify Industrial chemicals and their environmental impacts in metallurgy
3.	Able to know applications of environmental segments
4.	Able to establish relationship between energy and environment

## Syllabus

### Module-I: Industrial Gases and Inorganic Chemicals (10 Lectures)

*Industrial Gases:* Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

*Inorganic Chemicals:* Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

### Module-II: Industrial Metallurgy (5 Lectures)

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

### Module-III: Environment and its segments (10 Lectures)

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.

Pollution by SO<sub>2</sub>, CO<sub>2</sub>, CO, NO<sub>x</sub>, H<sub>2</sub>S and other foul smelling gases. Methods of estimation of CO, NO<sub>x</sub>, SO<sub>x</sub> and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

**Water Pollution:** Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.

**Water purification methods.** Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

#### **Module-IV: Energy& Environment**

**(10 Lectures)**

**Sources of energy:** Coal, petrol and natural gas. Nuclear Fusion/Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.

**Nuclear Pollution:** Disposal of nuclear waste, nuclear disaster and its management.

#### **Module-V: Biocatalysis**

**(8 Lectures)**

Introduction to biocatalysis: Importance in “Green Chemistry” and Chemical Industry.

#### **Reference Books:**

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel’s Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
7. S. E. Manahan, Environmental Chemistry, CRC Press (2005).
8. G. T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
9. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Teacher’s Assessment</b>	<b>5</b>
<b>Mid Sem</b>	<b>25</b>
<b>Two Quizzes</b>	<b>10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	M	M	L
CO3	H	H	H	M
CO4	M	H	H	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L09</b>	<b>1</b>	Industrial Gases and Inorganic Chemicals	<b>T1, T2 R3,R1</b>	<b>1,2</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-7</b>	<b>L10-L13</b>	<b>2</b>	Industrial Metallurgy	<b>T1,T2, R2</b>	<b>2</b>	<b>-do-</b>
<b>7-11</b>	<b>L14-L27</b>	<b>3</b>	Environment and its segments	<b>T1,T2R3</b>	<b>4</b>	<b>-do-</b>
<b>11-13</b>	<b>L28-L36</b>	<b>4</b>	Energy & Environment	<b>T1,T2</b>	<b>5</b>	<b>-do-</b>
<b>13-15</b>	<b>L37-L45</b>	<b>5</b>	Biocatalysis	<b>T1,R2</b>	<b>6</b>	<b>-do-</b>

**Course code:** CH 305  
**Course title:** Inorganic Materials of Industrial Importance  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To know about Silicate & Fertilizers
B.	To know about Surface Coatings.
C.	To know about batteries and alloys
D.	To know about catalysis and explosives

### Course Outcomes

After the completion of this course, students will be:

1.	To characterise Silicate & Fertilizers
2.	To do Surface Coatings
3.	Able to know applications related to chemo and bio-informatic related to drug design.
4.	Able to understand the function of batteries and alloys
5.	Able to understand about catalysis and explosives

## Syllabus

### Module-I: Silicate & Fertilizers Industries:

(9 Lectures)

*Glass:* Glassy state and its properties, classification (silicate and non-silicate glasses).

Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

*Ceramics:* Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

*Cements:* Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

### Module-II: Surface Coatings:

(9 Lectures)

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

### Module-III: Batteries & Alloys:

(9 Lectures)

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

#### **Module-IV: Catalysis:**

**(9 Lectures)**

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts.

Phase transfer catalysts, application of zeolites as catalysts.

#### **Module-V: Chemical explosives:**

**(9 Lectures)**

Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

#### **Reference Books:**

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Teacher's Assessment</b>	<b>5</b>
<b>Mid Sem</b>	<b>25</b>
<b>Two Quizzes</b>	<b>10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	M	M	L
CO3	H	H	H	M
CO4	M	H	H	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L09</b>	<b>1</b>	Silicate & Fertilizers Industries	<b>T1, T2 R3,R1</b>	<b>1,2</b>	<b>PPT DigiClass/Chock-Board</b>
<b>3-7</b>	<b>L10-L18</b>	<b>2</b>	Surface Coatings	<b>T1,T2, R2</b>	<b>2</b>	<b>-do-</b>
<b>7-11</b>	<b>L19-L27</b>	<b>3</b>	Batteries & Alloys	<b>T1,T2R3</b>	<b>4</b>	<b>-do-</b>
<b>11-13</b>	<b>L28-L36</b>	<b>4</b>	Catalysis	<b>T1,T2</b>	<b>5</b>	<b>-do-</b>
<b>13-15</b>	<b>L37-L45</b>	<b>5</b>	Chemical explosives	<b>T1,R2</b>	<b>6</b>	<b>-do-</b>



**Course code:** CH 306  
**Course title:** Molecular Modelling & Drug Design  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

This course enables the students:

A.	To understand the concepts and 3D chemical structure, molecular orbitals, bonding and its applications in theoretical chemistry.
B.	To strengthen the fundamental concepts of structural chemistry including conformation and configuration. Builds an interface with their applications in physical and biological science.
C.	To apply basic chemistry, structural and drawing skills using modeling software, conduct simulation experiments on computer/high performance computing, analyze the results, and its application in drug design.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to understand, draw, visualize and demonstrate the 3D chemical structure of small and large molecule.
2.	Able to understand the drug, ligand and protein data bases.
3.	Able to know applications related to chemo and bio-informatic related to drug design.
4.	Able to do modeling experiments, computational calculation, physico-chemical properties estimation using modeling software.
5.	Able to generate 3D structure file to demonstrate the atomic level understanding including non-covalent bonding, QSAR studies and molecular recognition.

### Syllabus

#### **Module I: Introduction to Molecular Modelling: (9 Lectures)**

Introduction. Useful Concepts in Molecular Modelling: Coordinate Systems. Potential Energy Surfaces. Molecular Graphics. Surfaces. Computer Hardware and Software. The Molecular Modelling Literature.

#### **Module II: Force Fields: (9 Lectures)**

Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. van der Waals Interactions. Hydrogen bonding in Molecular Mechanics. Force Field Models for the Simulation of Liquid Water.

#### **Module III: Energy Minimization and Computer Simulation: (9 Lectures)**

Minimization and related methods for exploring the energy surface. Non-derivative method, First and second order minimization methods. Computer simulation methods. Simple thermodynamic properties and Phase Space. Boundaries. Analyzing the results of a simulation and estimating Errors.

#### **Module IV: Molecular Dynamics & Monte Carlo Simulation: (9 Lectures)**

Molecular Dynamics Simulation Methods. Molecular Dynamics using simple models. Molecular Dynamics with continuous potentials. Molecular Dynamics at constant temperature and pressure. Metropolis method. Monte Carlo simulation of molecules. Models used in Monte Carlo simulations of polymers.

#### **Module V: Structure Prediction and Drug Design: (9 Lectures)**

Structure prediction - Introduction to comparative Modeling. Sequence alignment. Constructing and evaluating a comparative model. Predicting protein structures by 'Threading', Molecular docking. Structure based de novo ligand design, Drug Discovery – Chemoinformatics – QSAR.

#### Reference Books:

1. A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
2. J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
3. Satya Prakash Gupta, QSAR and Molecular Modeling, Springer – Anamaya Publishers, 2008.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

##### Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Quiz (s)	√	√	√	√	
Assignment	√	√	√	√	
Mid Sem	√	√	√		
End Sem Examination Marks	√	√	√	√	√

##### **Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	H	L
CO3	H	H	M	L
CO4	M	M	H	L
CO5	M	H	H	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-2	L1-L09	1	3D structure, Coordinate System Theory Drawing & Data Bases	T1, R1	1	PPT Digi Class/ Chalk-Board
2-3	L10-L18	2	Software Application and Hardware	T1, R1	2	-do-
3-6	L19-L27	3	Molecular Mechanics and Force Field	T1, R1, R2	3	-do-
7-9	L28-L36	4	Energy Minimization and Computer Simulation	T1, R1, R2	4	-do-
10-12	L37-L45	5	Molecular Dynamics & Monte Carlo Simulation, Structure Prediction and Drug Design	T1, R1, R2	5	-do-

**Course code:** CH 307  
**Course title:** Physical Chemistry-V Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

## **Syllabus**

### **UV/Visible spectroscopy**

- I. Study the 200-500 nm absorbance spectra of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  (in 0.1 M  $\text{H}_2\text{SO}_4$ ) and determine the  $\lambda_{\text{max}}$  values. Calculate the energies of the two transitions in different units ( $\text{J molecule}^{-1}$ ,  $\text{kJ mol}^{-1}$ ,  $\text{cm}^{-1}$ , eV).
- II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of  $\text{K}_2\text{Cr}_2\text{O}_7$ .
- III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

### **Colourimetry**

- I. Verify Lambert-Beer's law and determine the concentration of  $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  in a solution of unknown concentration
- II. Determine the concentrations of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  in a mixture.
- III. Study the kinetics of iodination of propanone in acidic medium.
- IV. Determine the amount of iron present in a sample using 1,10-phenanthroline.
- V. Determine the dissociation constant of an indicator (phenolphthalein).
- VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
- VII. Analysis of the given vibration-rotation spectrum of HCl

### **Reference Books**

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

**Course code:** CH 308  
**Course title:** Organic Chemistry-IV Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

### **Syllabus**

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/fat.
8. Isolation and characterization of DNA from onion/cauliflower/peas.

### **Reference Books:**

1. Manual of Biochemistry Workshop, Department of Chemistry, University of Delhi, 2012,
2. Arthur, I. V. Quantitative Organic Analysis, Pearson.

**Course code:** CH 309  
**Course title:** Lab: Analytical Methods in Chemistry  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

## **Syllabus**

### **I. Separation Techniques**

#### 1. Chromatography:

##### (a) Separation of mixtures

(i) Paper chromatographic separation of  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ , and  $\text{Cr}^{3+}$ .

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the  $R_f$  values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their  $R_f$  values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

### **II. Solvent Extractions:**

(i) To separate a mixture of  $\text{Ni}^{2+}$  &  $\text{Fe}^{2+}$  by complexation with DMG and extracting the  $\text{Ni}^{2+}$  DMG complex in chloroform, and determine its concentration by spectrophotometry.

(ii) Solvent extraction of zirconium with amberlite LA-1, separation from a mixture of irons and gallium.

3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

5. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

6. Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

### **III Spectrophotometry**

1. Determination of pKa values of indicator using spectrophotometry.

2. Structural characterization of compounds by infrared spectroscopy.

3. Determination of dissolved oxygen in water.

4. Determination of chemical oxygen demand (COD).

5. Determination of Biological oxygen demand (BOD).

6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

### **Reference Books:**

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.

7. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

**Course code:** CH 310  
**Course title:** Industrial Chemicals and Environment Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. V  
**Branch:** Chemistry  
**Name of Teacher:**

## **Syllabus**

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ( $\text{AgNO}_3$  and potassium chromate).
6. Estimation of total alkalinity of water samples ( $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ) using double titration method.
7. Measurement of dissolved  $\text{CO}_2$ .
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

## **Reference Books:**

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.



**Course code: CH 311**

**Course title: Lab: Inorganic Materials of Industrial Importance**

**Pre-requisite(s): Intermediate level chemistry**

**Co- requisite(s):**

**Credits: 2      L: 0      T: 0      P: 2**

**Class schedule per week: 04**

**Class: I. M. Sc.**

**Semester / Level: I. M. Sc. V**

**Branch: Chemistry**

**Name of Teacher:**

## **Syllabus**

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn ) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

## **Reference Books:**

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

**Course code:** CH 312

**Course title:** Lab: Molecular Modelling & Drug Design

**Pre-requisite(s):** Intermediate level chemistry

**Co- requisite(s):**

**Credits:** 2      L: 0      T: 0      P: 4

**Class schedule per week:** 04

**Class:** I. M. Sc.

**Semester / Level:** I. M. Sc. V

**Branch:** Chemistry

**Name of Teacher:**

## Syllabus

i. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene.

Visualize the molecular orbitals of the ethane  $\sigma$  bonds and ethene, ethyne, benzene and pyridine  $\pi$  bonds.

ii. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans* 2-butene.

iii. Visualize the electron density and electrostatic potential maps for LiH, HF, N<sub>2</sub>, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules.

iv. (a) Relate the charge on the hydrogen atom in hydrogen halides with their acid character. (b) Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine.

v. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 °C, 100 °C, 108 °C, 82 °C, respectively).

vi. Build and minimize organic compounds of your choice containing the following functional groups. Note the dipole moment of each compound: (a) alkyl halide (b) aldehyde (c) ketone (d) amine (e) ether (f) nitrile (g) thiol (h) carboxylic acid (i) ester (j) amide.

vii. (a) Determine the heat of hydration of ethylene. (b) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.

viii. Arrange 1-hexene, 2-methyl-2-pentene, (*E*)-3-methyl-2-pentene, (*Z*)-3-methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.

ix. (a) Compare the optimized bond angles H<sub>2</sub>O, H<sub>2</sub>S, H<sub>2</sub>Se. (b) Compare the HAH bond angles for the second row dihydrides and compare with the results from qualitative MO theory.

*Note:* Software: ChemSketch, ArgusLab ([www.planaria-software.com](http://www.planaria-software.com)), TINKER 6.2 ([dasher.wustl.edu/ffe](http://dasher.wustl.edu/ffe)), WebLab Viewer, Hyperchem, or any similar software.

## Reference Books:

1. A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
2. J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
3. Gupta, S.P. QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008.

**Course code:** CH 313  
**Course title:** Inorganic Chemistry-IV  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To learn the basic principles of qualitative inorganic analysis
B.	To learn the basic organometallic chemistry
C.	To study the basics of inorganic reaction mechanism

### Course Outcomes

After the completion of this course, students will be:

1.	Able to find the experimental techniques for qualitative inorganic analysis
2.	Able to explain the basic organometallic chemistry
3.	To predict the mechanism of some basic inorganic reactions

### Syllabus

#### Module I: Theoretical Principles in Qualitative Analysis (H<sub>2</sub>S Scheme) (9 Lectures)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

#### Module II: Organometallic Compounds I (9 Lectures)

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.  $\pi$ -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

#### Module III: Organometallic Compounds II (9 Lectures)

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler-Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

#### Module IV: Reaction Kinetics and Mechanism (9 Lectures)

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

#### Module V: Catalysis by Organometallic Compounds (9 Lectures)

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes

**Text books:**

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996.
2. Cotton, F. A. G.; Wilkinson & Gaus, P.L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
3. Huheey, J. E.; Keiter, E. A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
4. Sharpe, A.G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
5. Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry 3rd Ed., John Wiley and Sons, NY, 1994.
6. Greenwood, N.N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
7. Lee, J.D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008.
8. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
9. Shriver, D.D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
10. Basolo, F. & Pearson, R. Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed., John Wiley & Sons Inc; NY.

**Reference books:**

1. Purcell, K.F. & Kotz, J.C., Inorganic Chemistry, W.B. Saunders Co. 1977
2. Miessler, G. L. & Tarr, D.A. Inorganic Chemistry 4th Ed., Pearson, 2010.
3. Collman, J. P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
4. Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.
5. Spessard, G. O. & Miessler, G.L. Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall, 1996.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Mid Sem	25
Assignment	5
Two Quizzes	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Mid Sem	√	√	
Quiz –I	√		
Quiz II			√
End Sem Examination Marks	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	M	M	L
CO3	H	H	H	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3,	CD1
CD2	Tutorials/Assignments	CO1, 2, 3,	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3,	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3,	CD6
CD7	Simulation	CO2	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-4</b>	L1-L09	<b>1</b>	Theoretical Principles in Qualitative Analysis	<b>T1, T2 T3,R1</b>	<b>1,2</b>	<b>PPT Digi Class/Chalk- Board</b>
<b>5-6</b>	L10-L18	<b>2</b>	Organometallic Compounds I	<b>T1,T3 R1,R2</b>	<b>1,2</b>	<b>-do-</b>
<b>7-9</b>	L19-L27	<b>3</b>	Organometallic Compounds II	<b>T1,T2,R3</b>	<b>3,4</b>	<b>-do-</b>
<b>9-13</b>	L28-L36	<b>4</b>	Reaction Kinetics and Mechanism	<b>T9, T10</b>	<b>4</b>	<b>-do-</b>
<b>14-16</b>	L37-L45	<b>5</b>	Catalysis by Organometallic Compounds	<b>T10, R5</b>	<b>5</b>	<b>-do-</b>

**Course code:** CH 314  
**Course title:** Organic Chemistry-V  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand about working principles of different characterization techniques used in the structure elucidation of the organic molecules
B.	To learn about the carbohydrates and their classification, synthesis and biological activities
C.	To know about the different dyes and their structures and application
D.	To know about various polymers and polymerization processes and their applications

### Course Outcomes

After the completion of this course, students will be:

1.	To deduce the structure of the organic molecules from given spectroscopic data
2.	To understand the carbohydrates and their biological activities
3.	To understand the dyes and dyeing processes
4.	To calculate the molecular weights of the polymers
5.	To understand the nature and application of plastics and fibres

## Syllabus

### Module I: Organic Spectroscopy

(10 Lectures)

General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions,  $\lambda_{\max}$ , Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of  $\lambda_{\max}$  for the following systems:  $\alpha,\beta$  unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between *cis* and *trans* isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

Applications of IR, UV and NMR for identification of simple organic molecules.

### Module II: Carbohydrates

(8 Lectures)

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation;

Disaccharides – Structure elucidation of maltose, lactose and sucrose.

Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

### Module III: Dyes

(7 Lectures)

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

#### **Module IV: Polymers I**

**(11 Lectures)**

Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.

Polymerisation reactions- Addition and condensation- Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene);

#### **Module V: Polymers II**

**(9 Lectures)**

Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers– natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

#### **Text books:**

1. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
4. Solomons, G. T.W. Organic Chemistry, John Wiley & Sons, Inc.
5. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Prakashan (2010).
6. Kemp, W. Organic Spectroscopy, Palgrave.

#### **Reference books:**

1. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
3. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
4. Pavia, D. L. et al. Introduction to Spectroscopy 5th Ed. Cengage Learning India Ed., 2015.
5. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets



**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem	√	√			
Quiz –I	√				
Quiz II			√	√	
End Sem Examination Marks	√	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	H	L
CO3	H	H	M	L
CO4	M	M	H	L
CO5	M	H	H	L

### Mapping between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4, 5	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3, 5	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4, 5	CD6
CD7	Simulation	CO2, 4, 5	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-5	L1-L09	11	Organic Spectroscopy	T6,T1, T2 R3,R1	1,2	PPT Digi Class/Chock-Board
5-7	L10-L18	13	Carbohydrates	T1,T2, R2,R1	2	-do-
7-9	L19-L27	3	dyes	T3,T1,T2,R3,R5	4	-do-
9-13	L28-L36	4	Polymer I	T3,T1,T2,R3	5	-do-
13-15	L37-L45	5	Polymer II	T3,T1,R2,R3	6	-do-

**Course code:** CH 315  
**Course title:** Applications of Computers in Chemistry  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 4      T: 0      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

### **Module I: Basics:** (9 Lectures)

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions.

### **Module II: Elements of the BASIC language:** (9 Lectures)

BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.

### **Module III: Numerical methods:** (9 Lectures)

Roots of equations: Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.  
Differential calculus: Numerical differentiation.

### **Module IV: Integral calculus:** (9 Lectures)

Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values.  
Simultaneous equations: Matrix manipulation: addition, multiplication. Gauss-Siedal method.  
Interpolation, extrapolation and curve fitting: Handling of experimental data.

### **Module V: Conceptual background of molecular modelling:** (9 Lectures)

Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

### **Reference Books:**

1. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
2. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
3. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co. (1985).
4. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi (1996).

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

**Course code:** CH 316  
**Course title:** Novel Inorganic Solids  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand synthesis and modification of inorganic solids
B.	To know Inorganic solids of technological importance
C.	To know about nano materials
D.	To know about engineering and composite materials

### Course Outcomes

After the completion of this course, students will be:

1.	To carry out synthesis and modification of inorganic solids
2.	To characterise and analyse Inorganic solids of technological importance
3.	To understand nano materials
4.	To characterise engineering and composite materials

### Syllabus

#### **Module I: Synthesis and modification of inorganic solids: (9 Lectures)**

Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydrothermal method, Ion-exchange and Intercalation methods.

#### **Module II: Inorganic solids of technological importance: (9 Lectures)**

Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments.

Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.

#### **Module III: Nanomaterials: (9 Lectures)**

Overview of nanostructures and nanomaterials: classification.

Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

Bio-inorganic nanomaterials, DNA and nanomaterials, natural and antisocial nanomaterials, bionano composites.

#### **Module IV: Introduction to engineering materials for mechanical construction: (9 Lectures)**

Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

#### **Module V: Composite materials & Speciality polymers: (9 Lectures)**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites,

fibre-reinforced composites, environmental effects on composites, applications of composites.

Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrrole, applications of conducting polymers, Ion-exchange resins and their applications. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

#### Reference Books:

1. Shriver & Atkins. Inorganic Chemistry, Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)
2. Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry. John Wiley & Sons, 1974.
3. Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley & Sons, 2003.
4. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

##### Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem	25
Assignment	05
Two Quiz	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz -1	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	H	L	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Synthesis and modification of inorganic solids	T1, T2, R1,R2	1	PPT Digi Class/Chock -Board
4-6	L10-L18	2	Inorganic solids of technological importance	T1, R1,R2	2	-do-
7-10	L19-L27	3	Nanomaterials	T1, R1,R2	3	-do-
11-13	L28-L36	4	Introduction to engineering materials for mechanical construction	T1, T2, R2	4	-do-
14-15	L37-L45	5	Composite materials & Speciality polymers	T1, T2, R1	4	-do-

**Course code:** CH 317

**Course title:** Polymer Chemistry

**Pre-requisite(s):** Intermediate level chemistry

**Co- requisite(s):**

**Credits:** 4      L: 3      T: 1      P: 0

**Class schedule per week:** 04

**Class:** I. M. Sc.

**Semester / Level:** I. M. Sc. VI

**Branch:** Chemistry

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To know about the type of polymers and their functionalities
B.	To learn the polymerization techniques
C.	To know the theory of polymer solution
D.	To know about the properties of polymers

### Course Outcomes

After the completion of this course, students will be:

1.	Able to classify polymers based on its structure and functionality
2.	Able to explain the mechanism of polymer synthesis
3.	Able to explain the thermodynamic properties of polymer solution
4.	Able to explain thermal, electrical and mechanical properties polymer

### Syllabus

#### **Module I: Polymeric materials, its functionality and importance:**

**(9 Lectures)**

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems.

#### **Module II: Kinetics of Polymerization:**

**(9 lectures)**

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

#### **Module III: Nature and structural properties of polymers:**

**(9 Lectures)**

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Structure Property relationships.

( $M_n$ ,  $M_w$ , etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

Glass transition temperature ( $T_g$ ) and determination of  $T_g$ , Free volume theory, WLF equation, Factors affecting glass transition temperature ( $T_g$ ).

#### **Module IV: Polymer Solution**

**(8 Lectures)**

Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

**Module V: Properties of Polymers (Physical, thermal, Flow & Mechanical Properties)****(10 Lectures)**

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

**Reference Books:**

1. R. B. Seymour & C.E. Carraher: Polymer Chemistry: An Introduction, Marcel Dekker, Inc. New York, 1981.
2. G. Odian: Principles of Polymerization, 4th Ed. Wiley, 2004.
3. F.W. Billmeyer: Textbook of Polymer Science, 2nd Ed. Wiley Interscience, 1971.
4. P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill Education, 1991.
5. R.W. Lenz: Organic Chemistry of Synthetic High Polymers. Interscience Publishers, New York, 1967.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Mid Sem	25
Assignment	05
Two Quiz	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz -I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√



**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	H	L	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Polymeric materials, its functionality and importance	T1, T2, R1,R2	1	PPT Digi Class/Chock -Board
4-5	L10-L18	2	Kinetics of Polymerization	T1, R1,R2	2	-do-
6-11	L19-L27	3	Nature and structural properties of polymers	T1, R1,R2	1	-do-
11-13	L28-L36	4	Polymer Solution	T1, T2, R2	3	-do-
13-15	L37-L45	5	Properties of Polymers (Physical, thermal, Flow &Mechanical Properties)	T1, T2, R1	4	-do-

**Course code:** CH 318  
**Course title:** Instrumental Methods of Chemical Analysis  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To know about different type of spectroscopic method of analysis
B.	To learn about sample separation techniques
C.	To know the techniques of elemental analysis
D.	To know the principle of NMR, X-ray and electron spectroscopic analysis and theory of potentiometry & voltammetry

### Course Outcomes

After the completion of this course, students will be:

1.	Able to analysis the property of sample applying UV-Vis, IR spectroscopic data
2.	Able to identify samples from their mass spectra and chromatographic analysis
3.	Able to explain the origin of atomic spectrum of elements
4.	Able to use the electroanalytical and X-ray data for structure elucidation

## Syllabus

### Module I: Introduction to spectroscopic methods of analysis: (9 Lectures)

Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation.

#### *Infrared spectroscopy:*

Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.

*UV-Visible/ Near IR* – emission, absorption, fluorescence and photoacoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoacoustic, fluorescent tags).

### Module II: Separation techniques (9 Lectures)

*Chromatography:* Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and

liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.

*Immunoassays and DNA techniques*

*Mass spectroscopy:* Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

**Module III: Elemental analysis**

**(9 Lectures)**

Mass spectrometry (electrical discharges).

Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence.

Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

**Module IV: NMR spectroscopy:**

**(9 Lectures)**

Principle, Instrumentation, Factors affecting chemical shift, Spin-coupling, Applications.

**Module V: Other Methods of Analysis:**

**(9 Lectures)**

Electroanalytical Methods: Potentiometry & Voltammetry

Radiochemical Methods, X-ray analysis and electron spectroscopy (surface analysis)

**Reference books:**

1. D. A. Skoog, F. J. Holler & S. Crouch (ISBN0-495-01201-7) Principles of Instrumental Analysis, Cengage Learning India Edition, 2007.
2. Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, 7th ed, IBH Book House, New Delhi.
3. Atkins, P. W & Paula, J. D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
4. Kakkar, R. Atomic and Molecular Spectroscopy: Concepts and Applications. Cambridge University Press, 2015.
5. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
6. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
7. Smith, B. C. Infrared Spectral Interpretations: A Systematic Approach. CRC Press, 1998.
8. Moore, W.J., Physical Chemistry Orient Blackswan, 1999.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Mid Sem	25
Assignment	05
Two Quiz	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz -1	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	H	L	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-5</b>	L1-L09	<b>1</b>	Introduction to spectroscopic methods of analysis	<b>T1, T2, R1,R2</b>	<b>1</b>	<b>PPT Digi Class/Chock -Board</b>
<b>5-9</b>	L10-L18	<b>2</b>	Separation techniques	<b>T1, R1,R2</b>	<b>2</b>	<b>-do-</b>
<b>10-11</b>	L19-L27	<b>3</b>	Elemental analysis	<b>T1, R1,R2</b>	<b>3</b>	<b>-do-</b>
<b>11-12</b>	L28-L36	<b>4</b>	NMR spectroscopy	<b>T1, T2, R2</b>	<b>4</b>	<b>-do-</b>
<b>13-15</b>	L37-L45	<b>5</b>	Other methods of sampleanalysis	<b>T1, T2, R1</b>	<b>4</b>	<b>-do-</b>

**Course code:** CH 319  
**Course title:** Inorganic Chemistry-IV Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

$\text{CO}_3^{2-}$ ,  $\text{NO}_2^-$ ,  $\text{S}^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{S}_2\text{O}_3^{2-}$ ,  $\text{CH}_3\text{COO}^-$ ,  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{NO}_3^-$ ,  $\text{BO}_3^{3-}$ ,  $\text{C}_2\text{O}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{NH}_4^+$ ,  $\text{K}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Bi}^{3+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Sb}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$

Mixtures should preferably contain one interfering anion, or insoluble component ( $\text{BaSO}_4$ ,  $\text{SrSO}_4$ ,  $\text{PbSO}_4$ ,  $\text{CaF}_2$  or  $\text{Al}_2\text{O}_3$ ) or combination of anions e.g.  $\text{CO}_3^{2-}$  and  $\text{SO}_3^{2-}$ ,  $\text{NO}_2^-$  and  $\text{NO}_3^-$ ,  $\text{Cl}^-$  and  $\text{Br}^-$ ,  $\text{Cl}^-$  and  $\text{I}^-$ ,  $\text{Br}^-$  and  $\text{I}^-$ ,  $\text{NO}_3^-$  and  $\text{Br}^-$ ,  $\text{NO}_3^-$  and  $\text{I}^-$ .

Spot tests should be done whenever possible.

- Measurement of 10 Dq by spectrophotometric method
- Verification of spectrochemical series.
- Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
- Preparation of acetylacetonato complexes of  $\text{Cu}^{2+}/\text{Fe}^{3+}$ . Find the  $\lambda_{\text{max}}$  of the complex.
- Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

## Reference Books:

- Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla. Pearson Education, 2002.
- Marr & Rockett Practical Inorganic Chemistry. John Wiley & Sons 1972.

**Course code:** CH 320  
**Course title:** Organic Chemistry-V Lab  
**Pre-requisite(s):** Intermediate level Chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P:3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

## **Syllabus**

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

## **Reference Books:**

1. Vogel, A. I. Quantitative Organic Analysis, Part 3, Pearson (2012).
2. Mann, F. G. & Saunders, B. C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B. S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
4. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
5. Ahluwalia, V. K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

**Course code:** CH 321  
**Course title:** Lab: Applications of Computers in Chemistry  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

## **Syllabus**

Computer programs based on numerical methods for

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.
5. Simple exercises using molecular visualization software.

### **Reference Books:**

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
4. Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
5. Harris, D. C. Quantitative Chemical Analysis. Chapters 3-5, 6th Ed., Freeman (2007).
6. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, 487 pages, Cambridge Univ. Press (2001).
7. Noggle, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).
8. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi (1996).



**Course code: CH 322**

**Course title: Lab: Novel Inorganic Solids**

**Pre-requisite(s): Intermediate level chemistry**

**Co- requisite(s):**

**Credits: 1.5    L: 0    T: 0    P: 3**

**Class schedule per week: 03**

**Class: I. M. Sc.**

**Semester / Level: I. M. Sc. VI**

**Branch: Chemistry**

**Name of Teacher:**

### **Syllabus**

1. Determination of cation exchange method
2. Determination of total difference of solids.
3. Synthesis of hydrogel by co-precipitation method.
4. Synthesis of silver and gold metal nanoparticles.

### **Reference Book:**

1. Fahlman, B. D. Materials Chemistry, Springer, 2004.

**Course code:** CH 323  
**Course title:** Polymer Chemistry Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 03  
**Class:** I. M. Sc.  
**Semester / Level:** I. M. Sc. VI  
**Branch:** Chemistry  
**Name of Teacher:**

## **Syllabus**

### **1. Polymer synthesis**

1. Free radical solution polymerization of styrene (St)/Methyl Methacrylate (MMA)/Methyl Acrylate (MA)/Acrylic acid (AA).
  - a. Purification of monomer
  - b. Polymerization using benzoyl peroxide (BPO)/2,2'-azo-bis-isobutyronitrile (AIBN)
2. Preparation of nylon 66/6
  1. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
  - a. Preparation of IPC
  - b. Purification of IPC
  - c. Interfacial polymerization
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

### **Polymer characterization**

1. Determination of molecular weight by viscometry:
  - (a) Polyacrylamide-aq. NaNO<sub>2</sub> solution
  - (b) (Polyvinyl propylidene (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

### **Polymer analysis**

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis

**NOTE:** At least 7 experiments to be carried out.

### **Reference Books:**

1. M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press, 1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
3. F.W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)

4. J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
5. P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
6. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
7. M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005).
8. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

**Course code: CH 324**

**Course title: Lab: Instrumental Methods of Chemical Analysis**

**Pre-requisite(s): Intermediate level chemistry**

**Co- requisite(s):**

**Credits: 1.5    L: 0    T: 0    P: 3**

**Class schedule per week: 03**

**Class: I. M. Sc.**

**Semester / Level: I. M. Sc. VI**

**Branch: Chemistry**

**Name of Teacher:**

## **Syllabus**

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/ Ferricyanide Couple
14. Nuclear Magnetic Resonance
15. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids.
16. Use of "presumptive tests" for anthrax or cocaine
17. Collection, preservation, and control of blood evidence being used for DNA testing
18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome)
19. Use of sequencing for the analysis of mitochondrial DNA
20. Laboratory analysis to confirm anthrax or cocaine
21. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
22. Detection of illegal drugs or steroids in athletes
23. Detection of pollutants or illegal dumping
24. Fibre analysis

**Note: At least 10 experiments to be performed.**

## **Reference Books:**

1. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.

**Integrated M. Sc. Chemistry (Semester VII- X<sup>th</sup>)  
and M.Sc. Chemistry (Semester I-IV<sup>th</sup>)**

**Course code: CH 401**

**Course title: Inorganic Chemistry-V: Basic Inorganic Chemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co- requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. I/ I. M. Sc. VII**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To know about the chemical bonding quantum mechanically
B.	To understand the reaction mechanism of coordination complexes
C.	To understand the principle of electronic spectroscopy
D.	To study the experimental spectrum

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the chemical bonding by quantum mechanics
2.	Able to explain the kinetics in coordination complexes
3.	Able to explain the principle of electronic absorption
4.	Able to interpret the experimental spectrum

## Syllabus

### Module I: Chemical Bonding: Valency Theories- Quantum Chemical Approach (9 Lectures)

Huckel approximation applied to  $H_2^+$  and  $H_2$  type systems, comparative study of the application of VB and MO methods to diatomic (homo and hetero) species; MO of polyatomic molecules; Walsh diagram, configuration interaction, orbital construction for  $Hn$  type systems, localized and delocalized M.O.,  $\sigma$ ,  $\pi$ ,  $\delta$  bonds, polyatomic molecules, electron deficient and hypervalent molecules.

### Module II: Quantitative basis of Crystal Fields

(9 Lectures)

Crystal Field Theory, The octahedral Crystal Field potential, The effect of  $V_{oct}$  on the  $d$  wave-functions, the evaluation of  $\Delta$ , The tetrahedral and cubic potentials. Energy level of transition metal ions, Effect of ligands fields on the energy levels of transition metal ions.

### Module III: Reaction Mechanism of Transition Metal Complexes

(9 Lectures)

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valency bond and crystal field theory, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, substitution reaction in square complexes, trans effect, redox reactions, electron transfer reactions, mechanism of one electron transfer reaction, outer sphere type reactions, inner sphere type reactions.

### Module IV: Introduction to electronic Spectra of transition metal complexes (9 Lectures)

Important features of transition metal electronic spectra- band intensities, band energies, band width and sets; characteristic spectra of complexes of first row transition metal ions, Octahedral, tetrahedral and square planar complexes of first row transition metal ions; Effect of temperature on electronic bands, Spectrochemical & Nephelauxetic series.

### Module V: Theoretical basis of Electronic Spectra of transition metal complexes (9 Lectures)

Spectroscopic ground state, Orgel and Tanabe-Sugano diagrams for transition metal complexes, calculations of  $D_q$ , B and beta parameters, Charge transfer spectra: Intraligand charge transfer spectra,

Metal to ligand charge transfer spectra, Ligand to metal charge transfer spectra Absorption spectra of *f*-block elements.

**Text books:**

1. G. Wulfsberg, Inorganic Chemistry, University Science Books, 2000.
2. C. J. Ballhausen & H. B. Gray, Molecular Orbital Theory, W.A. Benjamin, 1978.
3. F. Basolo & R. G. Pearson, Inorganic Reaction Mechanism, 2nd ed., John Wiley & Sons Inc., 1967.
4. A. B. P. Lever, Inorganic Electronic Spectroscopy, Elsevier, 1984.

**Reference books:**

1. B. N. Figgis and M. A. Hitchman, Ligand Field Theory and its Applications, Wiley–VCH, New York, 2000.
2. I. B. Bersuker, Electronic Structure and Properties of transition metal compounds, 2nd ed., Wiley, 2010.
3. C. J. Ballhausen, Introduction to Ligand Field Theory, McGraw-Hill Inc., 1962.
4. R. B. Jordon, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd ed., Oxford University Press, 2007.
5. D. N. Sathyanarayana, Electronic Absorption Spectroscopy, Universities Press, 2001.
6. E. A. B. Ebsworth, D. W. H. Rankin, S. Cardock, Structural Methods in Inorganic Chemistry; 2nd ed., Wiley-Blackwell, 1991.
7. A. K. Das, M. Das, Fundamental Concepts of Inorganic Chemistry; Volume-1-5; CBS Publishers, 2012.
8. R Sarkar, General and Inorganic Chemistry- Volume-I and Volume-II, 3rd revised ed., New Central Book Agency, 2011.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	M	M	L
CO3	H	H	H	M
CO4	M	H	H	M

**Mapping between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7



**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	L1-L09	<b>1</b>	Chemical Bonding: Valency Theories- Quantum Chemical Approach	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock -Board</b>
<b>4-6</b>	L10-L18	<b>2</b>	Quantitative basis of Crystal Field Theory	<b>T2, R2</b>	<b>2</b>	<b>-do-</b>
<b>7-9</b>	L19-L27	<b>3</b>	Reaction mechanism of Transition metal complexes	<b>T1, R1</b>	<b>3</b>	<b>-do-</b>
<b>10-12</b>	L28-L36	<b>4</b>	Introduction to Electronic spectra	<b>T1, R4</b>	<b>3</b>	<b>-do-</b>
<b>13-15</b>	L37-L45	<b>5</b>	Theory-electronic spectra	<b>T1, R3</b>	<b>4</b>	<b>-do-</b>

**Course code: CH 402**

**Course title: Physical Chemistry-VI: Chemical Kinetics & Surface Chemistry**

**Pre-requisite(s): B.Sc. (H) Chemistry**

**Co-requisite(s):**

**Credits: 3      L: 3      T: 0      P: 0**

**Class schedule per week: 03**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. I/ I. M. Sc. VII**

**Branch: Chemistry**

**Name of Teacher:**

**Course Objectives**

This course enables the students:

A.	To apply the knowledge of chemical kinetics for very fast reactions, photophysical, photochemical and surface processes.
B.	To apply theories and concept of electrochemistry to study electrode kinetics.
C.	To develop concepts on photophysical and photochemical processes.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to solve problems on rate/rate constants/efficiency for complex reactions and electronically excited state dynamics.
2.	Able to understand the mechanism of chemical reactions for optimizing the experimental conditions and apply homogeneous and heterogeneous catalysis in chemical synthesis.
3.	Able to calculate electrochemical cell parameters, current and overpotential under given condition, amount of corrosion and its rate and plot potential vs current, surface coverage vs. potential, potential vs. pH, concentration profile vs. distance from the electrode.
4.	Able to explain the mechanism of fluorescence and phosphorescence.
5.	Able to understand the importance of adsorption process and its application.
6.	Able to develop the concept of colloidal material and their stability for many practical uses.

## Syllabus

### Module I: Chemical Reaction Dynamics

**(10 lectures)**

Introduction to reaction kinetics; Temperature dependence of reaction rate: Linear and non-linear Arrhenius equation, Interpretation of Arrhenius parameters; Theories of reaction rates: Collision theory and Activated complex theory (ACT) thermodynamic treatment of bimolecular gaseous reactions (Eyring equation). Theories of unimolecular gaseous reactions: Lindemann-Hinshelwood, RRK and RRKM theories. Kinetics of reactions in solution. Kinetics of fast reactions: Relaxation method, Flow methods, Pulse methods, flash photolysis. Molecular reaction dynamics, potential energy surfaces. Electron transfer reactions. Heterogeneous catalysis: Kinetics of surface reactions unimolecular and bimolecular. Autocatalysis and oscillatory reactions.

### Module II: Electrochemistry

**(10 lectures)**

Debye-Hückel theory of ion-ion interaction and activity coefficient, Applicability and limitations of Debye-Hückel limiting law, its modification, Effect of ion-solvent interaction on activity coefficient. Debye-Hückel-Onsager theory of conductance of electrolyte solution: Its applicability and limitations. Thermodynamic treatment of electrified interfaces, Introduction to electrical double layer, Introduction to electrode kinetics: Butler-Volmer equation, polarography, cyclic voltammetry, corrosion, fuel cells.

### Module III: Photochemistry

**(10 lectures)**

Consequences of light absorption; Kinetics of photochemical reactions:  $\text{H}_2\text{-Br}_2$ ,  $\text{H}_2\text{-Cl}_2$  & decomposition of HI. The Jablonski diagram. Potential energy diagram, Franck-Condon principle. Photophysical processes: fluorescence emission, triplet states and phosphorescence emission, delayed fluorescence.

Measurement of emission characteristics—fluorescence, phosphorescence, and chemiluminescence. Photophysical kinetics of unimolecular processes. Bimolecular collisions in gases and vapours and the mechanism of fluorescence quenching. Kinetics of collisional quenching: Stern-Volmer equation. Techniques for the study of transient species in photochemical reactions. Actinometry, Lasers in photochemical kinetics.

**Module IV: Surface Chemistry:**

**(9 lectures)**

Adsorption by solids-Types and applications. Adsorption of gases by solids. Adsorption isotherms: Freundlich and Langmuir adsorption isotherms, BET theory of multilayer adsorption, Types of adsorption isotherms. Adsorption from solution: Gibbs adsorption isotherm. Modern techniques for investigating surfaces.

**Module V: Colloidal States:**

**(6 lectures)**

Basics of colloidal states, electrical and electrokinetic properties, Micelles: Surface active agents, Classifications, micellization, hydrophobic interaction, CMC, factors affecting the CMC surfaces, counter ion binding, Thermodynamics of micellization-phase separation, solubilization, Micro-emulsion, Reverse micelles

**Text books:**

1. P. Atkins and J. Paula, Physical Chemistry, 10th ed., Oxford University Press, Oxford, 2014.
2. K. J. Laidler, Chemical Kinetics, 3rd ed., Harper & Row, New York, 1998.
3. J. O'M. Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol. 2, 2nd ed., Plenum Press, New York, 1998.
4. K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age International Pvt. Ltd.; 3rd ed., New Delhi, 2014.
5. A. W. Adamson and A. P. Gast, Physical Chemistry of Surfaces, 5th ed., Wiley, 1997.

**Reference books:**

1. M. R. Wright, An introduction to chemical kinetics, 1st ed., Wiley, 2005.
2. I. N. Levine, Physical Chemistry, 5th ed., 2002.
3. M. J. Pilling and A. P.W, Seakins, Reaction Kinetics, Oxford Science Publication, New York, 1998.
4. J. G. Calvert and J. N. Pitts, Jr., Photochemistry, John Wiley & Sons, New York, 1966.
5. R. P. Wayne, Principles and Applications of Photochemistry, Oxford University Press, Oxford, 1988.
6. J. I. Steinfeld, J. S. Francisco, W. L. Hase, Chemical Kinetics and Dynamics, 2nd ed., Pearson, 1998.
7. M. Satake, S. A. Iqbal, Colloidal & Surface Chemistry, Discovery Publishing Pvt. Ltd, 2003.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Assignment	√	√	√	√		
Quiz –I	√	√				
Quiz II			√	√	√	
End Sem Examination Marks	√	√	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L
CO5	M	H	M	L
CO6	M	H	M	L

**Mapping of Course Outcomes onto Program Outcomes:**

<b>Mapping Between COs and Course Delivery (CD) methods</b>			
<b>CD</b>	<b>Course Delivery methods</b>	<b>Course Outcome</b>	<b>Course Delivery Method</b>
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4, 5, 6	CD1
CD2	Tutorials/Assignments	CO2, 3, 4, 5, 6	CD1, 2
CD3	Seminars	CO3, 4	CD3
CD4	Mini projects/Projects	CO1, 2, 3, 4, 5	CD4
CD5	Laboratory experiments/teaching aids	CO2, 3	CD5
CD6	Industrial/guest lectures	CO4	CD6, 7
CD7	Self- learning such as use of NPTEL materials and internet	CO1, 2, 3, 4, 5, 6	CD7
CD8	Simulation	CO1 ,2	CD8

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-4</b>	<b>L1-L12</b>	<b>1</b>	Dynamics of Chemical Reactions	<b>T1, T2, R1</b>	<b>1,2</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-7</b>	<b>L13-L20</b>	<b>2</b>	Theory of Ion Transport	<b>T3, R2</b>	<b>3</b>	<b>-do-</b>
<b>7-10</b>	<b>L21-L32</b>	<b>3</b>	Photophysical and Photochemical Processes	<b>T4, R4</b>	<b>4</b>	<b>-do-</b>
<b>11-13</b>	<b>L33-L41</b>	<b>4</b>	Surface Science and its Applications	<b>T1, T5, R7</b>	<b>5</b>	<b>-do-</b>
<b>14-15</b>	<b>L42-L45</b>	<b>5</b>	Colloidal States of the matter	<b>T5, R7</b>	<b>6</b>	<b>-do-</b>

**Course code:** CH 403  
**Course title:** Reaction Mechanisms in Organic Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. I/ I. M. Sc. VII  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the physico-chemical factors affecting the course and outcome of an organic reaction
B.	To understand the different types of organic reactions operating on the aliphatic and aromatic systems

### Course Outcomes

After the completion of this course, students will be:

1.	To learn the various concepts of acids and bases, stereoelectronic effects, reactive intermediates and types of organic chemical reactions
2.	To understand the mechanisms of different types of substitution reactions operating on the aliphatic and aromatic systems
3.	To understand the mechanisms of elimination and addition reactions operating on the organic substrates
4.	To apply the influence of stereo-electronic effects on the course of a reaction from unimolecular to bimolecular or intra-molecular suitable for some particular types of substrate
5.	To differentiate the paths followed by aromatic and aliphatic substrates in a nucleophilic substitution reaction
6.	To analyse the conditions favoring the substitution and elimination pathway followed by a particular substrate

## Syllabus

### Module I: Fundamentals of Reaction Mechanism

[9 Lectures]

Acids and bases; nucleophile and electrophile, basicity vs nucleophilicity; Resonance and aromaticity- Huckel's rule for aromaticity in benzenoid and non-benzenoid compounds, antiaromaticity and homo-aromaticity, breaking and formation of bond, electronic effect: inductive, hyperconjugation, mesomerism and steric effect; reactive intermediates: generation, stability and fate of carbocation, carbanion, free radical, carbene and nitrene.

### Module II: Aliphatic substitution reactions

[12 Lectures]

Nucleophilic substitution: The  $S_N2$ ,  $S_N1$ , mixed  $S_N1$  and  $S_N2$  and SET mechanisms, neighbouring group participation by pi and sigma bonds, anchimeric assistance, The  $S_{Ni}$  mechanism, Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon, Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium; Electrophilic bimolecular mechanism- $S_E2$  and  $S_{Ei}$ : The  $S_{E1}$  mechanism, electrophilic substitution accompanied by double bond shift, effect of substrates, leaving group and the solvent polarity on the reactivity.

### Module III: Aromatic substitution reactions

[6 Lectures]

The arenium ion mechanism, orientation and reactivity, energy profile diagrams, The *ortho/para* ratio, ipso attack, Diazonium coupling, Vilsmeier reaction, Gattermann-Koch reaction, The  $S_{NAr}$ ,  $S_{N1}$ , benzyne and  $S_{RN}1$  mechanisms, Reactivity-effect of substrate structure, leaving group and attacking nucleophile, The Von Richter, Sommelet-Hauser, Smiles Rearrangement.

**Module IV: Addition and Elimination Reactions****[9 Lectures]**

Mechanism and stereochemical aspects of addition reaction in carbon-carbon and carbon-hetero multiple bonds, regio- and chemoselectivity, orientation and reactivity, Mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Perkin and Stobbe reactions.

The E2, E1 and E1cB mechanism and their spectrum, orientation of the double bond, Reactivity- effect of substrates structure, attacking base, the leaving group and the medium, Mechanism and orientation in pyrolytic elimination.

**Module V: Rearrangement Reaction****[9 Lectures]**

General Mechanistic considerations – nature of migration, migratory aptitude, A detailed study of the following rearrangements involving carbonation (Wagner-Meerwein, Pinacol-Pinacolone rearrangement), reaction involving acyl cation, PPA cyclization and Fries rearrangement, rearrangement of carbenes (Wolff & Arndt-Eistert synthesis), rearrangement of nitrenes (Hoffman, Curtius, Schmidt, Lossen, Beckman rearrangement).

**Text books:**

1. I. L. Finar, Organic Chemistry, Vol. I and II, 5th ed., Longman Ltd., New Delhi, 2011.
2. P. Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th ed., John Wiley & Sons, New York, 1985.
3. T. W. G. Solomons, Fundamentals of Organic Chemistry, 4th ed., John Wiley, 1994.
4. R. N. Morrison & R. N. Boyd, Organic Chemistry, 7th ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2010.

**Reference books:**

1. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 2nd ed., Oxford Press, 2012,
2. J. March, Organic reaction and mechanism-structure and reactivity, 7th ed., John Wiley, 2015.
3. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, Springer, New York, 2006.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Assignment	√	√	√	√	√	
Quiz –I	√	√	√			
Quiz II				√	√	
End Sem Examination Marks	√	√	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L
CO5	M	H	M	L
CO6	M	H	M	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4,5,6	CD1
CD2	Tutorials/Assignments	CO1, 2, 3,	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3,5	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4, 5	CD7



**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Fundamentals of reaction mechanism	<b>T1, T2, R1</b>	<b>1,2</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-7</b>	<b>L10-L21</b>	<b>2</b>	Aliphatic substitution reaction	<b>T3, R2</b>	<b>3</b>	<b>-do-</b>
<b>8-9</b>	<b>L22-L27</b>	<b>3</b>	Aromatic substitution reaction	<b>T4, R3</b>	<b>4</b>	<b>-do-</b>
<b>10-12</b>	<b>L28-L36</b>	<b>4</b>	Addition-elimination reactions	<b>T1, T4, R2</b>	<b>5</b>	<b>-do-</b>
<b>13-15</b>	<b>L37-L45</b>	<b>5</b>	Rearrangement reactions	<b>T1, R4</b>	<b>6</b>	<b>-do-</b>

**Course code: CH 404**

**Course title: Inorganic Chemistry-VI: Organometallic Chemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co- requisite(s):**

**Credits: 3**      L: 3      T: 0      P: 0

**Class schedule per week: 03**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. I/ I. M. Sc. VII**

**Branch: Chemistry**

**Name of Teacher:**

**Course Objectives**

This course enables the students:

A.	To learn the basics of organometallic chemistry
B.	To grow concept of bonding in organometallic compounds
C.	To study the reactivity of organometallic compounds
D.	To know the application of organometallic compounds

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the basic features of organometallic compounds
2.	Able to explain the bonding in organometallic compounds
3.	Able to predict the reactivity of organometallic compounds
4.	Able to discuss the application of organometallic compounds

## Syllabus

### Module I: Organometallic Complexes: General properties and types (9 Lectures)

Introduction, Classical and non-classically bonded organometallic compounds, 18 electron rule in Organometallic complexes-Ionic and Covalent Model; Metal Alkyls, Aryls, and Hydrides and Related  $\sigma$ -Bonded Ligands: Transition Metal Alkyls and Aryls, Related  $\sigma$ -Bonded Ligands, Metal Hydride Complexes,  $\sigma$  Complexes, Bond Strengths for Classical  $\sigma$ -Bonding Ligand; Complexes of  $\pi$ -Bound Ligands: Alkene and Alkyne Complexes, Allyl Complexes, Diene Complexes, Cyclopentadienyl Complexes, Arenes and Other Alicyclic Ligands, Metalacycles and Isoelectronic and Isolobal Replacement, Stability of Polyene and Polyenyl Complexes.

### Module II: Metal-Ligand Multiple Bonds (9 Lectures)

Carbenes: Fischer Versus Schrock Carbenes - conditions, synthesis examples reactivity and structure, Cases Intermediate Between Fischer and Schrock Carbenes, Boryl Complexes, Vinylidene Carbynes-synthesis, examples and reactivity, structure, Bridging Carbenes and Carbynes, N-Heterocyclic Carbenes-synthesis examples reactivity and structure, Multiple Bonds to Heteroatoms.

### Module III: Reactivity of Organometallic Complexes: I (9 Lectures)

Oxidative Addition and Reductive Elimination: Concerted Additions,  $S_N2$  Reactions, Radical Mechanisms, Ionic Mechanisms, Reductive Elimination,  $\sigma$ -Bond Metathesis, Oxidative Coupling and Reductive Cleavage.

Insertion and Elimination: Reactions Involving CO, Insertions Involving Alkenes, Other Insertions,  $\alpha$ ,  $\beta$ ,  $\gamma$ , and  $\delta$  Elimination.

### Module IV: Reactivity of Organometallic Complexes: II (9 Lectures)

Nucleophilic and Electrophilic Addition and Abstraction: Nucleophilic Addition to CO, Nucleophilic Addition to Polyene and Polyenyl Ligands, Nucleophilic Abstraction in Hydrides, Alkyls and Acyls, Electrophilic Addition, Electrophilic Abstraction of Alkyl Groups, Single-Electron Transfer Pathways, Reactions of Organic Free Radicals with Metal Complexes.

Homogeneous Catalysis: Alkene Isomerization, Alkene Hydrogenation, Alkene Hydroformylation, Hydrocyanation of Butadiene, Alkene Hydrosilation and Hydroboration, Coupling Reactions, Surface and Supported Organometallic Catalysis.

### Module V: Applications of Organometallic Chemistry

(9 Lectures)

Alkene Metathesis- mechanism, Type and commercial application, Dimerization, Oligomerization, and Polymerization of Alkenes- mechanism, Type and commercial application, Activation of CO and CO<sub>2</sub> - mechanism, Type and commercial application, CH Activation- mechanism, Type and commercial application, Organometallic Materials and Polymers.

#### Text books:

1. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, Wiley-Interscience; 4th ed., 2005.

#### Reference books:

1. B- M. Bochmann, Organometallic Chemistry: (Oxford series), 1994.
2. R. C. Mehrotra & A. Singh, Organometallic Chemistry, New Age Int. Publishers, 2nd ed., 1991.
3. M. Gielen, R. Willem, B. Wrackmeyer, Fluxanol Organometallic and Coordination compounds, Wiley, 1st ed., 2008.
4. F. A. Cotton, G. Willkinson, Advanced Inorganic Chemistry, Wiley, 6th ed., 2007.
5. J. E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 4th ed. 2006.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

##### Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Quiz –I	√	√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-2	L1-L10	1	Organometallic Complexes: General properties and types	T1, R1	1	PPT Digi Class/Chock-Board
2-3	L11-20	2	Metal–Ligand Multiple Bonds	T1, R2	2	-do-
3-4	L21-28	3	Reactivity of Organometallic Complexes: I	T1, R3	3	-do-
5-6	L29-35	4	Reactivity of Organometallic Complexes: II	T1, R4	4	-do-
6-9	L36-45	5	Applications of Organometallic Chemistry	T1, R5	5	-do-

**Course code:** CH 405  
**Course title:** Principles of Organic Synthesis  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. I/ I. M. Sc. VII  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand effect of conformation on chemical reactivity of organic molecule
B.	To correlate stereochemistry with the chemical reaction mechanism
C.	To understand the requirement and principles for organic reaction
D.	To identify the mechanistic approach for chemical (including concerted) reaction

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain effect of conformation on chemical reactivity of organic molecule
2.	Able to define stereochemistry with the chemical reaction mechanism
3.	Able to explain the principles for various types of organic reaction
4.	Able to analyse the mechanism of chemical (including concerted) reaction

## Syllabus

### Module I: Conformation and Reactivity

[9 Lectures]

Conformation of acyclic systems (substituted ethane/n-propane/n-butane), conformation around  $sp^3$ - $sp^2$  and  $sp^2$ - $sp^2$  bond, conformation around carbon hetero atom bond, conformations of cyclic system (cyclopentane, cyclohexane with mono and di substituted cyclohexanes, cycloheptane, cyclooctane and decalins), conformation of cyclohexane with  $1/2$   $sp^2$  bond, conformation analysis of heterocycles, the conformations of sugars, anomeric effect and reverse anomeric effect, conformationally rigid and mobile diastereomer, conformation and reactivity in cyclic system (substitution, addition, elimination, rearrangement etc.).

### Module II: Stereochemistry

[9 Lectures]

Optical rotatory dispersion (ORD) and circular dichroism (CD), classification of ORD and CD Curves, Cotton effect curves and their application to stereochemical problems; the Octant rule and its application to alicyclic ketones, stereoisomerism, molecular dissymmetry and chirality- elements of symmetry, enantiomerism, diastereomerism, pseudoasymmetric carbon, diastereo isomerism in acyclic and cyclic-systems, interconversion of Fischer, Newman and Sawhorse projections, methods of resolution, optical purity, prochirality, enantiotopic and diastereotopic atoms, groups and faces, optical activity in absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape, geometrical isomerism in alkenes and oximes, methods of determining the configuration.

### Module III: Principles of organic reaction

[9 Lectures]

Reagent type and reaction type, Investigation of reaction mechanism (nature of products, kinetic data, use of isotope, study of intermediate, stereochemical criteria. Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, free energy relationships, kinetic and thermodynamic control, Nature of reaction energy, Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, nonkinetic methods of determining reaction mechanism, isotope effects, solvent effect.

**Module IV: Principles of reaction mechanism****[9 Lectures]**

Hammond's postulate, Curtin-Hammett principle, Hammett energy diagrams and reaction rate laws, Hammett's  $\sigma_x$  and  $\rho$  values and their physical significance through-conjugation, deviations from straight line plots; steric effects: Taft equation, Softness (Hardness) Scales, HSAB principle, HSAB application for organic reactions: Reaction Selectivity, Alkylation vs. Acylation, C- vs. O-Alkylation, Reactions of Organosulfur Compounds, Reactions of Organophosphorus Compounds, Elimination and Substitution, Addition to Double Bonds, Addition to Carbonyl Compounds.

**Module V: Concerted reaction****[9 Lectures]**

Definition, ionic, radical and concerted reaction, classification, Molecular orbital symmetry, Woodward-Hoffman correlation diagram method and perturbation of molecular (PMO) approach for the explanation of pericyclic reactions under thermal and photochemical conditions, frontier orbitals of ethylene, 1,3 Butadiene, 1,3,5- Hexatriene, allyl system, FMO approach, types of cyclo-additions and cyclo-reversion reactions, electrocyclic reaction and the electroreversion reactions, sigmatropic reactions, group transfer reaction.

**Text books:**

1. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 2nd ed., Oxford Press, 2012.
2. I. L. Finar, Organic Chemistry, Vol. I & II, 5th ed., Longman Ltd., New Delhi, 2011.

**Reference books:**

1. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th ed., John Wiley & Sons, New York, 1985.
2. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd ed., New Age Int., New Delhi, 1994.
3. I. Fleming, Pericyclic Reactions, Oxford Scientific Publication, Cambridge, 1998.
4. E. V. Anslyn and D.A. Dougherty, Modern Physical Organic Chemistry, University Science Books, USA, 2006.
5. L. P. Hammett, Physical Organic Chemistry, 1st ed., McGraw-Hill Book Co. Inc., New York, 1940.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Quiz –I	√	√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Conformation and reactivity	T1, T2, R1	1	PPT Digi Class/Chock-Board
4-6	L10-L18	2	Stereochemistry	T2, R2	2	-do-
7-8	L19-L27	3	Principles of organic reactions	T1, R1	3	-do-
9-12	L28-L36	4	Principles of reaction mechanism	T1, R4	3	-do-
13-15	L37-L45	5	Concerted reaction	T1, R3	4	-do-



Course code: CH 406  
Course title: Physical Chemistry-VI Lab  
Pre-requisite(s): B. Sc. (H) Chemistry  
Co- requisite(s):  
Credits: 2      L: 0      T: 0      P: 4  
Class schedule per week: 04  
Class: M. Sc. and I. M.Sc.  
Semester / Level: M. Sc. I/ I. M. Sc. VII  
Branch: Chemistry  
Name of Teacher:

## Syllabus

### Adsorption: (any two)

- (i) To study surface tension-concentration relationship for solutions.
- (ii) To study the adsorption of iodine from alcoholic solution of charcoal.
- (iii) To study the adsorption of acetic acid on charcoal.

### Chemical equilibrium: (any one)

- (i) To determine congruent composition & temperature of a binary system- Phenol-water.
- (ii) To determine glass transition temperature of a given salt conductometrically.
- (iii) To construct the phase diagram for a three component systems.
- (iv) To determine the equilibrium constant for the reaction  $KI + I_2 = KI_3$ .

### Chemical Kinetics: (any two)

- (i) To determine rate constant of saponification ethyl acetate by NaOH.
- (ii) To determine the velocity constant of hydrolysis of an ester in micellar media.
- (iii) To determine the rate constant for the oxidation of iodide ion by hydrogen peroxide, studying the kinetics as an iodine clock reaction.

### Conductometry: (any two)

- (i) To determine velocity constant, order of reaction and energy of activation for saponification of ethyl acetate by NaOH conductometrically.
- (ii) To determine solubility and solubility product of sparingly soluble salt conductometrically.
- (iii) To determine the strength of strong and weak acids in a given mixture conductometrically.
- (iv) To determine activity co-efficient of zinc ions in the solution of 0.002 M  $ZnSO_4$  using Debye-Huckel's limiting law.

### Potentiometry-pH metry: (any one)

- (i) To determine the strengths of halides in a mixture potentiometrically.
- (ii) To determine the valancy of mercurous ions potentiometrically.
- (iii) To determine the strength of strong and weak acids in a given mixture using a potentiometer-pH meter.
- (iv) To determine the temperature dependence of E.M.F. of a cell.
- (v) Acid-base titration in a non-aqueous media using a pH meter.
- (vi) To determine the transport number by Hittrof's method.

### Cyclic voltametry:

- (i) To find the redox potential of the given sample using cyclic voltametry.

### Polarography: (one one)

- (i) To determine DO in aqueous solution of organic solvent
- (ii) To determine half way potential of Cd & Zn EMF:
- (iii) To determine single electrode potential of  $Cu/Cu^{2+}$
- (iv) Potentiometric titration of a redox system.
- (v) To determine E.M.F. of concentration cell.

### Polarimetry: (any one)

- (i) To determine rate constant for hydrolysis/inversion of sugar using a Polarimeter.
- (ii) Enzyme kinetics-inversion of sucrose.

**Spectroscopy:(any one)**

- (i) To determine  $pK_a$  of an indicator in aqueous and micellar medium.
- (ii) To determine stoichiometry and stability constant of inorganic (ferric-salicylic acid) and organic (amine-iodine) complexes.

**Thermochemistry: (any one)**

- (i) To determine the enthalpy of neutralization of hydrochloric acid with NaOH
- (ii) Enthalpy of combustion of benzoic acid using DSC.

**Text books:**

- 1. J. B. Yadav, Advanced Practical Physical Chemistry, 22nd ed., Goel Publishing House, Krishna Prakashan Media, 2014.
- 2. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, Viva Books, 2012.

**Reference books:**

- 1. B. P. Levitt, Findlay's Practical Physical Chemistry, 9th ed., Longman, London, 1985.
- 2. A. M. Halpern and G. C. McBane, Experimental Physical Chemistry: A Laboratory Text Book, 3rd ed., W. H. Freeman, 2006.
- 3. A. M. James and F. E. Prichard, Practical Physical Chemistry, Prentice Hall Press, 1974.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 407  
**Course title:** Organic Chemistry-VI Lab  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** I. M. Sc. and M.Sc.  
**Semester / Level:** M. Sc. I/ I. M. Sc. VII  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Identification of functional groups through qualitative analysis in a given binary mixture of organic compounds.
2. Isolation of the organic compounds from above mentioned binary mixture through solvent extraction and verifying their complete separation through thin layer chromatography.
3. Identification of the isolated organic compounds through derivative preparation and characterization by FTIR, UV-VIS & NMR.
4. Electrophilic aromatic substitution: acylation of bromobenzene and checking thin layer chromatography to check the reaction outcome (product distribution and extent of reaction).

## Reference Books:

1. A. I. Vogel, Quantitative Organic Analysis, Part 3, Pearson, 2012.
2. F. G. Mann, & B. C. Saunders, Practical Organic Chemistry, Pearson Education, 2009.
3. B.S. Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, Practical Organic Chemistry, 5th Ed., Pearson, 2012.
4. V.K. Ahluwalia, & R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2000.
5. V. K. Ahluwalia, & S. Dhingra, Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press, 2000.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code: CH 408**

**Course title: Inorganic Chemistry-VII: Advanced Inorganic Chemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co-requisite(s):**

**Credits: 3      L: 3      T: 0      P: 0**

**Class schedule per week: 03**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. II/ I. M. Sc. VIII**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the general properties of magnetic bodies
B.	To study the effect of thermal energy on magnetism
C.	To understand the anomalous magnetic moments
D.	To study about the inorganic rings, chains and clusters

### Course Outcomes

After the completion of this course, students will be:

1.	Able to classify the magnetic bodies
2.	Able to explain the effect of temperature on magnetic properties
3.	Able to interpret the anomalous magnetic properties
4.	Able to explain several types of inorganic rings, chains and clusters

## Syllabus

### Module I: Magnetic properties of coordination Complexes (9 Lectures)

Definition of magnetic properties, Types of magnetic bodies, Experimental arrangements for the determination of magnetic susceptibility: Guoy method, Faraday method, Vibrating sample magnetometer, SQUID, NMR method; Diamagnetism in atoms and polynuclear systems, Pascals constant, Two sources of paramagnetism.

### Module II: Thermal energy and magnetic properties (10 Lectures)

Spin & Orbital effects, Spin orbit coupling, Lande interval rule, Energies of J levels, Multiplet width and temperature; Curie equation, Curie & Curie-Weiss law, 2nd order Zeeman Effect, Temperature independent paramagnetism, Van Vleck susceptibility equation, Thermal Equilibrium between High Spin and Low spin state in Spin Cross over region, Magnetic behavior of lanthanides & actinides, Anomalous magnetic moments, magnetic properties of binuclear and polynuclear complexes—ferromagnetism and anti-ferromagnetism.

### Module III: Anomalous Magnetic Moments in Coordination Complexes (9 Lectures)

Superexchange interaction in terms of Goodenough-Kanamori-Anderson Rules (GKA Rules), Interpretation of magnetic exchange by GKA Rule in terms of Molecular Orbital Theory, Antiferromagnetism in magnetically concentrated system, Cooperative magnetic interactions in binuclear Cu(II) complexes, Antiferromagnetic coupling in other metal complexes: Dimers of oxidovanadium(IV) and oxido-molybdenum(V) complexes, Dinuclear complexes of Ti(III), Dimeric Cr(II) acetate-monohydrate,  $\text{Mn}_2(\text{CO})_{10}$

### Module IV: Inorganic Rings and Cages (8 Lectures)

Rings: Homocyclic rings of S, Se and Te. Heterocyclic rings of S, N, P and O; Cages: Higher boron hydrides: structures and reactions, equation of balance, Lipscomb topological diagrams, polyhedral skeletal electron pair theory (PSEPT), carboranes, metalloboranes and heteroboranes, metallocarboranes.

**Module V: Inorganic Cluster****(9 Lectures)**

Clusters in elemental states, cluster classification, Low nuclearity ( $M_3 - M_4$ ) and high nuclearity cluster ( $M_5 - M_{10}$ ), Metal metal bonding (MOT), Carbonyl clusters, skeletal electron counting, Wade-Mingos-Luber rule, application of isolobal and isoelectronic analogy, capping rules, carbide, nitride, chalcogenide and halide containing cluster of Re, Nb, Ta, Mo, W, Zintl ions, chevreton compounds, infinite metal chains, application of cluster compounds in catalysis.

**Text books:**

1. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, Wiley, 6th ed., 2007.
2. J. E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 4th ed. 2006.
3. R. L. Dutta, A. Syamal, Elements of Magnetochemistry, East-West Press, 1993.
4. A. K. Das, M. Das, Fundamental Concepts of Inorganic Chemistry; Volume-6; CBS Publishers, 2012.

**Reference books:**

1. G. Wilkinson, R. D. Gillars & J. A. McCleverty, Comprehensive Co-ordination Chemistry, 2nd ed., Elsevier, 2003.
2. J. D. Lee, Concise Inorganic Chemistry, 5th ed., Oxford, 2008.
3. F. E. Mabbs and D. J. Machin, Magnetism and Transition Metal complexes, Dover Publications; 2008.
4. N. N. Greenwood and E. A. Earnshaw; Chemistry of elements, 2nd ed., Butterworth- Heinemann, 1997.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz -1		√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD 1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD 2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD 3	Seminars	CO 2, 3	CD3
CD 4	Mini projects/Projects	CO3, 4	CD4
CD 5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD 6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD 7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-2</b>	<b>L1-L8</b>	<b>1</b>	Definition of magnetic properties, Types of magnetic bodies, Experimental arrangements for the determination of magnetic susceptibility: Guoy method, Faraday method, Vibrating sample magnetometer, SQUID, NMR method	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	<b>L9-L20</b>	<b>2</b>	Spin & Orbital effects, Spin orbit coupling, Lande interval rule, Multiplet width and temperature; Curie equation, Curie & Curie–Weiss law, 2nd order Zeeman Effect, Van Vleck susceptibility equation	<b>T1, T3, R2</b>	<b>2</b>	<b>-do-</b>
<b>5-6</b>	<b>L21-L30</b>	<b>3</b>	Superexchange interaction in terms of Goodenough-Kanamori-Anderson Rules (GKA Rules), Interpretation of magnetic exchange by GKA Rule in terms of Molecular Orbital Theory, Antiferromagnetism	<b>T1, T2, T3, R1</b>	<b>3</b>	<b>-do-</b>
<b>7-10</b>	<b>L31-L38</b>	<b>4</b>	Rings: Homocyclic rings of S, Se and Te. Heterocyclic rings of S, N, P and O; Cages: Higher boron hydrides: structures and reactions, equation of balance, Lipscomb topological diagrams, polyhedral skeletal electron pair theory (PSEPT)	<b>T1, T2, T3, R2</b>	<b>4</b>	<b>-do-</b>
<b>11-15</b>	<b>L39-L45</b>	<b>5</b>	Clusters in elemental states, cluster classification, Low nuclearity ( $M_3 - M_4$ ) and high nuclearity cluster ( $M_5 - M_{10}$ ), Metal metal bonding (MOT), Carbonyl clusters, skeletal electron counting, Wade-Mingos-Luber rule,	<b>T1, T2, T3, R2</b>	<b>5</b>	<b>-do-</b>

**Course code: CH 409**

**Course title: Physical Chemistry-VII: Quantum Chemistry & Group Theory**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co-requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. II/ I. M. Sc. VIII**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To use operators in quantum mechanics to derive and solve Schrodinger equation.
B.	To solve elementary model problems in quantum mechanics, particle in a potential-free box, particle on a ring, harmonic oscillator and particle in a Coulomb potential exactly and demonstrate the solutions for hydrogen atom.
C.	To use techniques of approximations to solve the quantum mechanical problems.
D.	To apply the concept of linear combination of atomic orbitals to hybridization and directed bonding in polyatomic molecules.
E.	To show that molecular symmetry operations form a group and can be characterized by fundamental representations of groups known as irreducible representations and apply the great orthogonality theorem to derive simple point groups.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to solve the model problems in quantum mechanics for which exact analytical methods and solutions are available which forms the foundations for advanced study of the subject.
2.	Able to apply this knowledge to complex problems of atomic and molecular energy levels and structure.
3.	Able to determine the symmetry elements of any small and medium-sized molecules.

### Syllabus

#### **Module I: Classical Mechanics and Postulates of Quantum Mechanics (9 lectures)**

Postulates of quantum mechanics. Operators in quantum mechanics: Linear and Hermitian operators, operator algebra, eigenvalues and eigenfunctions, commutation relations. Solution of Schrödinger's equation for (i) particle in 3D-boxes and applications, (ii) particle in a ring and sphere, spherical harmonics, angular momentum rigid rotator, (iii) Simple harmonic oscillator, and (iv) Hydrogen atom. Stark and Zeeman effect.

#### **Module II: Approximation Methods (8 lectures)**

Perturbation (Time-independent & Time-dependent) and Variation methods: Examples of Variation methods: (i) Hydrogen atom, Hydrogen atom in an electric field, (ii) Helium atom. Examples of Perturbation method: (i) perturbed particle in a box, (ii) perturbed harmonic oscillator (iii) Hydrogen atom in electric field.

#### **Module III: Atomic Spectra and Atomic Structure (9 lectures)**

The spectrum of atomic hydrogen: Electronic configuration of atoms, addition of angular momenta, spectroscopic term symbols, spin-orbit coupling, selection rules for atomic spectra; The structure of helium; Many-electron atoms: Antisymmetric wave functions of many electron atoms, Slater determinants, Hartree and Hartree-Fock self-consistent field model for atoms.



**Module IV: Theory of Angular Momentum & Chemical Bonding (9 lectures)**

*Angular momentum:* Classical & quantum mechanical concept, application in many-electron atom, splitting of term level into atomic levels. *Molecular structure & Chemical bonding:* Born–Oppenheimer approximation, Hydrogen molecule ion. LCAO–MO and VB treatments of the hydrogen molecule. Hybridization and MOT of H<sub>2</sub>O, NH<sub>3</sub> and CH<sub>4</sub>. Huckel pi-electron theory and its applications to ethylene, butadiene and benzene.

**Module V: Basic Concept of Symmetry & Group Theory (10 lectures)**

Definition and theorem of group theory. Molecular symmetry & the symmetry group: Symmetry operations & symmetry elements, classification of molecules, multiplication tables. Representation of molecular point groups, character, reducible and irreducible representations. The Great Orthogonality Theorem (GOT, without proof), use of GOT to construct character table, character table for point groups & their uses.

**Text books:**

1. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics, 4th edition, Oxford University Press, Oxford, 2005.
2. D. A. McQuarrie, Quantum Chemistry, University Science Books, 1983.
3. R. K. Prasad, Quantum Chemistry, 3rd ed., New Age International, 2006.
4. A. K. Chandra, Introductory Quantum Chemistry, Tata Mcgraw-Hill, New Delhi, 1988.
5. F. A. Cotton, Chemical Applications of Group Theory, Wiley, 1996.

**Reference books:**

1. H. Eyring, J. Walter and G. E. Kimball, Quantum Chemistry, John Wiley, New York, 1944.
2. I. N. Levine, Quantum Chemistry, 5th ed., Pearson Educ., Inc., New Delhi, 2000.
3. D. J. Griffiths, Introduction to Quantum Mechanics, Pearson Education, 2005.
4. J. P. Lowe and K. A. Peterson, Quantum Chemistry, 3rd ed., Academic Press, 2005.
5. D. M. Bishop, Group theory and Chemistry, Dover, 1993.
6. S. N. Datta, Lectures on Chemical bonding and quantum chemistry, Prism Books, Bangalore, 1997.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Assignment	√	√	
Quiz –I	√		
Quiz II		√	
End Sem Examination Marks	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping of Course Outcomes onto Program Outcomes:**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	H	L
CO2	H	H	H	L
CO3	H	H	M	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3	CD1
CD2	Tutorials/Assignments	CO2, 3	CD1, 2
CD3	Seminars	CO3	CD3
CD4	Mini projects/Projects	CO1, 2, 3	CD4
CD5	Laboratory experiments/teaching aids	CO2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO1 ,2, 3	CD6
CD7	Simulation	CO1, 2, 3	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book /References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Introduction to Quantum Mechanics	<b>T1, T2,T3,R2, R3</b>	<b>1</b>	<b>PPT Digi Class/Chock -Board</b>
<b>4-6</b>	<b>L10-L17</b>	<b>2</b>	Perturbation and Variation Methods	<b>T1,T2,R2,R3</b>	<b>1</b>	<b>-do-</b>
<b>6-9</b>	<b>L18-L26</b>	<b>3</b>	Atomic Spectrum	<b>T1, T2,R2</b>	<b>2</b>	<b>-do-</b>
<b>9-12</b>	<b>L27-L35</b>	<b>4</b>	Molecular Structure and Chemical Bonding	<b>T2,R6</b>	<b>2</b>	<b>-do-</b>
<b>12-15</b>	<b>L36-L45</b>	<b>5</b>	Symmetry and Group Theory	<b>T5,R5</b>	<b>3</b>	<b>-do-</b>

**Course code:** CH 410  
**Course title:** Modern Organic Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. II/ I. M. Sc. VIII  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the photochemical, free radical and pericyclic reactions and their mechanisms
B.	To understand the heterocyclic systems, their synthetic principles and their chemical reactivity
C.	To understand the various principles and rules of reaction mechanism and their stereochemical outcomes

### Course Outcomes

After the completion of this course, students will be:

1.	To learn different photophysical and photochemical fates of an organic compound upon photo-irradiation
2.	To learn the mechanisms of photochemical and free radical reactions
3.	To learn the different heterocycles, their synthesis and understand their reactivity
4.	To understand the mechanism of different pericyclic reactions and differentiate endo and exo additions, suprafacial and antarafacial shifts and conrotatory and disrotatory motions
5.	To apply the rules of organic reactions to determine the stereochemical outcome

## Syllabus

### Module I: Organic Photochemistry

(9 Lectures)

Singlet and triplet excited state, radiative and non-radiative transitions, potential energy surfaces, photoreduction, photoaddition, photorearrangement, photooxidation, aromatic substitution, Norrish Type I, Norrish Type II, excimers and exciplexes, photochemistry of alkenes, carbonyl, aromatic compounds.

### Module II: Free Radical Reaction

(10 Lectures)

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighboring group assistance, Reactivity for aliphatic and aromatic substrates, Reactivity in the attacking radicals, the effect of solvents on reactivity, Allylic halogenation, Oxidation of aldehydes to carboxylic acids, auto-oxidation, Sandmeyer reaction, free radical rearrangement, Hunsdiecker reaction.

### Module III: Pericyclic Reaction

(8 Lectures)

FMO & PMO approach, Electrocyclic reactions – conrotatory and disrotatory motions,  $4n$ ,  $4n+2$  and allyl systems, Cycloaddition Reaction: Antarafacial and suprafacial additions,  $4n$  and  $4n+2$  systems,  $2+2$  addition of ketenes, 1,3 dipolar cycloadditions and Cheletropic Reactions, Effect of Diene and dienophile stereochemistry, Endo rule in Diels-Alder Reaction, Reverse electron Demand Diels-Alder Reaction, Intramolecular Diels-Alder Reaction, Regioselective Diels-Alder Reactions, Sigmatropic rearrangements: Suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5-sigmatropic rearrangements, Claisen, Cope and aza-Cope rearrangements, Ene and Retro Ene Reactions.

**Module IV: Heterocyclic Chemistry****(9 Lectures)**

Heterocyclic synthesis: Principles of heterocyclic synthesis involving cyclization and cycloaddition (1,3-dipolar, hetero-diels alder and 2+2 cycloaddition reactions).

Heterocyclic chemistry of 3 and 4, 5 and 6 membered rings. Synthesis, medicinal applications and reactions of oxirane, aziridine, azetidinone ( $\beta$ -lactam), oxetane, pyridine, pyrylium salts and pyrones. Heterocyclic chemistry of benzo-fused derivatives: Synthesis, medicinal applications and reactions of benzofurans, benzothiophenes, quinolines, isoquinolines, quinolizines, Indolizines, benzopyrylium salts, coumarin, chromene, chromones.

**Module V: Asymmetric synthesis****(9 Lectures)**

Cram's rule, Felkin's rule, Prelog's rule, Karabatsos's rule and their application in organic synthesis (stereoselectivity in hydride reduction), Homogenous and heterogenous asymmetric catalysis.

**Text books:**

1. J. March, M. B. Smith, Advanced Organic Chemistry – Reactions, Mechanism and Structure, 7th ed., John Wiley, 2015.
2. S. M. Mukherjee, Pericyclic Reactions: A Mechanistic Study, 3rd ed., Macmillan, India, 2010.
3. I. L. Finar, Organic Chemistry, Vol. I & II, 5th ed., Longman Ltd., New Delhi, 2011.
4. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd ed., New Age Int., New Delhi, 1994.

**Reference books:**

1. T. H. Lowry and K. S. Richardson, Mechanisms and Theory in Organic Chemistry, 2nd ed., Harper and Row, New York, 1981.
2. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, Springer, New York 2006.
3. I. Fleming, Frontier orbitals and organic chemical reactions, John Wiley and sons, Student edition, 2009.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Assignment	√	√	
Quiz –I	√		
Quiz II		√	
End Sem Examination Marks	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	M	H	L
CO4	M	H	H	L
CO5	M	H	M	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4, 5	CD1
CD2	Tutorials/Assignments	CO1, 2, 3	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3	CD6
CD7	Simulation	CO2	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Organic photochemistry	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-7</b>	<b>L10-L21</b>	<b>2</b>	Free radical reactions	<b>T3, R2</b>	<b>1</b>	<b>-do-</b>
<b>8-9</b>	<b>L22-L27</b>	<b>3</b>	Pericyclic reactions	<b>T2, R3</b>	<b>1</b>	<b>-do-</b>
<b>10-12</b>	<b>L28-L36</b>	<b>4</b>	Heterocyclic chemistry	<b>T1, T3, R2</b>	<b>2</b>	<b>-do-</b>
<b>13-15</b>	<b>L37-L45</b>	<b>5</b>	Asymmetric synthesis	<b>T1, R4</b>	<b>3</b>	<b>-do-</b>

**Course code:** CH 411

**Course title:** Physical Chemistry-VIII: Equilibrium, Non-Equilibrium & Statistical Thermodynamics

**Pre-requisite(s):** B. Sc. (H) Chemistry

**Co- requisite(s):**

**Credits:** 3      L: 3      T: 0      P: 0

**Class schedule per week:** 03

**Class:** M. Sc. and I. Msc.

**Semester / Level:** M. Sc. II/ I. M. Sc. VIII

**Branch:** Chemistry

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basic principles of equilibrium and non-equilibrium thermodynamics.
B.	To familiarize with the fundamental concepts of statistical thermodynamics.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to calculate change in thermodynamic properties, equilibrium constants, partial molar quantities, chemical potential.
2.	Able to solve numerical problems based on non-ideal solutions, chemical potentials, thermodynamic properties.
3.	Able to measure the partition function of ideal and real gases.

### Syllabus

#### Module I: Equilibrium Thermodynamics Basics

(8 lectures)

Introduction to thermodynamics: Concept of work and heat, first law of thermodynamics, enthalpy and heat capacities, concept of entropy, second law of thermodynamics, third law of thermodynamics-residual entropy. Maxwell's Relations and its applications and thermodynamic equations of state.

#### Module II: Equilibrium Thermodynamics Applications

(9 lectures)

Free energy, free energy of mixing of gases and variation of free energy with temperature, pressure and volume (Gibbs-Helmholtz equations with its applications). Chemical potential, Gibbs-Duhem equation, determination of partial molar quantities, equilibrium constant, temperature dependence of equilibrium constant. Clapeyron & Clapeyron-Clausius equation, fugacity & activity of gas and liquid. Third law of thermodynamics: Determination of absolute entropy of solids, liquids & gases, Boltzmann entropy equation.

#### Module III: Statistical Thermodynamics Basics

(8 lectures)

Concept of distribution, Thermodynamic probability and most probable distribution, Maxwell-Boltzmann statistics, Bose-Einstein statistics, Fermi-Dirac statistics. Ensemble averaging, Canonical, Grand canonical and micro canonical ensembles.

#### Module IV: Statistical Thermodynamics Applications

(10 lectures)

*Ideal Gases:* Partition functions: Translational, rotational, Vibrational and electronic partition functions and calculation of thermodynamic properties in terms of partition functions for ideal monatomic and diatomic gas. Equilibrium constant of an ideal gas reaction in terms of partition function. *Real gases:* intermolecular potential and virial coefficients. Debye and Einstein theory of heat capacity of solids. Structure and thermal properties of liquids, Pair correlation functions. *Solids:* Thermodynamics of solids - Einstein and Debye models.  $T^3$  dependence of heat capacity of solids at low temperatures (universal feature). *Metals:* Fermi function, Fermi energy, free electron model and density of states, chemical potential of conduction electrons.



**Module V: Non-equilibrium thermodynamics****(10 lectures)**

Thermodynamic criteria for non-equilibrium state, Phenomenological laws and Onsager reciprocal relations, Conservation of mass and energy in closed and open system. Entropy production: Due to heat flow, involving chemical reactions. Entropy production and entropy flow in open system. Transformation properties of fluxes and forces. Electrokinetic phenomena. Stationary non-equilibrium state: Prigogine's principle. Irreversible thermodynamics for biological systems.

**Text books:**

1. D. A. McQuarrie and J. D. Simon, Molecular Thermodynamics, Viva Books Private Limited, 1st Indian edition, 2004.
2. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A molecular Approach, Viva, 1998.
3. C. Kalidas and M. V. Sangaranarayan, Non-Equilibrium Thermodynamics: Principles and Applications, McMillan India Ltd., 2002.
4. R. P. Rastogi and R. R. Misra, An Introduction to Chemical Thermodynamics, Vikas Publishing House Pvt. Ltd., 6th ed., 2000.
5. S. Glasstone, Thermodynamics for Chemists, East-West Press Pvt. Ltd. 2008.

**Reference books:**

1. P. W. Atkins, Physical Chemistry, 7th ed., Oxford University Press, New York, 2002.
2. I. N. Levine, Physical Chemistry, 5th ed., Tata McGraw Hill Pub. Co. Ltd., New Delhi. 2002.
3. F. W. Sears & G. L. Salinger, Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Narosa, 1986.
4. I. Prigogine, Introduction to Thermodynamics of Irreversible Processes. 3rd ed., Interscience, New York, 1978.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Assignments	√	√	
Quiz I	√		
Quiz II		√	
End Sem Examination Marks	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping of Course Outcomes onto Program Outcomes:**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	M	L
CO3	H	H	M	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3	CD1
CD2	Tutorials/Assignments	CO1, 2, 3	CD1, 2
CD3	Seminars	CO3, 4	CD3
CD4	Mini projects/Projects	CO1, 2, 3, 4, 5	CD4
CD5	Laboratory experiments/teaching aids	CO2, 3	CD5
CD6	Industrial/guest lectures	CO4	CD6, 7
CD7	Simulation	CO5	CD8

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L8</b>	<b>1</b>	Basics of Equilibrium Thermodynamics	<b>T1, T2,T3,R2</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	<b>L9-L17</b>	<b>2</b>	Applications of Equilibrium Thermodynamics	<b>T1,T2,T3 R2,R3</b>	<b>1</b>	<b>-do-</b>
<b>6-9</b>	<b>L18-L25</b>	<b>3</b>	Basics of Statistical Thermodynamics	<b>T2, T3,R2</b>	<b>1, 2</b>	<b>-do-</b>
<b>9-12</b>	<b>L26-L35</b>	<b>4</b>	Application of Statistical Thermodynamics	<b>T1,R4</b>	<b>3</b>	<b>-do-</b>
<b>12-15</b>	<b>L36-L45</b>	<b>5</b>	Basics of Non-equilibrium Thermodynamics	<b>T1,T2</b>	<b>2</b>	<b>-do-</b>

**Course code:** CH 412  
**Course title:** Analytical Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. II/ I. M. Sc. VIII  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basics of analytical Chemistry
B.	To understand several separation techniques
C.	To know about the classical analytical methods
D.	To learn the thermal and electrochemical techniques of analysis

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the basics of analytical Chemistry
2.	Separate the mixtures by different separation methods
3.	Able to determine the sample by volumetric and gravimetric analysis
4.	Determine the samples through different thermal and electrochemical techniques of analysis

## Syllabus

### Module I: Introduction to Analytical Chemistry (10 lectures)

Types of analysis-qualitative and quantitative. Classification of analytical methods- classical and instrumental, basis of their classification with examples. Statistical analysis and validation: Errors in chemical analysis. Classification of errors- systematic and random, additive and proportional, absolute and relative. Accuracy and precision. Mean, median, average deviation and standard deviation. Significant figures and rules to determine significant figures. Calculations involving significant figures. Confidence limit, correlation coefficient and regression analysis. Comparison of methods: F-test and T-test. Rejection of data based on Q test. Least squares method for deriving calibration graph. Validation of newly developed analytical method. Certified reference materials (CRMs). Numerical problems.

### Module II: Separation Techniques (10 lectures)

**Chromatography:** Definition and Classification. Techniques used in Paper, Thin Layer and Column chromatography. Applications in qualitative and quantitative analysis.

**Ion exchange:** Principle and technique. Types of ion exchangers. Ion exchange equilibria. Ion exchange capacity. Effect of complexing ions. Zeolites as ion-exchangers. Applications.

**Solvent extraction:** Principle and techniques. Distribution ratio and distribution coefficient. Factors affecting extraction efficiency: Ion association complexes, chelation, synergistic extraction, pH. Numericals based on multiple extractions. Role of chelating ligands, crown ethers, calixarenes and cryptands in solvent extraction. Introduction to Solid phase extraction (SPE) and Microwave assisted extraction (MAE), Applications.

### Module III: Classical Methods of Analysis (9 lectures)

**Volumetric analysis:** General principle. Theory of indicators. Types of titrations with examples- Acid-base, precipitation, redox and complexometric. Titration curves for monoprotic and polyprotic acids and bases. Indicators used in various types of titrations. Masking and demasking agents.

**Gravimetric analysis:** General principles and conditions of precipitation. Concepts of solubility, solubility product and precipitation equilibria. Steps involved in gravimetric analysis. Purity of precipitate: Co-precipitation and post-precipitation. Fractional precipitation. Precipitation from homogeneous solution. Particle size, crystal growth, colloidal state, aging and peptization phenomena. Ignition of precipitates.

**Module IV: Thermal Methods of Analysis**

**(7 lectures)**

Principle, methodology and applications: thermogravimetric and differential thermal analysis, differential scanning calorimetry; Thermo-mechanical and dynamic mechanical analysis; thermometric titrations

**Module V: Electrochemical Methods of Analysis**

**(9 lectures)**

**Conductometry:** Concepts of electrical resistance, conductance, resistivity and conductivity. Specific, molar and equivalent conductance and effect of dilution on them. Measurement of conductance. Kohlrausch's law, Applications of conductometry in determination of dissociation constant, solubility product. Conductometric titrations. High frequency titrations. Numerical problems.

**Potentiometry:** Circuit diagram of simple potentiometer. Indicator electrodes: hydrogen electrode, quinhydrone electrode, antimony electrode and glass electrode. Reference electrodes: Calomel electrode and Ag/AgCl electrode. Theory of potentiometric titrations. Acid-base, redox, precipitation and complexometric titrations. Nernst equation, standard electrode potential, Determination of cell potential,  $n$ ,  $K_f$  and  $K_{sp}$ . pH titrations. Buffers and buffer capacity. pH of buffer mixtures based on Henderson-Hasselbalch equation.

**Text books:**

1. G. D Christian, Analytical Chemistry. 5th ed., John – Wiley and Sons Inc., 1994.
2. D. A. Skoog, D. M. West and F. J. Holler, Fundamentals of Analytical Chemistry. 7th ed., Saunders College Publishing, 1996.
3. H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Set, Instrumental methods of Analysis, CBS Publishers, 1996.

**Reference books:**

1. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5th ed., McGraw-Hill, New York, 1988.
2. A. J. Bard & L. R. Faulkner, Electrochemical methods, 2nd ed., Wiley, New York, 2000.
3. Vogel's text book of Quantitative Chemical analysis 5th edition, Ed., Jeffery et al. ELBS/Longman, 1989.
4. Encyclopedia of Analytical Chemistry: Ed. by R.A. Meyers Vol. 1-15, John Wiley, 2000.
5. D. M. Skoog, D. M. West and F. J. Holler, Fundamentals of Instrumental Analysis, 8th ed., Saunders College Publishing, 2004.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz -1		√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-4	L1-L09	1	Introduction to Analytical Chemistry	T1, R1,R3	1	PPT Digi Class/Chock-Board
4-7	L10-L18	2	Separation Techniques	T1,T2 R1,R3	1	-do-
7-10	L19-L27	3	Classical Methods of Analysis	T1, R2,R3	2	-do-
10-11	L28-L36	4	Thermal Methods of Analysis	T1	3	-do-
12-15	L37-L45	5	Electrochemical Methods of Analysis	T1	4	-do-

**Course code:** CH 413  
**Course title:** Inorganic Chemistry-V Lab  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      L:      T:      P: 4  
**Class schedule per week:** 04  
**Class:** M.Sc. and I M.Sc.  
**Semester / Level:** M. Sc. II/ I. M. Sc. VIII  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Semi micro qualitative analysis of mixtures containing two anions, two common cations and one rare earth elements: W, Mo, Ce, Th, Zr, V, U and Li.
2. Gravimetric determination of Fe in iron ore as  $\text{Fe}_2\text{O}_3$ .
3. Chemical Analysis of Alloy samples: Dissolution, sample preparation & Analysis. (any one)
  - a) Analysis of brass: Estimation of copper by gravimetry and zinc by EDTA titration.
  - b) Analysis of bronze: Estimation of copper by volumetry and tin by gravimetry
4. Inorganic Synthesis:
  - a) Nano-chemistry: Synthesis and characterization of manganese dioxide nanoparticles
  - b) Synthesis of pentaamminechlorocobalt(III) chloride.
  - c) Preparation of *cis* and *trans*-dichlorobis-(ethylenediamine)cobalt(III) chloride
  - d) Ligand synthesis for multimetal complex: Preparation of *bis*-(*N,N*-disalicylidene ethylenediamine)
  - e) Synthesis and characterization of *tris*-triphenylphosphinecopper(I) nitrate
  - f) Preparation of *bis*-(*N,N'*-disalicylaethylene-diamine)- $\mu$ -aquadichlorocobalt(II)

## Reference Books:

1. Vogel's Text book of Qualitative Chemical Analysis, J. Bassett, G. H. Jeffery and J. Mendham, ELBS, 1986.
2. Vogel's text book of Quantitative Chemical Analysis, 5th Edition, J. Bassett, G. H. Jeffery and J. Mendham, and R. C. Denny, Longman Scientific and Technical, 1999.
3. J. D. Woollins, Inorganic Experiments; VCH, Weinheim, 1994.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)



**Course code:** CH 414  
**Course title:** Theoretical & Computational Chemistry Lab  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      **L:** 0      **T:** 0      **P:** 4  
**Class schedule per week:** 04  
**Class:** M.Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. II/ I. M. Sc. VIII  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. A) Draw and clean the 2D chemical structure for given molecules (e.g.; Barbituric Acid, N-acetylneuraminic acid, Cholesterol) as per ACS format using ChemDraw Software. B) Perform the analysis of the drawn structure to report IUPAC name, molecular weight, exact mass and elemental analysis. C) Convert the 2D chemical structure into 3D structure using Chem3D software and demonstrate the various molecular models.
2. Draw the suitable conformers of 2,3-dibromobutane and demonstrate in Sawhorse, Newmann, and Fisher projection. Minimize the eclipsed and staggered conformer and evaluate the energies by molecular mechanics (MM) for both conformers.
3. Compute the physico-chemical properties such as log p, solubility, molar refractivity and NMR for a given molecule.
4. Draw the reaction mechanism for a given name reaction using ChemDraw tools in ACS (American Chemical Society) format.
5. Compute the partial atomic charges (extended Huckel) in phenol and display by color gradient.
6. Draw and demonstrate the HOMO-LUMO diagram using ethylene molecule. Minimize the energy of the given molecule and calculate HOMO-LUMO energy gap using Gaussian Software.
7. (a) Introduction about the computational chemistry software Schrodinger, understanding and use of its Graphical interface "Maestro" to prepare the molecular system for computer simulation. (b) Draw the 3D structure of a given chiral molecule (tamiflu) in Maestro workspace, clean the structure by short minimization using MM.
8. Generate the all stereochemical structure of a given molecules (tamiflu or zanamavir) using maestro interface of Schrodinger.
9. Conduct the molecular docking experiment for a given ligands with a large protein structure. Report the docking score and binding mode of ligands within the protein active site. Compare the docking result to conclude the remarks for its bindingaffinity.
10. Determine the single point energy of benzene (assume: singlet and uncharged) by density-function calculation with the B3LYP functional and a 6-31G\*\* basis set. Optimize the geometry of the output structure from experiment-9 using BLYP/6-31G\*\* level.
11. Run the calculation to demonstrate the electrostatic potential (ESP) of vinyl alcohol. Label atoms in the workspace with atomic properties derived from the ESP and examine the electrostatic potential (ESP) on the molecular surface.
12. Predict and describe the pKa values of organic bases such as methylamine, dimethyl amine and trimethyl amine using ChemOffice.
13. Draw and describe the 3D conformational features of *trans*-1,3-dimethyl cyclohexane. Draw, demonstrate and compare the electrostatic potential map of CH<sub>3</sub>-Cl and CH<sub>3</sub>-Li. Explain the significance of this experiment.

**Text books:**

1. F. Jensen, Introduction to Computational Chemistry, Wiley, New York, 1999.
2. A. Szabo and N. S. Ostlund, Modern Quantum Chemistry, Introduction to Advanced Electronic Structure Theory, 1st ed., revised Dover, 1989. More mathematical detail for many of the ab initio electronic structure methods.

**Reference book:**

1. D. A. McQuarrie, Quantum Chemistry, University Science Books, Mill Valley, CA, 1983.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code: CH 501**

**Course title: Spectroscopic Elucidation of Molecular Structure**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co- requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. III/ I. M. Sc. IX**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To interpret spectra collected through different characterization tools
B.	To deduce the structure of molecules from given spectral data

### Course Outcomes

After the completion of this course, students will be:

1.	Learn fundamental principal of different characterization techniques
2.	Apply the basics of structural elucidation principles in deducing the molecular structure
3.	Analyse the given spectrum to decipher the molecular structure

## Syllabus

### UV-Visible & IR Spectroscopy

**(8 Lectures)**

Electronic transitions, Chromophores, Auxochromes, Bathochromic and hypsochromic shifts, Solvent effects, Woodward –Fieser Rules for dienes, enones and aromatic compounds.

Vibrational Transitions, Important group frequencies, Factors affecting I.R. group frequency, Applications of I.R. Instrumentation and recording of spectra.

### Nuclear Magnetic Resonance Spectroscopy

**(10 Lectures)**

<sup>1</sup>H-NMR: chemical shift, spin-spin interaction, shielding mechanism, chemical shift values and correlation for protons bonded to carbons and other nucleus, chemical exchange, effect of deuteration, complex spin-spin interaction between 2, 3, 4 and 5 nuclei, virtual coupling, stereochemistry, hindered rotation, simplification of complex spectra, nuclear magnetic double resonance, contact shift reagents, solvent effects, <sup>13</sup>C-NMR: General considerations, chemical shifts, coupling constants and examples 2D-NMR: spectroscopy-COSY, NOESY, DEPT. DEPT with 3 different angles, interpretation of 2D spectra and examples.

### Mass Spectrometry

**(9 Lectures)**

Introduction, ion production, factors affecting fragmentation, ion analysis, ion abundance, mass spectro fragmentation in organic compounds, common functional groups, molecular ion peak, high resolution mass spectrometry, examples of mass spectral fragmentation of organic compounds w.r.t. their structure determination.

### Electron Spin Resonance Spectroscopy & Mossbauer Spectroscopy

**(11 Lectures)**

Hyperfine coupling, Spin polarization for atoms and transition metal ions, spin orbit coupling and significance of g-tensors, applications to transition metal complexes having one unpaired electron including biological systems and to inorganic free radicals such as PH<sub>4</sub>, F<sub>2</sub><sup>-</sup> and (BH<sub>3</sub>)<sup>-</sup>.

Mossbauer Spectroscopy: Basic principles, spectral parameters and spectrum display, applications to the study of bonding and structures of Fe<sup>2+</sup> and Fe<sup>3+</sup> compounds, Sn<sup>2+</sup> and Sn<sup>4+</sup> compounds– nature of M-L bond, Co-ordination number, structure and detection of oxidation state.

**Spectra and Structure: Combined application****(7 Lectures)**

UV, IR, NMR and Mass spectral data to elucidate unknown compound structure.

**Text books:**

1. D. H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, McGraw-Hill Education; 6th ed. 2007.
2. R. M. Silverstein, F. X. Webster, D. J. Kiemle, Spectrometric Identification of Organic Compounds, 7th ed.; Wiley: Hoboken, NJ, 2005.
3. W. Kemp, Organic Spectroscopy, McMillan, Reprint 2009.

**Reference books:**

1. J. R. Dyer, Applications of Spectroscopy of Organic Compounds, Prentice Hall, Reprint 2010.
2. R. S. Macomber, A Complete Introduction to Modern NMR Spectroscopy, Wiley-Interscience; 1st ed., 1997.
3. H. Gunther, NMR Spectroscopy, Basic Principles, Concepts and Applications in Chemistry, 3rd ed., Wiley VCH, 2013.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>
<b>Quiz -1</b>	√		
<b>Quiz II</b>		√	
<b>End Sem Examination Marks</b>	√	√	√

**Indirect Assessment –****1. Student Feedback on Faculty****2. Student Feedback on Course Outcome****Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	M	L	H
CO3	H	M	L	H

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3	CD1
CD2	Tutorials/Assignments	CO1, 2, 3	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3	CD6
CD7	Simulation	CO2	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-2	L1-L09	1	UV-Vis and IR spectroscopy	T1, T2	1	PPT Digi Class/Chock -Board
3-6	L10-L18	2	NMR Spectroscopy	T1,T2,T3 R1,R3	1	-do-
7-9	L19-L27	3	Mass Spectrometry	T2, T3	1, 2	-do-
10-12	L28-L36	4	EPR and Mossbauer Spectroscopy	T3,R1	3	-do-
13-15	L37-L45	5	Structure determination from given combination of spectra	T1,T2,T3, R1,R2	2	-do-

**Course code: CH 502 (SPL-I)**

**Course title: Inorganic Chemistry-VIII: Solid state and Nuclear Chemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co- requisite(s):**

**Credits: 4**      L: 3      T: 1      P: 0

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. III/ I. M. Sc. IX**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basics of nuclear chemistry
B.	To grow concept of nuclear structure
C.	To know about the nuclear reactions
D.	To know about the structure of the solids and their reactivities

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the basics of nuclear chemistry
2.	Able to explain the nuclear stability
3.	Able to predict the nuclear reactions
4.	Able to explain the structure of the solids and their reactivities

## Syllabus

### Module I: Basic Nuclear Chemistry

**(9 Lectures)**

Systematic of alpha, beta and gamma decays, Alpha decay, energy curve, spectra of alpha particles, Geiger-Nuttall law, theory of alpha decay, penetration of potential barrier, beta decay, range of energy relationship, beta spectrum, sergeants curve, Fermi theory of beta decay, matrix elements, allowed and forbidden transitions, curie plots, gamma decay, Nuclear energy levels, selection rule, isomeric transitions, Internal conversion, Auger effect.

### Module II: Nuclear Structure and Stability

**(9 Lectures)**

Nuclear Potential, Binding energy, empirical mass equation, The Nuclear Models: Shell model-salient features, forms of the nuclear potential, filling of orbitals, nuclear configuration, Liquid drop model, Fermi gas model, Collective model and Optical model.

### Module III: Nuclear reactions

**(9 Lectures)**

Introduction, production of projectiles, nuclear cross section, nuclear dynamics, threshold energy of nuclear reaction, Coulomb scattering, potential barrier, potential well, formation of a compound nucleus, Nuclear reactions, direct Nuclear reactions, heavy ion induced nuclear reactions, photonuclear reactions. Fission and Fusion reactions: Fission barrier and threshold, fission cross section, mass energy and charge distribution of fission products, symmetric and Asymmetric fission, decay chains and delayed neutrons.

### Module IV: The Structure of solids

**(9 Lectures)**

The types of matter, classification of solids, close packing of atoms; Voids in closest packings; Radius ratio rule, Structure of ionic Crystals; Ionic Crystals with stoichiometry MX, Ionic Crystals with stoichiometry MX<sub>2</sub>, spinel structure, perovskite structure. Perfect and Imperfect Crystals, intrinsic and extrinsic defects- Point defects, line and plane defects, Vacancies- Schottky and Frenkel defects. Thermodynamics of Schottky and Frenkel defects formation, Colour centres, Non-stoichiometry and

defects. Evolution of band structure, Brillouin zone, Effective mass of electron, Intrinsic semiconductors, Hall effect, Electrical conductivity of metals, alloys & semiconductors. Fermi levels in metals & semiconductors, Direct & indirect band gap semiconductors, Photo-conductivity, Properties of junctions: metal – metal, metal – semiconductor & semiconductor – semiconductor. Application: Diode system, Photocatalytic systems

#### **Module V: Solid State Reactions**

**(9 Lectures)**

Thermal decomposition reactions- Type I, Type II, Polymorphism, Enantiotropy & Monotropy, Order-disorder transitions, Buerger's Classification, Polytypism, Sintering, Zone refining, Crystal growth, Growth from solutions, Flame fusion method, Vapour deposition technique, Chemical transport reaction, Growth by condensation.

#### **Text books:**

1. H. J. Arnikaar, Essentials of Nuclear Chemistry, 4th ed. Wiley Eastern, 1987.
2. A. R. West, Solid State Chemistry and its Applications, 2nd ed., Student Edition, Wiley, 2014.

#### **Reference books:**

1. G. Friedlander, T. W. Kennedy, E. S. Macias and J. M. Miller, Introduction of Nuclear and Radiochemistry, 3rd ed., John Wiley, 1981.
2. H. J. M. Bowen, Chemical Applications of Radioisotopes, Methuen, 1969.
3. C. N. R. Rao, New Directions in Solid State Chemistry, 2nd ed., Cambridge University Press, 1997.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz –I	√	√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

### **Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7



**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-2</b>	L1-L09	<b>1</b>	Basic Nuclear Chemistry: Systematic of alpha, beta and gamma decays, Alpha decay, energy curve, spectra of alpha particles, Geiger-Nuttal law, theory of alpha decay	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	L10-L18	<b>2</b>	Nuclear Structure and Stability Nuclear Potential, Binding energy, empirical mass equation, The Nuclear Models	<b>T1, T3, R2</b>	<b>2</b>	<b>-do-</b>
<b>5-6</b>	L19-L27	<b>3</b>	<b>Nuclear reactions</b> Introduction, production of projectiles, nuclear cross section, nuclear dynamics, threshold energy of nuclear reaction, Coulomb scattering, potential barrier, potential well	<b>T1, T2, R1</b>	<b>3</b>	<b>-do-</b>
<b>7-10</b>	L28-L36	<b>4</b>	<b>The Structure of solids</b> The types of matter, classification of solids, close packing of atoms, Ionic Crystals with stoichiometry $MX_2$ , spinel structure, perovskite structure. Perfect and Imperfect Crystals, Schottky and Frenkel defects. Colour centres, Non-stoichiometry and defects.	<b>T1, R2</b>	<b>4</b>	<b>-do-</b>
<b>11-15</b>	L37-L45	<b>5</b>	Solid State Reactions: Thermal decomposition reactions- Type I, Type II, Polymorphism, Buerger's Classification, Polytypism, Sintering, Zone refining, Crystal growth, Growth from solutions	<b>T1, T2, R1</b>	<b>5</b>	<b>-do-</b>

**Course code:** CH 503(SPL-I)  
**Course title:** Molecular Spectroscopy  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To recognize the fundamental principles of optical and magnetic resonance and simple relations between experimentally observable spectroscopic quantities and molecule dependent parameters by introducing time dependent quantum mechanics.
B.	To show that spectroscopy connects matter with molecules through interaction of electromagnetic radiation.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to apply principles of microwave, infrared and electronic spectroscopies to identify the fingerprint region of small molecules.
2.	Able to identify the element present in the molecule along with oxidation state from their respective binding energies.
3.	Able to apply the concept of chemical shift and spin-spin coupling in both NMR and EPR spectroscopy to identify high resolution spectra of small organic molecules.
4.	Familiar with modern spectrometers and methods, which are applied in industrial and scientific laboratories in the field of synthesis and structural determination.

### Syllabus

#### Module I: Rotational spectroscopy

(9 lectures)

Classification of polyatomic molecules: Linear, symmetric rotor, spherical rotor and asymmetric rotor molecules. The Stark effect in hetero-nuclear diatomic molecules. Rotational Raman spectroscopy. Applications of microwave spectroscopy.

#### Module II: Vibrational spectroscopy

(9 lectures)

Infrared (IR) spectroscopy, Raman spectroscopy; Polyatomic molecules: Group vibrations, Number of normal vibrations of each symmetry species, Vibrational selection rules, Vibration-rotation spectroscopy, Anharmonicity. Techniques and instrumentation-Analysis by IR spectroscopy.

#### Module III: Electronic spectroscopy

(9 lectures)

Diatomic molecules. Selection rules. Breakdown of selection rules. Franck-Condon factors. Dissociation energies. Transition moments, assignment of electronic transitions of N<sub>2</sub>, H<sub>2</sub>O and formaldehyde using group theory. Qualitative ideas of solvent effects- viscosity, polarity, hydrogen bonding. Fluorescence and phosphorescence.

#### Module IV: Photoelectron spectroscopy

(9 lectures)

Ionization processes and Koopman's theorem, Ultraviolet photoelectron spectroscopy, X-ray photoelectron spectroscopy. Auger electron spectroscopy: introduction- instrumentation- classification of various transitions- quantification- applications. Electron energy loss spectroscopy: Franck and Hertz experiment- instrumentation - selection rules- theory- studies on molecules- surface states- high resolution spectroscopy- adsorption and catalysis- applications.

**Module V: Spin resonance spectroscopy****(9 lectures)**

The effect of magnetic fields on electron and nuclei, nuclear magnetic resonance (NMR): Bloch equations, Steady state (continuous wave) and Transient (pulsed) experiments, nuclear Overhauser effect, Polarization transfer, Selective Population Inversion. Electron spin resonance (ESR): g value, hyperfine structure, ESR of organic free radicals, solids, inorganic ions, simple free radicals in solutions. Mossbauer spectroscopy: principle & applications.

**Text books:**

1. P. W. Atkins, J.de Paula, Physical Chemistry, Oxford, London, 7th ed. 2002.
2. P. S. Sindhu, Fundamentals of Molecular Spectroscopy, New Age International (P) Ltd. Publishers, 2006.
3. C. M. Banwell, Molecular Spectroscopy, Tata McGraw Hill, 1998.
4. G. M. Barrow, Introduction to Molecular Spectroscopy, McGraw Hill, 1964.
5. M. Hollas, Modern Spectroscopy, Wiley; 4th ed., 2004.

**Reference books:**

1. A. Carrington and A. D. McLachlan, Introduction to Magnetic Resonance, Methuen, 1983.
2. J. D. Graybeal, Molecular Spectroscopy, McGraw Hill, 1993.
3. H. Friebolin, Basic One- and Two-Dimensional NMR Spectroscopy 5th ed., Wiley-VCH, 2010.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>
<b>Assignment</b>	√	√	√	
<b>Quiz –I</b>	√			
<b>Quiz II</b>		√	√	
<b>End Sem Examination Marks</b>	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	H	L
CO2	H	H	M	L
CO3	H	H	H	L
CO4	H	H	M	L

**Mapping of Course Outcomes onto Program Outcomes:**

Mapping Between COs and Course Delivery (CD) methods			
CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1, 2
CD3	Seminars	CO 1, 4	CD3
CD4	Mini projects/Projects	CO 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO1, 2, 3, 4	CD6
CD7	Simulation	CO 2, 3	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Microwave Spectroscopy	T1, T2 T3, T4	1, 4	PPT Digi Class/Chock -Board
4-6	L10-L18	2	Infrared and Raman Spectroscopy	T1,T3 R1,R3	1, 4	-do-
7-9	L19-L27	3	Absorption and Photoluminescence Spectroscopy	T3,T5, R2	1, 4	-do-
10-12	L28-L36	4	Photoelectron Spectroscopy	T4, T5	2	-do-
13-15	L37-L45	5	NMR and ESR Spectroscopy	T1, R1, R2, R3	3, 4	-do-

**Course code:** CH 504(SPL-I)  
**Course title:** Advanced Organic Synthesis  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand protection and deportation of different functional groups
B.	To know about important hydroboration, oxidation and reduction reagents
C.	To understand the hydroboration, oxidation and reduction mechanism
D.	To learn about some important name reaction

### Course Outcomes

After the completion of this course, students will be:

1.	Able to consider protection/deportation of functional groups during organic synthesis
2.	Able to perform and compare the hydroboration, oxidation and reduction reagents
3.	Able to explain the hydroboration, oxidation and reduction mechanisms
4.	Able to use the knowledge of name reaction for research and development purpose

### Syllabus

#### Module I: Protection and deprotection

(8 Lectures)

Principle of protection and deprotection of alcohol, amine, carbonyl and carboxyl groups

#### Module II: Hydroboration reactions

(10 Lectures)

Introduction, synthetic application of organoboranes: isomerization, formation of C-C bonds, aldehydes, ketones, trialkylcarbinols, reactions of alkenylboranes and trialkylalkynyl borates, free-radical reactions of organoborane.

#### Module III: Reagents for Oxidation

(9 Lectures)

SeO<sub>2</sub>, CrO<sub>3</sub>, CrO<sub>2</sub>Cl<sub>2</sub>, LTA, t-BuOOH, mCPBA, PdCl<sub>2</sub>, HgSO<sub>4</sub>, KMnO<sub>4</sub>, OsO<sub>4</sub>, OsO<sub>4</sub>/RuO<sub>4</sub>, H<sub>2</sub>O<sub>2</sub>, C<sub>6</sub>H<sub>5</sub>CO<sub>3</sub>H, CF<sub>3</sub>CO<sub>3</sub>H, I<sub>2</sub>/Py, HIO<sub>4</sub>, PCC, PDC, Des-Martin periodinane, IBX, NBS, AgNO<sub>3</sub>, Ag<sub>2</sub>CO<sub>3</sub>, Ag<sub>2</sub>O, AgO, MnO<sub>2</sub>, NaIO<sub>4</sub> cat. Ozone, DDQ, DDQ/PbO<sub>2</sub>.

#### Module IV: Reduction

(9 Lectures)

Catalytic hydrogenation and hydrogenolysis of various functional groups by Pt<sub>2</sub>O, Pd/C, raney nickel, Homogeneous hydrogenation by transition metal complexes {Rh, Ru}, dissolving metal {Li, Na in Liq. NH<sub>3</sub>, Zn/HCl or CH<sub>3</sub>COOH}, non-metallic reducing agent {hydrazine, Et<sub>3</sub>SiH, Ph<sub>2</sub>SiH<sub>2</sub>, formic acid}, Metal hydrides-based Reduction: LiAlH<sub>4</sub>, alkoxyaluminate, DIBAL-H, NaBH<sub>4</sub>, NaBH<sub>3</sub>CN, LiBH<sub>4</sub>, Zn(BH<sub>4</sub>)<sub>2</sub>, NaBH<sub>4</sub>/CeCl<sub>3</sub>, alkoxy/alkyl borohydrides, super-hydride, selectrides, n-Bu<sub>3</sub>SnH

#### Module V: Selected Name reactions

(9 Lectures)

Biginelli reaction, Hantzsch reaction, Passerini reaction, Ugi reaction, McMurry olefination, Suzuki, Heck and Sonogashira coupling, Stille coupling, Mitsunobu reaction, Nef reaction, Ring closing metathesis (RCM) - Grubb's reaction, Larock Indole synthesis.

**Text books:**

1. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 2nd ed., Oxford Press, 2012.
2. I. L. Finar, Organic Chemistry, Vol. I & II, 5th ed., Longman Ltd., New Delhi, 2011.
3. R. S. Monson, Advanced Organic Synthesis, Academic Press, New York, 2012.

**Reference books:**

1. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th ed., 7th Indian Reprint, Pearson Education, 2005.
2. Jerry March, Advanced Organic Chemistry, Wiley, 7th ed., 2013
3. Carey and Sundberg, Advanced Organic Chemistry, Springer, 5th ed.; 2000

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>
<b>Quiz –I</b>	√	√		
<b>Quiz II</b>			√	
<b>End Sem Examination Marks</b>	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	M	L
CO3	H	H	M	L
CO4	H	H	M	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-2	L1-L09	1	Protection and deprotection	T1, T2	1	PPT Digi Class/Chock-Board
3-5	L10-L18	2	Hydroboration reactions	T1,T2,T3 R1,R3	1	-do-
6-8	L19-L27	3	Reagents for oxidation	T2, T3, R2, R3	1, 2	-do-
9-12	L28-L36	4	Reduction	T3,R1, R2,R3	3	-do-
13-15	L37-L45	5	Selected name reactions	T1,T2,T3, R1,R2, R3	2	-do-

**Course code:** CH 505 (SPL-II)  
**Course title:** Inorganic Chemistry-IX: Bio Inorganic Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To grow knowledge on elements of life
B.	To study the role of oxygen in biology and its reactivity
C.	To know about the Hydrolase and Oxido-Reductase Enzymes
D.	To study the role of metals in medicine

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the role of different elements in biology
2.	Able to explain the oxygen management and oxygen transport mechanism in biology
3.	Able to explain role of Hydrolase and Oxido-Reductase Enzymes
4.	Able to explain the role of metals in drug

## Syllabus

### Module I Basic Bio-inorganic Chemistry

(9 Lectures)

Elements of life, the natural selection of elements, metallo-biomolecules– enzymes and proteins, their differences, Metal ion storage and transport: Ferritin, metallothioneins, cerruloplasmin; Siderophores– enterobactin, transferin;  $\text{Na}^+$ ,  $\text{K}^+$  pump,  $\text{Ca}^{2+}$  transport.

### Module II Oxygen management and oxygen transport

(9 Lectures)

Kinetics of biological and non-biological oxygenation, Reactive Oxygen Species (ROS): Super oxide dismutase - Occurance, types, active site structure and mechanism of catalytic activity, Catalase, Peroxidase - Occurance, types, active site structure and mechanism of catalytic activity Cytochrome c Oxidase, Cytochrome P– 450- Occurance, types, active site structure and mechanism of catalytic activity. Natural Oxygen carriers: Heme Type: Myoglobins and Hemoglobins, Properties of heme and iron-porphyrins, The heme iron–dioxygen bond, Mechanism of dioxygen binding and model systems. Di-iron Type: Hemerythrins and Myohemerythrins : Early history and distribution of hemerythrins, Protein structure , The di-iron site and formulation of the  $\text{O}_2$  binding reaction, Mechanism of dioxygen binding, Autoxidation, Cooperative hemerythrins, Dicopper Type: Hemocyanins: Protein structure and superstructure, The dicopper site, Mechanism of dioxygen binding.

### Module III Hydrolase and Oxido-Reductase Enzymes

(9 Lectures)

Zn Carbonic Anhydrase, Zn Carboxy peptidase, Fe Acid Phosphatase, Ni Urease, Alcohol dehydrogenase- Occurance, types, active site structure and mechanism and model system. catalytic activity of Cu proteins for biological oxidation: Tyrosinase, Galactose oxidase, Catecholase, phenoxazinone synthase.

### Module IV Model Systems in Bioinorganic Chemistry

(9 Lectures)

Chemistry of Vitamin  $\text{B}_{12}$  , Iron– Sulphur proteins, Cytochromes, Nitrogenase- biological nitrogen fixation, molybdenum nitrogenase, Nitrogenase model systems, Hydrogenase and model systems, Metal complexes in transmission of energy- Chlorophylls & Photosynthetic Water Oxidation.



**Module V Metals in Medicine****(9 Lectures)**

Metal Toxicity and Homeostasis, Chelation Therapy, Vanadium-Based Diabetes Drugs, Pt based Anti-Cancer Drugs, Mechanism of cisDDP Antitumor Activity, Anti-arthritis drugs, Imaging Agents: Technetium Imaging Agents, Gadolinium MRI Imaging Agents, Gold containing drugs used in the therapy of Rheumatoid Arthritis, Lithium in psychopharmacological drugs.

**Text books:**

1. I. Bertini, H. B. Gray, S. J. Lippard, J. S. Valentine, Bioinorganic Chemistry, University Science Books, Mill Valley, CA, 1994.
2. W. Kaim, B. Schwederski, A. Klein, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide, Wiley, 1994.
3. L. Stryer, J. M. Berg, J. L. Tymoczko, 5th ed., W. H. Freeman & Co Ltd, 2002.

**Reference books:**

1. R. R. Crichton, Biological Inorganic Chemistry, 2nd ed., Elsevier, 2012.
2. R. M. Roat-Malone, Bioinorganic Chemistry: A Short Course, Wiley, 2002.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>
<b>Quiz –I</b>	√	√		
<b>Quiz II</b>			√	
<b>End Sem Examination Marks</b>	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

### Mapping between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-2</b>	L1-L09	<b>1</b>	Elements of life, the natural selection of elements, metallo-biomolecules– enzymes and proteins, their differences, Metal ion storage and transport	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	L10-L18	<b>2</b>	Oxygen management and oxygen transport, Reactive Oxygen Species	<b>T1, T3, R2</b>	<b>2</b>	<b>-do-</b>
<b>5-6</b>	L19-L27	<b>3</b>	Hydrolase and Oxido-Reductase Enzymes, Zn Carbonic Anhydrase, Zn Carboxy peptidase, Fe Acid Phosphatase, Ni Urease, Alcohol dehydrogenase-	<b>T1, T2, R1</b>	<b>3</b>	<b>-do-</b>
<b>7-10</b>	L28-L36	<b>4</b>	Model Systems in Bioinorganic Chemistry, Chemistry of Vitamin B <sub>12</sub> , Iron– Sulphur proteins, Cytochromes, Nitrogenase- biological nitrogen fixation	<b>T1, R2</b>	<b>4</b>	<b>-do-</b>
<b>11-15</b>	L37-L45	<b>5</b>	Metal Toxicity and Homeostasis, Chelation Therapy, Vanadium-Based Diabetes Drugs, Pt based Anti-Cancer Drugs, Mechanism of cisDDP Antitumor Activity, Anti-arthritis drugs, Imaging Agents	<b>T1, T2, R1</b>	<b>5</b>	<b>-do-</b>

**Course code:** CH 506 (SPL-II)  
**Course title:** Advanced Electrochemistry  
**Pre-requisite(s):** B.Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To learn electrode kinetics, corrosion and corrosion control.
B.	To know the principle and applications of electroanalytical, Spectro-electrochemical and spectroscopic techniques.
C.	To learn about the electrochemical energy systems used as power sources and for energy storage.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to calculate electrochemical kinetics parameters, exchange current density, Tafel slope.
2.	Familiar with the basic concepts of corrosion, factors which influence the corrosion and gain the knowledge about the control of corrosion in real situation.
3.	Familiar with electrochemical techniques like cyclic voltammetry, polarography, chrono methods, electrochemical impedance spectroscopy.
4.	Familiar with the reversible and irreversible cells and their applications in various fields and able to distinguish batteries, fuel cells and capacitors.

### Syllabus

#### Module I: Electrode Kinetics

(9 lectures)

Mass transfer by Diffusion and Migration – models of electrode reactions – current potential characteristics–general mass transfer equation. Kinetics of an electrode reaction, Butler-Volmer equation, diffusion overpotential. Exchange current density, Tafel plot. Polarizable and non-polarizable interfaces. Irreversible electrode processes.

#### Module II: Corrosion

(9 lectures)

Different types of corrosion; Evans diagram, Pourbaix diagram; Corrosion current and Corrosion potential; Measurement of corrosion rate; Stern Geary equation; Mixed potential theory and prevention of corrosion.

#### Module III: Electroanalytical Techniques

(10 lectures)

*Potential Step Methods:* Types of techniques, step under diffusion control, Ilkovic equation–polarographic analysis–sampled current voltammetry, reversible, irreversible processes, multicomponent systems. *Chrono Methods:* Chronoamperometry, chronocoulometry. *Pulse polarographic methods:* *Potential Sweep Methods:* Cyclic Voltammetry; *Bulk Electrolysis Techniques:* Classification of methods–Controlled Potential methods: current – time behaviour, electrogravimetry, electroseparation–Coulometric measurements: controlled current methods: characteristics, coulometric methods–Electrometric end point detection: classification, potentiometric, amperometric methods.

#### Module IV: Spectro-electrochemical and spectroscopic techniques

(7 lectures)

Impedance Spectroscopy, Scanning Electrochemical Microscopy, Electrochemical AFM and STM, Electrochemical Quartz Crystal Microbalance.

**Module V: Electrochemical Energy Systems****(10 lectures)**

Electrochemical power sources - theoretical background on the basis of thermodynamic and kinetic considerations. Primary cells, secondary cells- magnesium and aluminium based cells magnesium reserve batteries, Li-ion batteries. Fuel cells - classification - chemistry of fuel cells - detailed description of hydrogen/oxygen fuel cells - methanol - molten carbonate solid polymer electrolyte and biochemical fuel cells. Photoelectrochemical cells, Electrochemical supercapacitors for energy storage.

**Text books:**

1. J.O'M. Bockris & A. K. N. Reddy, Modern Electrochemistry, Vol. 1 & 2A and 2 B, Plenum Press, New York, 2000.
2. A. J. Bard and L. R. Faulkner, Electrochemical methods, Wiley & Sons, 2nd ed., 2001.
3. S. Glasstone, Introduction to Electrochemistry, East West Press, reprint 2007.

**Reference books:**

1. D. R. Crow, The Principle of electrochemistry, Chapman Hall, 4th ed. 1994.
2. H. Kissinger, Electroanalytical Techniques, John wiley, 1998.
3. P. H. Reiger, Electrochemistry, Prentice Hall, 1987.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√	√	
Quiz –I	√			
Quiz II		√	√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	H	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	H	H	H	L

**Mapping Between COs and Course Delivery (CD) methods:**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO 2, 3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO1, 2, 3, 4	CD6
CD7	Simulation	CO1	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Electrode Kinetics	T1, T2 T3	1	PPT Digi Class/Chock-Board
3-5	L10-L18	2	Corrosion	T1,T3 R1	2	-do-
6-10	L19-L27	3	Different Electroanalytical Techniques	T1,T2, R2	3	-do-
11	L28-L36	4	Spectroelectrochemical Techniques	T1, T2	3	-do-
12-15	L37-L45	5	Electrochemical Energy Systems	T1, T2, R2, R3	4	-do-

**Course code:** CH 507 (SPL-II)  
**Course title:** Selected Topics in Organic Synthesis  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T:1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To know about advance spectroscopy of complex molecules
B.	To understand details on neighbouring group participation with mechanism
C.	To get idea about asymmetric synthesis using various catalyst
D.	To learn about retrosynthetic principle and approach

### Course Outcomes

After the completion of this course, students will be:

1.	Able to understand and identify the advance spectroscopy of complex molecules
2.	Able to explain the neighbouring group participation process and its mechanism
3.	Able to use the knowledge of asymmetric synthesis during the use of various catalyst
4.	Able to consider retrosynthetic approach during research and development

## Syllabus

### Module I: Advanced Stereochemistry

(9 Lectures)

Optical isomerism in compounds without any stereocenters (allenes, biphenyls), Enantiomerism in allenes, alkylidene cycloalkane, spiranes- configurational nomenclature, correlation of axial dissymmetry and centrodissymmetry, Stereochemistry of natural products, strychnine, podophyllotoxin, Conformation and reactivity of fused polycyclic systems: perhydrophenanthrenes.

### Module II: Neighboring Group Participation

(9 Lectures)

Concept of neighboring group participation with mechanism, neighboring group participation by  $\pi$  &  $\sigma$  bonds, classical and non-classical carbocations, Intramolecular displacement by hydrogen, Oxygen, nitrogen, sulphur and halogen. Anchimeric assistance using Alkyl, cycloalkyl, Aryl participation, participation in bicyclic system, migratory aptitude, intimate and solvent separated ion-pair, transannular, pinacol and carbocation rearrangements and related rearrangements in neighboring group participation, NGP in elimination and addition.

### Module III: Catalytic Asymmetric Synthesis

(9 Lectures)

Sharpless epoxidation and dihydroxylation; asymmetric cyclopropanation; asymmetric hydrogenation, Enzyme catalyzed asymmetric synthesis, CBS reduction, Reactions using Chiral Lewis Acids and Bronsted Acids, Hydrosilylation of Carbon-Carbon Double bonds and Related Reactions, Synthesis via C-H Activation: Introduction, types of C-H activation, oxidation of alkanes, addition of C-H bond to C-C double bonds, C-H activation in natural product synthesis.

**Module IV: Principles of Retrosynthesis****(9 Lectures)**

Methodologies in organic synthesis-basic ideas on synthons and synthetic equivalents, disconnection approach, functional group transformations and inter-conversions of simple functionalities, Disconnection Approaches, Functional Group Interconversions (FGI). Concept of synthetic efficiency: one pot, multi-component and atom economical reactions. linear and convergent synthesis.

**Module V: Retrosynthetic analysis****(9 Lectures)**

One group disconnections, Reactions examples One group C-C and C-X disconnection, Umpolung of reactivity and protecting groups. Two group C-C disconnections, Diels-Alder reaction, 1,3-difunctionalised compounds,  $\alpha$ ,  $\beta$ -unsaturated carbonyl compounds, control in carbonyl condensation, 1,5-difunctionalised compounds. Michael addition and Robinson annelation, Retrosynthetic analysis and synthetic design of Tamiflu and Reserpine.

**Text books:**

1. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications; New Age International Publishers, 2018
2. M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanism and Structure, 7ed, Wiley, 2015.
3. W. Carruthers, I. Coldham, Some modern methods of Organic Synthesis, 4th ed., Cambridge Univ. Press, 2015.
4. S. Warren, Organic Synthesis: The Disconnection Approach, Wiley 2007

**Reference books:**

1. E. L. Eliel, Stereochemistry of Organic Compounds, Wiley, 2008
2. S. Warren, P. Wyatt Workbook for Organic Synthesis: The Disconnection Approach, 2nd ed., Wiley, 2010.
3. Norman and Coxon, Principle of Organic Synthesis, 3rd ed., CRC Press, 1993.
4. I. Ojima, Catalytic Asymmetric Synthesis, 3rd ed, John Wiley & Sons, New Jersey, 2010.
5. V. Sunjic, V. P. Perokovic; Organic Chemistry from Retrosynthesis to Asymmetric Synthesis, Springer, 2016

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>



Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>TextBook /References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	L1-L09	<b>1</b>	Advanced Stereochemistry	<b>T1, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock -Board</b>
<b>3-5</b>	L10-L18	<b>2</b>	Neighboring Group Participation	<b>T2, R3</b>	<b>1</b>	<b>-do-</b>
<b>5-8</b>	L19-L27	<b>3</b>	Catalytic Asymmetric Synthesis	<b>T1, T2 R4</b>	<b>2</b>	<b>-do-</b>
<b>8-10</b>	L28-L36	<b>4</b>	Principles of Retrosynthesis	<b>T4, R2, R5</b>	<b>3</b>	<b>-do-</b>
<b>10-12</b>	L37-L45	<b>5</b>	Retrosynthetic analsis	<b>T4, R2, R5</b>	<b>3</b>	<b>-do-</b>

**Course code: CH 508**

**Course title: Advanced Characterization Lab**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co- requisite(s):**

**Credits: 2      L: 0      T: 0      P: 4**

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. III/ I. M. Sc. IX**

**Branch: Chemistry**

**Name of Teacher:**

## **Syllabus**

- I: Examples of organic sample characterization by UV-VIS, IR, NMR, Mass, CHN, mp and single crystal diffraction techniques.
- Experiment 1: Synthesis and characterization of sugar intermediates using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.
- Experiment 2: Synthesis of Nucleo-base analogs and characterization using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.
- Experiment 3: Synthesis of Benzanilide and characterization using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.
- II: Examples of bimolecular and polymeric materials characterization using Intense Viscosity Measurement, Molecular Weight Determination and Distribution using GPC, Light Scattering Technique, FTIR, NMR, SEM, XRD
- Experiment 1: Determination of  $T_g$  and  $T_m$  of Polyvinyl chloride and methylmethacrylate polymer using TGA/DSC.
- Experiment 2: Study of surface morphology of polymeric material /hybrid materials using XRD and SEM.
- Experiment 3: Finding out molecular weight of PMMA using light-scattering/GPC.
- III: Examples of inorganic sample characterization
- Experiment 1: Thermogravimetric analysis of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
- Experiment 2: Synthesis & characterization of Fluorescent Zn complexes by spectrofluorometer.
- Experiment 3: Study of surface morphology of inorganic materials using XRD and SEM.

## **Reference book:**

1. V. R. Gowariker, N. V. Viswanathan & J. Sreedhar, Polymer Science, New Age International (P) Ltd. Publishers, 1986.
2. W. Kemp, Organic Spectroscopy, Palgrave, Reprint 2009.
3. Suryanarayana, C.; Norton, M. G. X-Ray Diffraction - A Practical Approach, Springer Publishers, 1998.
4. Lyman, C. E. et al., K.-R. Scanning Electron Microscopy, X-Ray Microanalysis, and Analytical Electron Microscopy, Springer Publishers, 1990.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 509  
**Course title:** Inorganic Chemistry (SPL) Lab  
**Pre-requisite(s):** B.Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      L:      T:      P: 4  
**Class schedule per week:** 04  
**Class:** M.sc. and I M.Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Determination of conductivity of 1:1, 1:2 and 1:3 complexes.
2. Kinetics of Hg(II) catalysed reaction of  $[\text{FeCN}_6]^{4-}$  with 1,10-*ortho* phenonthroline and its application in the determination of trace quantity of Hg(II).
3. Study of the conductance of  $\text{H}[\text{Co}(\text{DMGH})_2\text{Cl}_2]$  in freshly prepared aqueous solution and its change with time for studying the rate of aquation.
4. pH metric determination of Proton- Ligand and Metal-Ligand stability constants.
5. Colorimetric study of the kinetics of the reduction of azidopentaminecobalt(III) chloride by aqueous Fe(II) ion.
6. Colorimetry: Simultaneous determination of chromium and manganese in a solution by visible spectroscopy.
7. Spectrofluorometric determination of lanthanide elements in dilute solution.
8. Quantitative determination of DNA–Ligand binding using fluorescence spectroscopy.
9. Determination of magnetic moment of the lanthanides by Gouy's method.
10. Use of ligand field tetragonality on the ground state spin of Ni(II) complexes.
11. Determination of formal potential of electronically non-innocent ligands.
12. Determination of formal potential of metal complexes.

## Reference books:

1. M. V. Cases, Principles of analytical chemistry, Springer, 2000.
2. D. Harvey, Modern Analytical Chemistry; Mcgraw-Hill, 2000.
3. A. J. Bard and I. Rubinstein, Electroanalytical Chemistry, CRC Press, 1998.
4. Electroanalytical Chemistry: A Series of Advances: Volume 24, A. J. Bard and C. Zoski, CRC Press, 2017.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 510  
**Course title:** Physical Chemistry (SPL) Lab  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. To determine pH of a buffer solution using quinhydrone electrode.
2. Oscillatory reaction: Chemical oscillation & pattern formation in B-Z system.
3. To study the phase diagram of two components forming a simple eutectic.
4. To determine the molecular weight of a polymer from viscosity measurements.
5. To determine magnetic susceptibility by Guoy balance.
6. To determine the surface area of alumina by BET surface area determination method.
7. To determine the solubility product by conductivity and potentiometric methods.
8. Stability constants of complexes by the use of pH meter, potentiometric method.
9. Reversibility of an electrochemical reactions and determination of concentration of a given reducible ion-Polarography.
10. To determine the Tafel constants, the corrosion current and the linear polarisation resistance from polarisation curves.
11. Electrochemical impedance spectroscopy (EIS) study and formation of equivalent circuit diagram.
12. To determine the effect of change of temperature, concentration of reactant and catalyst and ionic strength of the media on the velocity constant of hydrolysis of an ester.

### Text books:

1. B. Viswanathan, and P. S. Raghavan, Practical Physical Chemistry, Viva Books, 2010.
2. J. B. Yadav, Advanced Practical Physical Chemistry, 22<sup>nd</sup> edition, Goel publishing House, Krishna Prakashan Media Ltd. 2005.
3. V. Venkatesan, R. Veeraswamy and A.R. Kulandaivelu, Basic Principles of Practical Chemistry, 2nd ed., Sultan Chand and Sons Publication, New Delhi. 1997.
4. D. Harvey, Modern Analytical Chemistry; Mcgraw-Hill, 2000.

### Reference books:

1. B. P. Levitt, Findlays Practical Physical Chemistry, 9th ed., Longman, London, 1985.
2. G. R. Chatwal and S. K. Anand, Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi, 2000.
3. A. M. Halpern and G. C. McBane, Experimental Physical Chemistry: A Laboratory Text Book, 3rd ed., W. H. Freeman, 2006.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 511  
**Course title:** Organic Chemistry (SPL) Lab  
**Pre-requisite(s):** B.Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:**2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** M.Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Synthesis of alcohol from the reaction of a Grignard reagent and a ketone.
2. Synthesis of an alkene from dehydration of the alcohol prepared in previous step.
3. Multi-step reactions, (Cyclohexanone to methyl cyclohexane) using i) Grignard reaction ii) Dehydration iii) High-pressure hydrogenation.
4. Anthranilic acid from phthalic anhydride.
5. Synthesis of Nylon 6 starting from cyclohexanone.
6. Characterization of an organic compound through CHN, Mass, FTIR, NMR and single crystal X-ray diffraction.

## Reference Books:

1. A. I. Vogel, Quantitative Organic Analysis, Part 3, Pearson, 2012.
2. F. G. Mann, & B. C. Saunders, Practical Organic Chemistry, Pearson Education, 2009.
3. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Practical Organic Chemistry, 5th ed., Pearson, 2012.
4. V. K. Ahluwalia and R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2000.
5. V. K. Ahluwalia and S. Dhingra, Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press, 2000.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code: CH 513 (SPL-III)**

**Course title: Inorganic Chemistry-X: Inorganic Photochemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co- requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. IV/ I. M. Sc. X**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the photolytic excited state
B.	To know the techniques to study the excited state
C.	To learn the photochemistry of polypyridyl complexes and porphyrins
D.	To know the application of inorganic photochemistry

### Course Outcomes

After the completion of this course, students will be:

1.	To explain photochemical excited state
2.	To determine the properties of the excited state
3.	To explain the photochemical properties of polypyridyl complexes and porphyrins
4.	To explain the application of inorganic photochemistry

## Syllabus

### Module I Photophysical properties of excited state

(9 Lectures)

Absorption spectra and electronic transitions, Assignment of electronic transitions, Charge transfer transition, Radiative decay, Non-radiative decay and the energy gap law, Classification of the excited state- MLCT, MC & LC excited state, Reactivity pattern of the excited state, Electronic excited state of  $d^3$  and  $d^6$  complexes, Solvent effects and dipole moment of the excited state, Acid- base reactions of the excited states.

### Module II Photochemical reactions and techniques for the study of excited state (9 Lectures)

Bimolecular quenching of the excited state, Energy and electron transfer quenching, Energetics, Photoredox reactions of metal complexes - Thermal electron transfer process: Classical treatment and self exchange type, Energy transfer reactions of the excited state, Excited state acid-base reactions, Photoinduced electron transfer, Photoinduced energy transfer (Forster and Dexter mechanism), Characterization of the excited state by steady state methods and Time-Resolved methods (Flash Photolysis), Time resolved conductivity, Electron spin resonance, Photoselection, Study photo-redox and energy transfer reactions, Study of the photosubstitution reactions.

### Module III Photochemistry of the Polypyridyl complexes and porphyrins (9 Lectures)

Polypyridyl ligands as chelating agents, Free ligand and metal complexes excited state, Ground and excited state redox properties, General trends in polynuclear and ortho-metallated complexes, Polypyridyl complexes of Fe, Ru, Os, Cr and Cu Photochemical applications of Polypyridyl complexes: Catalysed photodecomposition of  $H_2O$  to  $H_2$ , and  $O_2$ , Catalysed photoreduction of CO and  $CO_2$ ,  $Ru(bpy)_3^{2+}$  as dye for DSSC.

### Module IV Photochemistry of Porphyrins

(9 Lectures)

Introduction to porphyrin, Types of porphyrin and their general features, Classification based on peripheral substitution, Reduced porphyrins, Electronic spectroscopy of metalloporphyrin- Classification

based on absorption and emission spectral feature, Description on metalloporphyrin ground and excited state, Different types of excited states of porphyrins.

Resonance Raman spectra of metalloporphyrins, Hypso porphyrins: luminiscent type- Cu Porphyrin, Ag Porphyrin, Phosporescent type- Au Porphyrins, Pt Porphyrins, Pd Porphyrins, Rh Porphyrins, Ru Porphyrins, Os Porphyrins; Radiationless Hypso Porphyrins: Fe and Co Porphyrins, Hyper porphyrine: d type- Cr and Mn Porphyrins, p Type-Metalloid porphyrins; Pseudo normal Porphyrins-Lanthanide porphyrins..

#### **Module V Application of Inorganic Photochemistry**

**(9 Lectures)**

Environment cleaning: Photocatalytic reactions of volatile hydrocarbons, Photocatalytic activity of  $\text{TiO}_2$  in cleaning air pollutants, Photocatalyst based air purifying materials.

Porphyrin and photosynthesis, Active site structure of Chlorophyl, Accessory Pigments and Extended Range of Light Absorption, Exciton Transfer; Central Photochemical Event: Light-Driven Electron Flow, The Pheophytin-Quinone Reaction Center, Functional modules of photosynthetic machinery- Z Scheme, Biomimetic energy production- Artificial photosynthesis, Photosynthetic cell, Dye Sensitised Solar Cell, Tandem Cell.

#### **Text books:**

1. K. Kalyanasundaram, Photochemistry of Polypyridine and Porphyrin Complexes; Academic Press Limited: London, 1992.

#### **Reference books:**

1. M. Kaneko, I. Okura, Photocatalysis: Science and Technilogy, Springer
2. E. A. B. Ebsworth, D. W. H. Rankin, S. Cardock, Structural methods in Inorganic Chemistry; 2nd ed., Wiley-Blackwell, 1991.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a commitee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>



Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz –I	√	√		
Quiz-II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-2</b>	L1-L09	<b>1</b>	Photophysical properties of excited state	<b>T1, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	L10-L18	<b>2</b>	Photochemical reactions and techniques for the study of excited state	<b>T1, R2</b>	<b>2</b>	<b>-do-</b>
<b>7-8</b>	L19-L27	<b>3</b>	Photochemistry of the Polypyridyl complexes and porphyrins	<b>T1, R1</b>	<b>3</b>	<b>-do-</b>
<b>8-13</b>	L28-L36	<b>4</b>	Photochemistry of Porphyrins	<b>T1</b>	<b>4</b>	<b>-do-</b>
<b>13-15</b>	L37-L45	<b>5</b>	Application of Inorganic Photochemistry	<b>T1, R1</b>	<b>5</b>	<b>-do-</b>

**Course code:** CH 514 (SPL-III)  
**Course title:** Chemical Applications of Group Theory  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. IV/ I. M. Sc. X  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To apply the great orthogonality theorem to derive simple point groups and illustrate its use in the applications in crystal field theory, pericyclic reactions and molecular spectroscopy.
----	---

### Course Outcomes

After the completion of this course, students will be:

1.	Able to determine the symmetry operations of any small and medium-sized molecule and apply point group theory to the study of electrical, optical and magnetic properties and selection rules for absorption.
----	---

### Syllabus

#### Module I: Molecular Vibrations

(9 lectures)

Group theory and normal modes of vibrations of polyatomic molecules. Procedure for determining the irreducible representation of the vibrational modes for H<sub>2</sub>O, NH<sub>3</sub> molecules. Selection rules for fundamental vibration transition.

#### Module II: Molecular Orbital (MO) Theory & its Application in Organic Chemistry

(9 lectures)

Symmetry factoring of secular equations, carbocyclic system, LCAO-MO  $\pi$ -bonding for naphthalene & formaldehyde. Electronic excitation, Selection Rule and Configuration interaction, Three-centre bonding, Symmetry-based selection rule for cyclization reaction.

#### Module III: MO Theory for Inorganic & Organometallic Compounds

(9 lectures)

Transform properties of atomic orbitals, hybridization scheme for  $\sigma$  &  $\pi$  bonding orbitals; MO theory for AB<sub>n</sub>-type of molecules and regular octahedral and tetrahedral molecules.

#### Module IV: Ligand Field Theory

(9 lectures)

Electronic structure of free atoms and ions; Splitting of levels and terms in chemical environment, Construction of energy level diagrams; Estimation of orbital energy; Selection rules and polarization; Double groups.

#### Module V: Crystallographic Symmetry

(9 lectures)

Two-dimensional space symmetries; Three-dimensional and their symmetries; Crystal symmetry; Interrelating lattice symmetry, crystal symmetry & diffraction symmetry; Additional symmetry elements & operations; Space groups and X-ray crystallography.

#### Text books:

1. F. A. Cotton, Chemical Applications of Group Theory, 3rd ed., Wiley Eastern Limited, 1985.
2. V. Ramakrishnan and M. S. Gopinathan: Group Theory in chemistry, Vishal Publication, 1986.

#### Reference books:

1. P. Atkins, R. Friedman, Molecular Quantum Mechanics, 4th ed., Oxford University Press, 2005.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1
Assignment	√
Quiz -1	√
Quiz II	√
End Sem Examination Marks	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	H	L

### Mapping between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO 1	CD1
CD2	Tutorials/Assignments	CO 1	CD1, 2
CD3	Seminars	CO 1	CD3
CD4	Mini projects/Projects	CO 1	CD4
CD5	Laboratory experiments/teaching aids	CO 1	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO 1	CD6
CD7	Simulation	CO 1	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Group Theory and normal modes of vibration for polyatomic molecules	T1, T2,R1	1	PPT Digi Class/Chock -Board
3-5	L10-L18	2	Molecular Orbital (MO) Theory and its Application	T1, T2,R1	1	-do-
6-10	L19-L27	3	MO Theory for Inorganic Compound	T1, T2,R1	1	-do-
11	L28-L36	4	Ligand Field Theory	T1, T2,R1	1	-do-
12-15	L37-L45	5	Crystallographic Symmetry	T1, T2,R1	1	-do-

**Course code:** CH 515 (SPL-III)  
**Course title:** Interdisciplinary Organic Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. IV/ I. M. Sc. X  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the structure and functions of Carbohydrate, peptides, proteins, flavonoids, terpenoids and steroids in biological system. How to differentiate reducing and non-reducing sugars.
B.	Study reactions involving peptide synthesis, biosynthesis of Steroids.
C.	To understand polymer chemistry including Properties of polymers, Methods of polymerization and processing.
D.	To design safer chemicals, safer solvents and auxiliaries, energy efficient reactions for Green synthesis.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain structure and functions of Carbohydrate, peptides, proteins, flavonoids, terpenoids and steroids.
2.	Able to explain properties of polymers, their methods of preparation and processing.
3.	Able to design safer chemicals, safer solvents and auxiliaries, energy efficient reactions for Green synthesis
4.	Able to explain the principles of green chemistry

## Syllabus

### Module I: Carbohydrate chemistry

(10 Lectures)

Biological importance of monosaccharides (aldohexose-glucose, mannose, galactose; epimers; ketohexose-fructose; aldopentose-ribose; deoxysugars-deoxyribose; fucose; rhamnose), polysaccharides (cellulose, glycogen, starch, chitin, agar), Glycoprotein, proteoglycan, glycosaminoglycan, muramic acid, sialic acid. Molish's test for carbohydrate, reaction of monosaccharides with nitric acid, bromine water, periodic acid and phenylhydrazine, osazone formation, reaction of deoxyribose with DPA and reaction of ribose with orcinol reagent; glycosidic linkage, disaccharides (sucrose-invert sugar, inversion of sucrose, maltose and lactose) reducing and non-reducing sugar (tests for reducing sugars, reaction with Benedict's reagent, Fehling's solution, Tollen's reagent, Seliwanoff test for ketose)

### Module II: Peptide Chemistry

(10 Lectures)

Example of biologically important peptides and their functions in brief (glutathione-peptide of non-protein origin), Merrifield solid-phase peptide synthesis using protection/ deprotection protocol (brief outline). Deprotection and racemization in peptide synthesis. Solution and solid phase techniques. Proteins: Definition & structure, primary, secondary, tertiary and quaternary structure (definition and example), structure of globular protein (albumin, globulin, haemoglobin & myoglobin – Structure, function and occurrence in brief) Behaviour of proteins in solutions, salting in and salting out, Denaturation and renaturation of proteins (example -RNase), absorbance of proteins, example of metalloprotein, lipoprotein.

**Module III: Natural Product Chemistry****(9 Lectures)**

Flavonoid Chemistry: Anthocyanins, Flavonols and flavones; Quinone chemistry. Terpenoids: Structure and Methods for Structure elucidation. Biosynthesis of Terpenoids: Gibberellins. Acyclic (Squalene), Lanosterol, Ursolic acid & Oleanolic acid. Alkaloid Chemistry: Opium, Ergot, Rauwolfia and Vinca alkaloids. Cyanogenic glycosides, Indoles and Chlorophylls. Steroid chemistry: Introduction & Biosynthesis of Steroids. Phytosterols, Saponins & Sapogenins, Cardiotonic glucosides, Steroidal alkaloids: Solanum and Kurchi alkaloids.

**Module IV: Polymer Chemistry****(8 Lectures)**

Methods of polymerization: Bulk, solution, suspension, emulsion, Addition, Melt and condensation. Properties of polymers: Viscosity, end-group analysis, hardness, abrasion resistance, crystallinity glassy state, glass transition temperature ( $T_g$ ) and melting point ( $T_m$ ). Additives in polymers: Plasticizers, stabilizers, antioxidants, fillers, pigments. Polymer processing: Compounding, calendaring, die/rotational/film casting, injection molding, extrusion molding, thermoforming, foaming and reinforcing.

**Module V: Green Chemistry****(8 Lectures)**

Introduction to the principles of green chemistry – prevention of waste, atom economy, less hazardous chemical syntheses, designing safer chemicals, safer solvents and auxiliaries, design for energy efficiency, reduce derivatives, renewable feedstock, catalysis, design for degradation, Green synthesis, clean routes, supercritical solvents, ionic liquids, Catalysis in green chemistry.

**Text books:**

1. I. L. Finar Organic Chemistry Vol. II., Stereochemistry and the Chemistry Natural Products, 5th ed., Longman Ltd., New Delhi, 2011.
2. A. Ravve, Principles of Polymer Chemistry, Plenum Press, New York, Springer 3<sup>rd</sup> Edition, May 2012.
3. V. R Gowarikar, Vishwanathan Srikanth, Polymer Chemistry, Wiley Eastern, Bombay, 2000.
4. V. K. Ahluwalia, Green Chemistry: Greener Alternatives to Synthetic Organic Transformations- Narosa Publishing House.

**Reference books:**

1. T.K. Lindhorst: Essentials of Carbohydrate Chemistry and Biochemistry, 3rd ed., Wiley-VCH, Weinheim 2007.
2. P. D. Bailey, An Introduction to Peptide Chemistry; Wiley-Blackwell; Revised ed. edition (22 April 1992)
3. S. V. Bhat, B. A. Nagasampagi, M. Shivakumar: Chemistry of Natural Products; Narosa Publishing House; Revised edition (27 September 2013)
4. V. K. Ahluwalia, Anuradha Mishra Polymer Science:, Ane Books Pvt. Ltd.
5. M. Lancaster, Green Chemistry: In Introductory Text, RSC Publishing, 2010

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

### Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

#### Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√	√	
Quiz -1	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

#### Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	M	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	L	H

#### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3



CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

#### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
<b>1-3</b>	L1-L09	<b>1</b>	Carbohydrate Chemistry	<b>T1, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-6</b>	L10-L18	<b>2</b>	Chemistry of Peptide and Proteins	<b>T1, R2</b>	<b>1</b>	<b>-do-</b>
<b>7-9</b>	L19-L27	<b>3</b>	Natural Product Chemistry	<b>T1, R3</b>	<b>2</b>	<b>-do-</b>
<b>10-12</b>	L28-L36	<b>4</b>	Polymer Chemistry	<b>T2, T3, R4</b>	<b>3</b>	<b>-do-</b>
<b>13-15</b>	L37-L45	<b>5</b>	Green Chemistry	<b>T4, R5</b>	<b>4</b>	<b>-do-</b>

**Foudation Science (FS)  
for  
Integrated MSc Programme**

**Course code:** CH 111  
**Course title:** General Chemistry-I  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** B. Sc.  
**Level:** I  
**Branch:** Chemistry  
**Name of Teacher:**

## Course Objectives

This course enables the students:

A.	To understand the structure of atom at electronic level
B.	To develop knowledge on the physical and chemical properties of the atoms
C.	To create concept of interaction of atomic orbitals
D.	To understand the basics of organic chemistry including stereochemistry perspectives

## Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the properties of the atoms quantum mechanically and calculate the atomic parameters
2.	Able to predict the chemical reactivity
3.	Able to explain the interaction between atoms
4.	Able to explain the organic reaction mechanism

## Syllabus

### Module I: Atomic Structure

(9 Lectures)

Bohr's theory, Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle, Schrödinger's wave equation, significance of  $\psi$  and  $\psi^2$ . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule, Aufbau's principle, Variation of orbital energy with atomic number.

### Module II: Periodicity of Elements

(9 Lectures)

*s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of properties of the elements with reference to *s* and *p*-block. Shielding effect, Slater rules, variation of properties in periodic table. Atomic & Ionic radii (van der Waals), Ionization enthalpy, electron gain enthalpy, Electronegativity, hybridization, group electronegativity. Sanderson's electron density ratio.

### Module III: Basics of Organic Chemistry

(9 Lectures)

Organic Compounds: Classification, Nomenclature, Hybridization, Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation, Dipole moment. Organic acids and bases. Homolytic and Heterolytic fission, arrow rules, Electrophiles and Nucleophiles; Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

### Module IV: Chemical Bonding

(9 Lectures)

*Ionic bond*: Radius ratio rule, Packing of ions in crystals. Born-Landé equation, Madelung constant, Born-Haber cycle. *Metallic Bond*: valence bond and band theories, defects in solids. *Weak Chemical Forces*: Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Hydrogen bonding. *Covalent bond*: Lewis structure, Valence Bond theory, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic

molecules, Valence shell electron pair repulsion theory (VSEPR), multiple bonding. Fajan's rules and consequences of polarization.

### Module V: Stereochemistry

(9 Lectures)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: *cis-trans* and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

#### Text books:

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B. E. and McDaniel, D. H. Concepts & Models of Inorganic Chemistry Oxford, 1970
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

#### Reference books:

1. Atkins, P. W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
2. Day, M. C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
3. Rodger, G. E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
4. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

### Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

#### Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	H	L

**Mapping between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
	<b>L1-L9</b>	<b>1</b>	Atomic Structure	<b>T1, T3, R3</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
	<b>L10-L18</b>	<b>2</b>	Periodicity of Elements	<b>T1, T3, R3</b>	<b>1</b>	<b>-do-</b>
	<b>L19-L27</b>	<b>3</b>	Basics of Organic Chemistry	<b>T1, T5</b>	<b>2</b>	<b>-do-</b>
	<b>L28-L36</b>	<b>4</b>	Chemical Bonding	<b>T3, R1,R2</b>	<b>3</b>	<b>-do-</b>
	<b>L37-L45</b>	<b>5</b>	Stereochemistry	<b>T5, R4</b>	<b>4</b>	<b>-do-</b>

**Course code:** CH 112  
**Course title:** General Chemistry- I Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 04  
**Class:** B. Sc.  
**Level:** II  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

### (A) Titrimetric Analysis

- (i) Calibration and use of apparatus
- (ii) Preparation of solutions of different Molarity/Normality of titrants

### (B) Acid-Base Titrations

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

### (C) Purification of organic compounds by crystallization using the following solvents:

- a. Water
- b. Alcohol
- c. Alcohol-Water

(D) Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

### Reference book:

- Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009).

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 213  
**Course title:** General Chemistry-II  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** B. Sc.  
**Level:** II  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To differentiate the states of matter based on molecular level interactions
B.	To understand the concept of ideal and real gases from the molecular level energetics
C.	To grow knowledge on the hybridization, bonding and structural properties of the molecules
D.	To create concept of molecular orbital, arrow in mechanism, with 3D structural understanding.
E.	To know the process of reaction driven by nucleophiles and electrophiles

### Course Outcomes

After the completion of this course, students will be:

1.	Able to derive the Van der Waals equation of state and explain the deviation of real gases from ideal gases
2.	Able to analyse surface tension and viscosity coefficient of liquids
3.	Able to calculate pH/pKa, degree of ionization, dissociation constant, solubility product of electrolytes
4.	Able to explain the interaction between reaction intermediates
5.	Able to predict and analyses the configuration and conformation of molecules

## Syllabus

### Module-I: States of Matter

(9 Lectures)

Gaseous state: Kinetic theory of gas, Maxwell distribution equation, *Ideal & real gases*, compressibility factor, Z. Van der Waals equation of state, Boyle temperature. Continuity of states, critical state, law of corresponding states. Liquid state: Physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity. Solid state: Miller indices, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law. Analysis of powder diffraction patterns

### Module-II: Ionic Equilibria

(9 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salt. Qualitative treatment of acid – base titration curves. Theory of acid-bases; Arrhenius, Bronsted Lowry, Lewis concept, SHAB, solvent systems; selection of indicators and their limitations. Hydrolysis and hydrolysis constants.



**Module-III: Chemistry of Aromatic Hydrocarbons****(9 Lectures)**

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: Isotopic effect, halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism & energy diagram,. Directing effects of the groups.

**Module-IV: Oxidation-Reduction****(8 Lectures)**

Galvanic cells and electrolytic cells, Daniel cell, different kind of half-cells, electromotive forces of a cell and its measurement, Nernst equation, Redox equilibrium, Standard Electrode Potential and its application to inorganic reactions, different types of galvanic cells, Thermodynamics of electrochemical cells and applications, Potentiometric titrations to determine various equilibrium constants.

**Module-V: Chemistry of Aliphatic Hydrocarbons****(10 Lectures)**

Carbon-Carbon sigma bonds: Chemistry of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation. Carbon-Carbon pi bonds: elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, *e.g.* propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. Alkanes & Cycloalkanes: Types, Conformational Analysis, relative stability & Energy diagrams.

**Text books:**

1. Kapoor, K. L. A Textbook of Physical Chemistry, Volume 1, Mcmillan Publishers India Ltd, 2004
2. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University Press (2014).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

**Reference books:**

1. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
2. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
3. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson (2013).
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Teacher's Assessment	5
Mid Sem	25
Two Quizzes	10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem	√	√		
Assignment	√	√	√	
Quiz -1	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	H	L	L
CO5	H	H	L	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-4	L01-L09	1	States of Matter	T1, T2, R1, R2, R4	1	PPT Digi Class/Chock-Board
5-6	L10-L18	2	Ionic Equilibrium	T1, T4, R1	2	-do-
7-9	L19-L28	3	Chemistry of Aliphatic Hydrocarbons	T3, T5, R3	3	-do-
10-13	L29-L36	4	Oxidation Reduction	T1, T4, R1, R2, R3	4	-do-
14-15	L37-L45	5	Chemistry of Aromatic Hydrocarbons	T3, T5, R3	2	-do-

**Course code:** CH 214  
**Course title:** General Chemistry- II Lab  
**Pre-requisite(s):** Intermediate level chemistry  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 3  
**Class schedule per week:** 04  
**Class:** B. Sc.  
**Level:** II  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Surface tension measurements.
  - a. Determine the surface tension by (i) drop number (ii) drop weight method.
  - b. Study the variation of surface tension of detergent solutions with concentration.
2. Viscosity measurement using Ostwald's viscometer.
3. Indexing of a given powder diffraction pattern of a cubic crystalline system.
4. pH metry
  - a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
  - b. Preparation of buffer solutions of different pH
  - c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
  - d. Determination of dissociation constant of a weak acid.
5. Oxidation-Reduction Titrimetry
6. Chromatography
  - a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
  - b. Separation of a mixture of two sugars by ascending paper chromatography
  - c. Separation of a mixture of *o*- and *p*-nitrophenol or *o*- and *p*-aminophenol by thin layer chromatography (TLC)

## Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009).
4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry*, 5th Ed., Pearson (2012).

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**New Course Structure- To be effective from academic session 2018-2019**  
**Based on CBCS System & OBE Model**

**For**

**M. Sc. Programme in Chemistry**



**DEPARTMENT OF CHEMISTRY**  
**BIRLA INSTITUTE OF TECHNOLOGY**  
**MESRA, RANCHI - 835215**

**98A, Academic Council, 2<sup>nd</sup> May, 2018**

## **CBCS Based Course structure and Syllabus for M.Sc. Programme in Chemistry**

### **Important notes:**

- The basic criteria of UGC have been followed in preparing the course structure of this programme.

### **Department Vision**

To become a recognized centre of excellence for teaching and research in Chemical Sciences through producing excellent academicians, professionals, entrepreneur and innovators

### **Department Mission**

Inoculate fundamental concepts of Chemical Sciences to students & scholars through our state of art laboratory, teaching and research facilities, Building a scientific environment and motivation towards innovation with quality research in chemical sciences and allied areas.

### **Program Educational Objectives of M.Sc. Programme in Chemistry**

1. To impart high quality education and research to develop future academicians, scientists and technocrats.
2. To develop a vibrant and motivational work environment by availability of high end research exposure at PG and research levels.
3. To instill values like work commitment, honesty, integrity, empathy as fundamental basis for serving humanity through chemical education and research.

### **Program Outcomes of M.Sc. Programme in Chemistry**

1. The students will be trained personnel resource in Chemical Sciences who will get through national and international level tests and be an asset to the nation.
2. They will have knowledge of basic fundamentals of chemical sciences and allied areas and will be able to compete national level tests such as UGC-CSIR NET, GATE, etc., successfully.
3. They will have an exposure to high end modern facilities used in research at par with global standards.
4. They will implement their educational and research skills with basic human values, integrity, empathy and ultimate objective of serving humanity.

**The contents of laboratory papers are designed to meet the course objectives and outcomes of their respective theory papers.**

## COURSE INFORMATION SHEET

**Course code:** CH 401

**Course title:** Inorganic Chemistry-V: Basic Inorganic Chemistry

**Pre-requisite(s):** B. Sc. (H) Chemistry

**Co- requisite(s):**

**Credits:** 4      L: 3      T: 1      P: 0

**Class schedule per week:** 04

**Class:** M. Sc. and I. M. Sc.

**Semester / Level:** M. Sc. I/ I. M. Sc. VII

**Branch:** Chemistry

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To know about the chemical bonding quantum mechanically
B.	To understand the reaction mechanism of coordination complexes
C.	To understand the principle of electronic spectroscopy
D.	To study the experimental spectrum

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the chemical bonding by quantum mechanics
2.	Able to explain the kinetics in coordination complexes
3.	Able to explain the principle of electronic absorption
4.	Able to interpret the experimental spectrum

## Syllabus

### Module I: Chemical Bonding: Valency Theories- Quantum Chemical Approach (9 Lectures)

Huckel approximation applied to  $H_2^+$  and  $H_2$  type systems, comparative study of the application of VB and MO methods to diatomic (homo and hetero) species; MO of polyatomic molecules; Walsh diagram, configuration interaction, orbital construction for  $H_n$  type systems, localized and delocalized M.O.,  $\sigma$ ,  $\pi$ ,  $\delta$  bonds, polyatomic molecules, electron deficient and hypervalent molecules.

### Module II: Quantitative basis of Crystal Fields (9 Lectures)

Crystal Field Theory, The octahedral Crystal Field potential, The effect of  $V_{oct}$  on the  $d$  wave-functions, the evaluation of  $\Delta$ , The tetrahedral and cubic potentials. Energy level of transition metal ions, Effect of ligands fields on the energy levels of transition metal ions.

### Module III: Reaction Mechanism of Transition Metal Complexes (9 Lectures)

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valency bond and crystal field theory, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, substitution reaction in square complexes, trans effect, redox reactions, electron transfer reactions, mechanism of one electron transfer reaction, outer sphere type reactions, inner sphere type reactions.

### Module IV: Introduction to electronic Spectra of transition metal complexes (9 Lectures)

Important features of transition metal electronic spectra- band intensities, band energies, band width and sets; characteristic spectra of complexes of first row transition metal ions, Octahedral, tetrahedral and square planar complexes of first row transition metal ions; Effect of temperature on electronic bands, Spectrochemical & Nephelauxetic series.

**Module V: Theoretical basis of Electronic Spectra of transition metal complexes (9 Lectures)**

Spectroscopic ground state, Orgel and Tanabe–Sugano diagrams for transition metal complexes, calculations of  $D_q$ , B and beta parameters, Charge transfer spectra: Intraligand charge transfer spectra, Metal to ligand charge transfer spectra, Ligand to metal charge transfer spectra Absorption spectra of *f*-block elements.

**Text books:**

1. G. Wulfsberg, Inorganic Chemistry, University Science Books, 2000.
2. C. J. Ballhausen & H. B. Gray, Molecular Orbital Theory, W.A. Benjamin, 1978.
3. F. Basolo & R. G. Pearson, Inorganic Reaction Mechanism, 2nd ed., John Wiley & Sons Inc., 1967.
4. A. B. P. Lever, Inorganic Electronic Spectroscopy, Elsevier, 1984.

**Reference books:**

1. B. N. Figgis and M. A. Hitchman, Ligand Field Theory and its Applications, Wiley–VCH, New York, 2000.
2. I. B. Bersuker, Electronic Structure and Properties of transition metal compounds, 2nd ed., Wiley, 2010.
3. C. J. Ballhausen, Introduction to Ligand Field Theory, McGraw-Hill Inc., 1962.
4. R. B. Jordon, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd ed., Oxford University Press, 2007.
5. D. N. Sathyanarayana, Electronic Absorption Spectroscopy, Universities Press, 2001.
6. E. A. B. Ebsworth, D. W. H. Rankin, S. Cardock, Structural Methods in Inorganic Chemistry; 2nd ed., Wiley-Blackwell, 1991.
7. A. K. Das, M. Das, Fundamental Concepts of Inorganic Chemistry; Volume-1-5; CBS Publishers, 2012.
8. R Sarkar, General and Inorganic Chemistry- Volume-I and Volume-II, 3rd revised ed., New Central Book Agency, 2011.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>



Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	M	M	L
CO3	H	H	H	M
CO4	M	H	H	M

### **Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	L1-L09	<b>1</b>	Chemical Bonding: Valency Theories- Quantum Chemical Approach	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock -Board</b>
<b>4-6</b>	L10-L18	<b>2</b>	Quantitative basis of Crystal Field Theory	<b>T2, R2</b>	<b>2</b>	<b>-do-</b>
<b>7-9</b>	L19-L27	<b>3</b>	Reaction mechanism of Transition metal complexes	<b>T1, R1</b>	<b>3</b>	<b>-do-</b>
<b>10-12</b>	L28-L36	<b>4</b>	Introduction to Electronic spectra	<b>T1, R4</b>	<b>3</b>	<b>-do-</b>
<b>13-15</b>	L37-L45	<b>5</b>	Theory-electronic spectra	<b>T1, R3</b>	<b>4</b>	<b>-do-</b>

**Course code: CH 402**

**Course title: Physical Chemistry-VI: Chemical Kinetics & Surface Chemistry**

**Pre-requisite(s): B.Sc. (H) Chemistry**

**Co-requisite(s):**

**Credits: 3      L: 3      T: 0      P: 0**

**Class schedule per week: 03**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. I/ I. M. Sc. VII**

**Branch: Chemistry**

**Name of Teacher:**

**Course Objectives**

This course enables the students:

A.	To apply the knowledge of chemical kinetics for very fast reactions, photophysical, photochemical and surface processes.
B.	To apply theories and concept of electrochemistry to study electrode kinetics.
C.	To develop concepts on photophysical and photochemical processes.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to solve problems on rate/rate constants/efficiency for complex reactions and electronically excited state dynamics.
2.	Able to understand the mechanism of chemical reactions for optimizing the experimental conditions and apply homogeneous and heterogeneous catalysis in chemical synthesis.
3.	Able to calculate electrochemical cell parameters, current and overpotential under given condition, amount of corrosion and its rate and plot potential vs current, surface coverage vs. potential, potential vs. pH, concentration profile vs. distance from the electrode.
4.	Able to explain the mechanism of fluorescence and phosphorescence.
5.	Able to understand the importance of adsorption process and its application.
6.	Able to develop the concept of colloidal material and their stability for many practical uses.

## Syllabus

### Module I: Chemical Reaction Dynamics

**(10 lectures)**

Introduction to reaction kinetics; Temperature dependence of reaction rate: Linear and non-linear Arrhenius equation, Interpretation of Arrhenius parameters; Theories of reaction rates: Collision theory and Activated complex theory (ACT) thermodynamic treatment of bimolecular gaseous reactions (Eyring equation). Theories of unimolecular gaseous reactions: Lindemann-Hinshelwood, RRK and RRKM theories. Kinetics of reactions in solution. Kinetics of fast reactions: Relaxation method, Flow methods, Pulse methods, flash photolysis. Molecular reaction dynamics, potential energy surfaces. Electron transfer reactions. Heterogeneous catalysis: Kinetics of surface reactions unimolecular and bimolecular. Autocatalysis and oscillatory reactions.

### Module II: Electrochemistry

**(10 lectures)**

Debye-Hückel theory of ion-ion interaction and activity coefficient, Applicability and limitations of Debye-Hückel limiting law, its modification, Effect of ion-solvent interaction on activity coefficient. Debye-Hückel-Onsager theory of conductance of electrolyte solution: Its applicability and limitations. Thermodynamic treatment of electrified interfaces, Introduction to electrical double layer, Introduction to electrode kinetics: Butler-Volmer equation, polarography, cyclic voltammetry, corrosion, fuel cells.

### Module III: Photochemistry

**(10 lectures)**

Consequences of light absorption; Kinetics of photochemical reactions:  $\text{H}_2$ - $\text{Br}_2$ ,  $\text{H}_2$ - $\text{Cl}_2$  & decomposition of HI. The Jablonski diagram. Potential energy diagram, Franck-Condon principle. Photophysical processes: fluorescence emission, triplet states and phosphorescence emission, delayed fluorescence.

Measurement of emission characteristics—fluorescence, phosphorescence, and chemiluminescence. Photophysical kinetics of unimolecular processes. Bimolecular collisions in gases and vapours and the mechanism of fluorescence quenching. Kinetics of collisional quenching: Stern-Volmer equation. Techniques for the study of transient species in photochemical reactions. Actinometry, Lasers in photochemical kinetics.

**Module IV: Surface Chemistry:**

**(9 lectures)**

Adsorption by solids-Types and applications. Adsorption of gases by solids. Adsorption isotherms: Freundlich and Langmuir adsorption isotherms, BET theory of multilayer adsorption, Types of adsorption isotherms. Adsorption from solution: Gibbs adsorption isotherm. Modern techniques for investigating surfaces.

**Module V: Colloidal States:**

**(6 lectures)**

Basics of colloidal states, electrical and electrokinetic properties, Micelles: Surface active agents, Classifications, micellization, hydrophobic interaction, CMC, factors affecting the CMC surfaces, counter ion binding, Thermodynamics of micellization-phase separation, solubilization, Micro-emulsion, Reverse micelles

**Text books:**

1. P. Atkins and J. Paula, Physical Chemistry, 10th ed., Oxford University Press, Oxford, 2014.
2. K. J. Laidler, Chemical Kinetics, 3rd ed., Harper & Row, New York, 1998.
3. J. O'M. Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol. 2, 2nd ed., Plenum Press, New York, 1998.
4. K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age International Pvt. Ltd.; 3rd ed., New Delhi, 2014.
5. A. W. Adamson and A. P. Gast, Physical Chemistry of Surfaces, 5th ed., Wiley, 1997.

**Reference books:**

1. M. R. Wright, An introduction to chemical kinetics, 1st ed., Wiley, 2005.
2. I. N. Levine, Physical Chemistry, 5th ed., 2002.
3. M. J. Pilling and A. P.W, Seakins, Reaction Kinetics, Oxford Science Publication, New York, 1998.
4. J. G. Calvert and J. N. Pitts, Jr., Photochemistry, John Wiley & Sons, New York, 1966.
5. R. P. Wayne, Principles and Applications of Photochemistry, Oxford University Press, Oxford, 1988.
6. J. I. Steinfeld, J. S. Francisco, W. L. Hase, Chemical Kinetics and Dynamics, 2nd ed., Pearson, 1998.
7. M. Satake, S. A. Iqbal, Colloidal & Surface Chemistry, Discovery Publishing Pvt. Ltd, 2003.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Assignment	√	√	√	√		
Quiz –I	√	√				
Quiz II			√	√	√	
End Sem Examination Marks	√	√	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L
CO5	M	H	M	L
CO6	M	H	M	L

**Mapping of Course Outcomes onto Program Outcomes:**

<b>Mapping Between COs and Course Delivery (CD) methods</b>			
<b>CD</b>	<b>Course Delivery methods</b>	<b>Course Outcome</b>	<b>Course Delivery Method</b>
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4, 5, 6	CD1
CD2	Tutorials/Assignments	CO2, 3, 4, 5, 6	CD1, 2
CD3	Seminars	CO3, 4	CD3
CD4	Mini projects/Projects	CO1, 2, 3, 4, 5	CD4
CD5	Laboratory experiments/teaching aids	CO2, 3	CD5
CD6	Industrial/guest lectures	CO4	CD6, 7
CD7	Self- learning such as use of NPTEL materials and internet	CO1, 2, 3, 4, 5, 6	CD7
CD8	Simulation	CO1, 2	CD8

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-4</b>	<b>L1-L12</b>	<b>1</b>	Dynamics of Chemical Reactions	<b>T1, T2, R1</b>	<b>1,2</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-7</b>	<b>L13-L20</b>	<b>2</b>	Theory of Ion Transport	<b>T3, R2</b>	<b>3</b>	<b>-do-</b>
<b>7-10</b>	<b>L21-L32</b>	<b>3</b>	Photophysical and Photochemical Processes	<b>T4, R4</b>	<b>4</b>	<b>-do-</b>
<b>11-13</b>	<b>L33-L41</b>	<b>4</b>	Surface Science and its Applications	<b>T1, T5, R7</b>	<b>5</b>	<b>-do-</b>
<b>14-15</b>	<b>L42-L45</b>	<b>5</b>	Colloidal States of the matter	<b>T5, R7</b>	<b>6</b>	<b>-do-</b>

**Course code:** CH 403  
**Course title:** Reaction Mechanisms in Organic Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. I/ I. M. Sc. VII  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the physico-chemical factors affecting the course and outcome of an organic reaction
B.	To understand the different types of organic reactions operating on the aliphatic and aromatic systems

### Course Outcomes

After the completion of this course, students will be:

1.	To learn the various concepts of acids and bases, stereoelectronic effects, reactive intermediates and types of organic chemical reactions
2.	To understand the mechanisms of different types of substitution reactions operating on the aliphatic and aromatic systems
3.	To understand the mechanisms of elimination and addition reactions operating on the organic substrates
4.	To apply the influence of stereo-electronic effects on the course of a reaction from unimolecular to bimolecular or intra-molecular suitable for some particular types of substrate
5.	To differentiate the paths followed by aromatic and aliphatic substrates in a nucleophilic substitution reaction
6.	To analyse the conditions favoring the substitution and elimination pathway followed by a particular substrate

## Syllabus

### Module I: Fundamentals of Reaction Mechanism

[9 Lectures]

Acids and bases; nucleophile and electrophile, basicity vs nucleophilicity; Resonance and aromaticity- Huckel's rule for aromaticity in benzenoid and non-benzenoid compounds, antiaromaticity and homo-aromaticity, breaking and formation of bond, electronic effect: inductive, hyperconjugation, mesomerism and steric effect; reactive intermediates: generation, stability and fate of carbocation, carbanion, free radical, carbene and nitrene.

### Module II: Aliphatic substitution reactions

[12 Lectures]

Nucleophilic substitution: The  $S_N2$ ,  $S_N1$ , mixed  $S_N1$  and  $S_N2$  and SET mechanisms, neighbouring group participation by pi and sigma bonds, anchimeric assistance, The  $S_{Ni}$  mechanism, Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon, Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium; Electrophilic bimolecular mechanism- $S_E2$  and  $S_{Ei}$ : The  $S_{E1}$  mechanism, electrophilic substitution accompanied by double bond shift, effect of substrates, leaving group and the solvent polarity on the reactivity.

### Module III: Aromatic substitution reactions

[6 Lectures]

The arenium ion mechanism, orientation and reactivity, energy profile diagrams, The *ortho/para* ratio, ipso attack, Diazonium coupling, Vilsmeier reaction, Gattermann-Koch reaction, The  $S_{NAr}$ ,  $S_{N1}$ , benzyne and  $S_{RN}1$  mechanisms, Reactivity-effect of substrate structure, leaving group and attacking nucleophile, The Von Richter, Sommelet-Hauser, Smiles Rearrangement.

**Module IV: Addition and Elimination Reactions****[9 Lectures]**

Mechanism and stereochemical aspects of addition reaction in carbon-carbon and carbon-hetero multiple bonds, regio- and chemoselectivity, orientation and reactivity, Mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Perkin and Stobbe reactions.

The E2, E1 and E1cB mechanism and their spectrum, orientation of the double bond, Reactivity- effect of substrates structure, attacking base, the leaving group and the medium, Mechanism and orientation in pyrolytic elimination.

**Module V: Rearrangement Reaction****[9 Lectures]**

General Mechanistic considerations – nature of migration, migratory aptitude, A detailed study of the following rearrangements involving carbonation (Wagner-Meerwein, Pinacol-Pinacolone rearrangement), reaction involving acyl cation, PPA cyclization and Fries rearrangement, rearrangement of carbenes (Wolff & Arndt-Eistert synthesis), rearrangement of nitrenes (Hoffman, Curtius, Schmidt, Lossen, Beckman rearrangement).

**Text books:**

1. I. L. Finar, Organic Chemistry, Vol. I and II, 5th ed., Longman Ltd., New Delhi, 2011.
2. P. Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th ed., John Wiley & Sons, New York, 1985.
3. T. W. G. Solomons, Fundamentals of Organic Chemistry, 4th ed., John Wiley, 1994.
4. R. N. Morrison & R. N. Boyd, Organic Chemistry, 7th ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2010.

**Reference books:**

1. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 2nd ed., Oxford Press, 2012,
2. J. March, Organic reaction and mechanism-structure and reactivity, 7th ed., John Wiley, 2015.
3. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, Springer, New York, 2006.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50



Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Assignment	√	√	√	√	√	
Quiz –I	√	√	√			
Quiz II				√	√	
End Sem Examination Marks	√	√	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L
CO5	M	H	M	L
CO6	M	H	M	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4,5,6	CD1
CD2	Tutorials/Assignments	CO1, 2, 3,	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3,5	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4, 5	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Fundamentals of reaction mechanism	<b>T1, T2, R1</b>	<b>1,2</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-7</b>	<b>L10-L21</b>	<b>2</b>	Aliphatic substitution reaction	<b>T3, R2</b>	<b>3</b>	<b>-do-</b>
<b>8-9</b>	<b>L22-L27</b>	<b>3</b>	Aromatic substitution reaction	<b>T4, R3</b>	<b>4</b>	<b>-do-</b>
<b>10-12</b>	<b>L28-L36</b>	<b>4</b>	Addition-elimination reactions	<b>T1, T4, R2</b>	<b>5</b>	<b>-do-</b>
<b>13-15</b>	<b>L37-L45</b>	<b>5</b>	Rearrangement reactions	<b>T1, R4</b>	<b>6</b>	<b>-do-</b>

**Course code: CH 404**

**Course title: Inorganic Chemistry-VI: Organometallic Chemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co-requisite(s):**

**Credits: 3      L: 3      T: 0      P: 0**

**Class schedule per week: 03**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. I/ I. M. Sc. VII**

**Branch: Chemistry**

**Name of Teacher:**

**Course Objectives**

This course enables the students:

A.	To learn the basics of organometallic chemistry
B.	To grow concept of bonding in organometallic compounds
C.	To study the reactivity of organometallic compounds
D.	To know the application of organometallic compounds

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the basic features of organometallic compounds
2.	Able to explain the bonding in organometallic compounds
3.	Able to predict the reactivity of organometallic compounds
4.	Able to discuss the application of organometallic compounds

## Syllabus

### Module I: Organometallic Complexes: General properties and types (9 Lectures)

Introduction, Classical and non-classically bonded organometallic compounds, 18 electron rule in Organometallic complexes-Ionic and Covalent Model; Metal Alkyls, Aryls, and Hydrides and Related  $\sigma$ -Bonded Ligands: Transition Metal Alkyls and Aryls, Related  $\sigma$ -Bonded Ligands, Metal Hydride Complexes,  $\sigma$  Complexes, Bond Strengths for Classical  $\sigma$ -Bonding Ligand; Complexes of  $\pi$ -Bound Ligands: Alkene and Alkyne Complexes, Allyl Complexes, Diene Complexes, Cyclopentadienyl Complexes, Arenes and Other Alicyclic Ligands, Metalacycles and Isoelectronic and Isolobal Replacement, Stability of Polyene and Polyenyl Complexes.

### Module II: Metal-Ligand Multiple Bonds (9 Lectures)

Carbenes: Fischer Versus Schrock Carbenes - conditions, synthesis examples reactivity and structure, Cases Intermediate Between Fischer and Schrock Carbenes, Boryl Complexes, Vinylidene Carbynes-synthesis, examples and reactivity, structure, Bridging Carbenes and Carbynes, N-Heterocyclic Carbenes-synthesis examples reactivity and structure, Multiple Bonds to Heteroatoms.

### Module III: Reactivity of Organometallic Complexes: I (9 Lectures)

Oxidative Addition and Reductive Elimination: Concerted Additions,  $S_N2$  Reactions, Radical Mechanisms, Ionic Mechanisms, Reductive Elimination,  $\sigma$ -Bond Metathesis, Oxidative Coupling and Reductive Cleavage.

Insertion and Elimination: Reactions Involving CO, Insertions Involving Alkenes, Other Insertions,  $\alpha$ ,  $\beta$ ,  $\gamma$ , and  $\delta$  Elimination.

### Module IV: Reactivity of Organometallic Complexes: II (9 Lectures)

Nucleophilic and Electrophilic Addition and Abstraction: Nucleophilic Addition to CO, Nucleophilic Addition to Polyene and Polyenyl Ligands, Nucleophilic Abstraction in Hydrides, Alkyls and Acyls, Electrophilic Addition, Electrophilic Abstraction of Alkyl Groups, Single-Electron Transfer Pathways, Reactions of Organic Free Radicals with Metal Complexes.

Homogeneous Catalysis: Alkene Isomerization, Alkene Hydrogenation, Alkene Hydroformylation, Hydrocyanation of Butadiene, Alkene Hydrosilation and Hydroboration, Coupling Reactions, Surface and Supported Organometallic Catalysis.

#### **Module V: Applications of Organometallic Chemistry**

**(9 Lectures)**

Alkene Metathesis- mechanism, Type and commercial application, Dimerization, Oligomerization, and Polymerization of Alkenes- mechanism, Type and commercial application, Activation of CO and CO<sub>2</sub> - mechanism, Type and commercial application, CH Activation- mechanism, Type and commercial application, Organometallic Materials and Polymers.

#### **Text books:**

1. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, Wiley-Interscience; 4th ed., 2005.

#### **Reference books:**

1. B- M. Bochmann, Organometallic Chemistry: (Oxford series), 1994.
2. R. C. Mehrotra & A. Singh, Organometallic Chemistry, New Age Int. Publishers, 2nd ed., 1991.
3. M. Gielen, R. Willem, B. Wrackmeyer, Fluxanol Organometallic and Coordination compounds, Wiley, 1st ed., 2008.
4. F. A. Cotton, G. Willkinson, Advanced Inorganic Chemistry, Wiley, 6th ed., 2007.
5. J. E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 4th ed. 2006.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Quiz –I	√	√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-2</b>	<b>L1-L10</b>	<b>1</b>	Organometallic Complexes: General properties and types	<b>T1, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>2-3</b>	<b>L11-20</b>	<b>2</b>	Metal–Ligand Multiple Bonds	<b>T1, R2</b>	<b>2</b>	<b>-do-</b>
<b>3-4</b>	<b>L21-28</b>	<b>3</b>	Reactivity of Organometallic Complexes: I	<b>T1, R3</b>	<b>3</b>	<b>-do-</b>
<b>5-6</b>	<b>L29-35</b>	<b>4</b>	Reactivity of Organometallic Complexes: II	<b>T1, R4</b>	<b>4</b>	<b>-do-</b>
<b>6-9</b>	<b>L36-45</b>	<b>5</b>	Applications of Organometallic Chemistry	<b>T1, R5</b>	<b>5</b>	<b>-do-</b>

**Course code:** CH 405  
**Course title:** Principles of Organic Synthesis  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. I/ I. M. Sc. VII  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand effect of conformation on chemical reactivity of organic molecule
B.	To correlate stereochemistry with the chemical reaction mechanism
C.	To understand the requirement and principles for organic reaction
D.	To identify the mechanistic approach for chemical (including concerted) reaction

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain effect of conformation on chemical reactivity of organic molecule
2.	Able to define stereochemistry with the chemical reaction mechanism
3.	Able to explain the principles for various types of organic reaction
4.	Able to analyse the mechanism of chemical (including concerted) reaction

## Syllabus

### Module I: Conformation and Reactivity

[9 Lectures]

Conformation of acyclic systems (substituted ethane/n-propane/n-butane), conformation around  $sp^3$ - $sp^2$  and  $sp^2$ - $sp^2$  bond, conformation around carbon hetero atom bond, conformations of cyclic system (cyclopentane, cyclohexane with mono and di substituted cyclohexanes, cycloheptane, cyclooctane and decalins), conformation of cyclohexane with 1/2  $sp^2$  bond, conformation analysis of heterocycles, the conformations of sugars, anomeric effect and reverse anomeric effect, conformationally rigid and mobile diastereomer, conformation and reactivity in cyclic system (substitution, addition, elimination, rearrangement etc.).

### Module II: Stereochemistry

[9 Lectures]

Optical rotatory dispersion (ORD) and circular dichroism (CD), classification of ORD and CD Curves, Cotton effect curves and their application to stereochemical problems; the Octant rule and its application to alicyclic ketones, stereoisomerism, molecular dissymmetry and chirality- elements of symmetry, enantiomerism, diastereomerism, pseudoasymmetric carbon, diastereo isomerism in acyclic and cyclic-systems, interconversion of Fischer, Newman and Sawhorse projections, methods of resolution, optical purity, prochirality, enantiotopic and diastereotopic atoms, groups and faces, optical activity in absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape, geometrical isomerism in alkenes and oximes, methods of determining the configuration.

### Module III: Principles of organic reaction

[9 Lectures]

Reagent type and reaction type, Investigation of reaction mechanism (nature of products, kinetic data, use of isotope, study of intermediate, stereochemical criteria. Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, free energy relationships, kinetic and thermodynamic control, Nature of reaction energy, Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, nonkinetic methods of determining reaction mechanism, isotope effects, solvent effect.

**Module IV: Principles of reaction mechanism****[9 Lectures]**

Hammond's postulate, Curtin-Hammett principle, Hammett energy diagrams and reaction rate laws, Hammett's  $\sigma_x$  and  $\rho$  values and their physical significance through-conjugation, deviations from straight line plots; steric effects: Taft equation, Softness (Hardness) Scales, HSAB principle, HSAB application for organic reactions: Reaction Selectivity, Alkylation vs. Acylation, C- vs. O-Alkylation, Reactions of Organosulfur Compounds, Reactions of Organophosphorus Compounds, Elimination and Substitution, Addition to Double Bonds, Addition to Carbonyl Compounds.

**Module V: Concerted reaction****[9 Lectures]**

Definition, ionic, radical and concerted reaction, classification, Molecular orbital symmetry, Woodward-Hoffman correlation diagram method and perturbation of molecular (PMO) approach for the explanation of pericyclic reactions under thermal and photochemical conditions, frontier orbitals of ethylene, 1,3 Butadiene, 1,3,5- Hexatriene, allyl system, FMO approach, types of cyclo-additions and cyclo-reversion reactions, electrocyclic reaction and the electroreversion reactions, sigmatropic reactions, group transfer reaction.

**Text books:**

1. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 2nd ed., Oxford Press, 2012.
2. I. L. Finar, Organic Chemistry, Vol. I & II, 5th ed., Longman Ltd., New Delhi, 2011.

**Reference books:**

1. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th ed., John Wiley & Sons, New York, 1985.
2. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd ed., New Age Int., New Delhi, 1994.
3. I. Fleming, Pericyclic Reactions, Oxford Scientific Publication, Cambridge, 1998.
4. E. V. Anslyn and D.A. Dougherty, Modern Physical Organic Chemistry, University Science Books, USA, 2006.
5. L. P. Hammett, Physical Organic Chemistry, 1st ed., McGraw-Hill Book Co. Inc., New York, 1940.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>



Assessment Components	CO1	CO2	CO3	CO4
Quiz –I	√	√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Conformation and reactivity	T1, T2, R1	1	PPT Digi Class/Chock-Board
4-6	L10-L18	2	Stereochemistry	T2, R2	2	-do-
7-8	L19-L27	3	Principles of organic reactions	T1, R1	3	-do-
9-12	L28-L36	4	Principles of reaction mechanism	T1, R4	3	-do-
13-15	L37-L45	5	Concerted reaction	T1, R3	4	-do-

Course code: CH 406  
Course title: Physical Chemistry-VI Lab  
Pre-requisite(s): B. Sc. (H) Chemistry  
Co- requisite(s):  
Credits: 2      L: 0      T: 0      P: 4  
Class schedule per week: 04  
Class: M. Sc. and I. M.Sc.  
Semester / Level: M. Sc. I/ I. M. Sc. VII  
Branch: Chemistry  
Name of Teacher:

## Syllabus

### Adsorption: (any two)

- (i) To study surface tension-concentration relationship for solutions.
- (ii) To study the adsorption of iodine from alcoholic solution of charcoal.
- (iii) To study the adsorption of acetic acid on charcoal.

### Chemical equilibrium: (any one)

- (i) To determine congruent composition & temperature of a binary system- Phenol-water.
- (ii) To determine glass transition temperature of a given salt conductometrically.
- (iii) To construct the phase diagram for a three component systems.
- (iv) To determine the equilibrium constant for the reaction  $KI + I_2 = KI_3$ .

### Chemical Kinetics: (any two)

- (i) To determine rate constant of saponification ethyl acetate by NaOH.
- (ii) To determine the velocity constant of hydrolysis of an ester in micellar media.
- (iii) To determine the rate constant for the oxidation of iodide ion by hydrogen peroxide, studying the kinetics as an iodine clock reaction.

### Conductometry: (any two)

- (i) To determine velocity constant, order of reaction and energy of activation for saponification of ethyl acetate by NaOH conductometrically.
- (ii) To determine solubility and solubility product of sparingly soluble salt conductometrically.
- (iii) To determine the strength of strong and weak acids in a given mixture conductometrically.
- (iv) To determine activity co-efficient of zinc ions in the solution of 0.002 M  $ZnSO_4$  using Debye-Huckel's limiting law.

### Potentiometry-pH metry: (any one)

- (i) To determine the strengths of halides in a mixture potentiometrically.
- (ii) To determine the valancy of mercurous ions potentiometrically.
- (iii) To determine the strength of strong and weak acids in a given mixture using a potentiometer-pH meter.
- (iv) To determine the temperature dependence of E.M.F. of a cell.
- (v) Acid-base titration in a non-aqueous media using a pH meter.
- (vi) To determine the transport number by Hittrof's method.

### Cyclic voltametry:

- (i) To find the redox potential of the given sample using cyclic voltametry.

### Polarography: (one one)

- (i) To determine DO in aqueous solution of organic solvent
- (ii) To determine half way potential of Cd & Zn EMF:
- (iii) To determine single electrode potential of  $Cu/Cu^{2+}$
- (iv) Potentiometric titration of a redox system.
- (v) To determine E.M.F. of concentration cell.

### Polarimetry: (any one)

- (i) To determine rate constant for hydrolysis/inversion of sugar using a Polarimeter.
- (ii) Enzyme kinetics-inversion of sucrose.

**Spectroscopy:(any one)**

- (i) To determine  $pK_a$  of an indicator in aqueous and micellar medium.
- (ii) To determine stoichiometry and stability constant of inorganic (ferric-salicylic acid) and organic (amine-iodine) complexes.

**Thermochemistry: (any one)**

- (i) To determine the enthalpy of neutralization of hydrochloric acid with NaOH
- (ii) Enthalpy of combustion of benzoic acid using DSC.

**Text books:**

- 1. J. B. Yadav, Advanced Practical Physical Chemistry, 22nd ed., Goel Publishing House, Krishna Prakashan Media, 2014.
- 2. B. Viswanathan and P. S. Raghavan, Practical Physical Chemistry, Viva Books, 2012.

**Reference books:**

- 1. B. P. Levitt, Findlay's Practical Physical Chemistry, 9th ed., Longman, London, 1985.
- 2. A. M. Halpern and G. C. McBane, Experimental Physical Chemistry: A Laboratory Text Book, 3rd ed., W. H. Freeman, 2006.
- 3. A. M. James and F. E. Prichard, Practical Physical Chemistry, Prentice Hall Press, 1974.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 407  
**Course title:** Organic Chemistry-VI Lab  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** I. M. Sc. and M.Sc.  
**Semester / Level:** M. Sc. I/ I. M. Sc. VII  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Identification of functional groups through qualitative analysis in a given binary mixture of organic compounds.
2. Isolation of the organic compounds from above mentioned binary mixture through solvent extraction and verifying their complete separation through thin layer chromatography.
3. Identification of the isolated organic compounds through derivative preparation and characterization by FTIR, UV-VIS & NMR.
4. Electrophilic aromatic substitution: acylation of bromobenzene and checking thin layer chromatography to check the reaction outcome (product distribution and extent of reaction).

## Reference Books:

1. A. I. Vogel, Quantitative Organic Analysis, Part 3, Pearson, 2012.
2. F. G. Mann, & B. C. Saunders, Practical Organic Chemistry, Pearson Education, 2009.
3. B.S. Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, Practical Organic Chemistry, 5th Ed., Pearson, 2012.
4. V.K. Ahluwalia, & R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2000.
5. V. K. Ahluwalia, & S. Dhingra, Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press, 2000.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code: CH 408**

**Course title: Inorganic Chemistry-VII: Advanced Inorganic Chemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co-requisite(s):**

**Credits: 3      L: 3      T: 0      P: 0**

**Class schedule per week: 03**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. II/ I. M. Sc. VIII**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the general properties of magnetic bodies
B.	To study the effect of thermal energy on magnetism
C.	To understand the anomalous magnetic moments
D.	To study about the inorganic rings, chains and clusters

### Course Outcomes

After the completion of this course, students will be:

1.	Able to classify the magnetic bodies
2.	Able to explain the effect of temperature on magnetic properties
3.	Able to interpret the anomalous magnetic properties
4.	Able to explain several types of inorganic rings, chains and clusters

## Syllabus

### Module I: Magnetic properties of coordination Complexes (9 Lectures)

Definition of magnetic properties, Types of magnetic bodies, Experimental arrangements for the determination of magnetic susceptibility: Guoy method, Faraday method, Vibrating sample magnetometer, SQUID, NMR method; Diamagnetism in atoms and polynuclear systems, Pascals constant, Two sources of paramagnetism.

### Module II: Thermal energy and magnetic properties (10 Lectures)

Spin & Orbital effects, Spin orbit coupling, Lande interval rule, Energies of J levels, Multiplet width and temperature; Curie equation, Curie & Curie-Weiss law, 2nd order Zeeman Effect, Temperature independent paramagnetism, Van Vleck susceptibility equation, Thermal Equilibrium between High Spin and Low spin state in Spin Cross over region, Magnetic behavior of lanthanides & actinides, Anomalous magnetic moments, magnetic properties of binuclear and polynuclear complexes—ferromagnetism and anti-ferromagnetism.

### Module III: Anomalous Magnetic Moments in Coordination Complexes (9 Lectures)

Superexchange interaction in terms of Goodenough-Kanamori-Anderson Rules (GKA Rules), Interpretation of magnetic exchange by GKA Rule in terms of Molecular Orbital Theory, Antiferromagnetism in magnetically concentrated system, Cooperative magnetic interactions in binuclear Cu(II) complexes, Antiferromagnetic coupling in other metal complexes: Dimers of oxidovanadium(IV) and oxidomolybdenum(V) complexes, Dinuclear complexes of Ti(III), Dimeric Cr(II) acetate-mono-hydrate,  $\text{Mn}_2(\text{CO})_{10}$

### Module IV: Inorganic Rings and Cages (8 Lectures)

Rings: Homocyclic rings of S, Se and Te. Heterocyclic rings of S, N, P and O; Cages: Higher boron hydrides: structures and reactions, equation of balance, Lipscomb topological diagrams, polyhedral skeletal electron pair theory (PSEPT), carboranes, metalloboranes and heteroboranes, metallocarboranes.

**Module V: Inorganic Cluster****(9 Lectures)**

Clusters in elemental states, cluster classification, Low nuclearity ( $M_3 - M_4$ ) and high nuclearity cluster ( $M_5 - M_{10}$ ), Metal metal bonding (MOT), Carbonyl clusters, skeletal electron counting, Wade-Mingos-Luber rule, application of isolobal and isoelectronic analogy, capping rules, carbide, nitride, chalcogenide and halide containing cluster of Re, Nb, Ta, Mo, W, Zintl ions, chevreton compounds, infinite metal chains, application of cluster compounds in catalysis.

**Text books:**

1. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, Wiley, 6th ed., 2007.
2. J. E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 4th ed. 2006.
3. R. L. Dutta, A. Syamal, Elements of Magnetochemistry, East-West Press, 1993.
4. A. K. Das, M. Das, Fundamental Concepts of Inorganic Chemistry; Volume-6; CBS Publishers, 2012.

**Reference books:**

1. G. Wilkinson, R. D. Gillars & J. A. McCleverty, Comprehensive Co-ordination Chemistry, 2nd ed., Elsevier, 2003.
2. J. D. Lee, Concise Inorganic Chemistry, 5th ed., Oxford, 2008.
3. F. E. Mabbs and D. J. Machin, Magnetism and Transition Metal complexes, Dover Publications; 2008.
4. N. N. Greenwood and E. A. Earnshaw; Chemistry of elements, 2nd ed., Butterworth- Heinemann, 1997.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz -1		√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD 1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD 2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD 3	Seminars	CO 2, 3	CD3
CD 4	Mini projects/Projects	CO3, 4	CD4
CD 5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD 6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD 7	Simulation	CO2, 4	CD7



**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-2	L1-L8	1	Definition of magnetic properties, Types of magnetic bodies, Experimental arrangements for the determination of magnetic susceptibility: Guoy method, Faraday method, Vibrating sample magnetometer, SQUID, NMR method	T1, T2, R1	1	PPT Digi Class/Chock-Board
3-6	L9-L20	2	Spin & Orbital effects, Spin orbit coupling, Lande interval rule, Multiplet width and temperature; Curie equation, Curie & Curie-Weiss law, 2nd order Zeeman Effect, Van Vleck susceptibility equation	T1, T3, R2	2	-do-
5-6	L21-L30	3	Superexchange interaction in terms of Goodenough-Kanamori-Anderson Rules (GKA Rules), Interpretation of magnetic exchange by GKA Rule in terms of Molecular Orbital Theory, Antiferromagnetism	T1, T2, T3, R1	3	-do-
7-10	L31-L38	4	Rings: Homocyclic rings of S, Se and Te. Heterocyclic rings of S, N, P and O; Cages: Higher boron hydrides: structures and reactions, equation of balance, Lipscomb topological diagrams, polyhedral skeletal electron pair theory (PSEPT)	T1, T2, T3, R2	4	-do-
11-15	L39-L45	5	Clusters in elemental states, cluster classification, Low nuclearity ( $M_3 - M_4$ ) and high nuclearity cluster ( $M_5 - M_{10}$ ), Metal metal bonding (MOT), Carbonyl clusters, skeletal electron counting, Wade-Mingos-Luber rule,	T1, T2, T3, R2	5	-do-

**Course code:** CH 409

**Course title:** Physical Chemistry-VII: Quantum Chemistry & Group Theory

**Pre-requisite(s):** B. Sc. (H) Chemistry

**Co- requisite(s):**

**Credits:** 4      L: 3      T: 1      P: 0

**Class schedule per week:** 04

**Class:** M. Sc. and I. M. Sc.

**Semester / Level:** M. Sc. II/ I. M. Sc. VIII

**Branch:** Chemistry

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To use operators in quantum mechanics to derive and solve Schrodinger equation.
B.	To solve elementary model problems in quantum mechanics, particle in a potential-free box, particle on a ring, harmonic oscillator and particle in a Coulomb potential exactly and demonstrate the solutions for hydrogen atom.
C.	To use techniques of approximations to solve the quantum mechanical problems.
D.	To apply the concept of linear combination of atomic orbitals to hybridization and directed bonding in polyatomic molecules.
E.	To show that molecular symmetry operations form a group and can be characterized by fundamental representations of groups known as irreducible representations and apply the great orthogonality theorem to derive simple point groups.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to solve the model problems in quantum mechanics for which exact analytical methods and solutions are available which forms the foundations for advanced study of the subject.
2.	Able to apply this knowledge to complex problems of atomic and molecular energy levels and structure.
3.	Able to determine the symmetry elements of any small and medium-sized molecules.

### Syllabus

#### **Module I: Classical Mechanics and Postulates of Quantum Mechanics (9 lectures)**

Postulates of quantum mechanics. Operators in quantum mechanics: Linear and Hermitian operators, operator algebra, eigenvalues and eigenfunctions, commutation relations. Solution of Schrödinger's equation for (i) particle in 3D-boxes and applications, (ii) particle in a ring and sphere, spherical harmonics, angular momentum rigid rotator, (iii) Simple harmonic oscillator, and (iv) Hydrogen atom. Stark and Zeeman effect.

#### **Module II: Approximation Methods (8 lectures)**

Perturbation (Time-independent & Time-dependent) and Variation methods: Examples of Variation methods: (i) Hydrogen atom, Hydrogen atom in an electric field, (ii) Helium atom. Examples of Perturbation method: (i) perturbed particle in a box, (ii) perturbed harmonic oscillator (iii) Hydrogen atom in electric field.

#### **Module III: Atomic Spectra and Atomic Structure (9 lectures)**

The spectrum of atomic hydrogen: Electronic configuration of atoms, addition of angular momenta, spectroscopic term symbols, spin-orbit coupling, selection rules for atomic spectra; The structure of helium; Many-electron atoms: Antisymmetric wave functions of many electron atoms, Slater determinants, Hartree and Hartree-Fock self-consistent field model for atoms.

**Module IV: Theory of Angular Momentum & Chemical Bonding (9 lectures)**

*Angular momentum:* Classical & quantum mechanical concept, application in many-electron atom, splitting of term level into atomic levels. *Molecular structure & Chemical bonding:* Born–Oppenheimer approximation, Hydrogen molecule ion. LCAO–MO and VB treatments of the hydrogen molecule. Hybridization and MOT of H<sub>2</sub>O, NH<sub>3</sub> and CH<sub>4</sub>. Huckel pi-electron theory and its applications to ethylene, butadiene and benzene.

**Module V: Basic Concept of Symmetry & Group Theory (10 lectures)**

Definition and theorem of group theory. Molecular symmetry & the symmetry group: Symmetry operations & symmetry elements, classification of molecules, multiplication tables. Representation of molecular point groups, character, reducible and irreducible representations. The Great Orthogonality Theorem (GOT, without proof), use of GOT to construct character table, character table for point groups & their uses.

**Text books:**

1. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics, 4th edition, Oxford University Press, Oxford, 2005.
2. D. A. McQuarrie, Quantum Chemistry, University Science Books, 1983.
3. R. K. Prasad, Quantum Chemistry, 3rd ed., New Age International, 2006.
4. A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill, New Delhi, 1988.
5. F. A. Cotton, Chemical Applications of Group Theory, Wiley, 1996.

**Reference books:**

1. H. Eyring, J. Walter and G. E. Kimball, Quantum Chemistry, John Wiley, New York, 1944.
2. I. N. Levine, Quantum Chemistry, 5th ed., Pearson Educ., Inc., New Delhi, 2000.
3. D. J. Griffiths, Introduction to Quantum Mechanics, Pearson Education, 2005.
4. J. P. Lowe and K. A. Peterson, Quantum Chemistry, 3rd ed., Academic Press, 2005.
5. D. M. Bishop, Group theory and Chemistry, Dover, 1993.
6. S. N. Datta, Lectures on Chemical bonding and quantum chemistry, Prism Books, Bangalore, 1997.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Assignment	√	√	
Quiz –I	√		
Quiz II		√	
End Sem Examination Marks	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping of Course Outcomes onto Program Outcomes:**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	H	L
CO2	H	H	H	L
CO3	H	H	M	M

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3	CD1
CD2	Tutorials/Assignments	CO2, 3	CD1, 2
CD3	Seminars	CO3	CD3
CD4	Mini projects/Projects	CO1, 2, 3	CD4
CD5	Laboratory experiments/teaching aids	CO2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO1 ,2, 3	CD6
CD7	Simulation	CO1, 2, 3	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book /References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Introduction to Quantum Mechanics	<b>T1, T2,T3,R2, R3</b>	<b>1</b>	<b>PPT Digi Class/Chock -Board</b>
<b>4-6</b>	<b>L10-L17</b>	<b>2</b>	Perturbation and Variation Methods	<b>T1,T2,R2,R3</b>	<b>1</b>	<b>-do-</b>
<b>6-9</b>	<b>L18-L26</b>	<b>3</b>	Atomic Spectrum	<b>T1, T2,R2</b>	<b>2</b>	<b>-do-</b>
<b>9-12</b>	<b>L27-L35</b>	<b>4</b>	Molecular Structure and Chemical Bonding	<b>T2,R6</b>	<b>2</b>	<b>-do-</b>
<b>12-15</b>	<b>L36-L45</b>	<b>5</b>	Symmetry and Group Theory	<b>T5,R5</b>	<b>3</b>	<b>-do-</b>

**Course code:** CH 410  
**Course title:** Modern Organic Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. II/ I. M. Sc. VIII  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the photochemical, free radical and pericyclic reactions and their mechanisms
B.	To understand the heterocyclic systems, their synthetic principles and their chemical reactivity
C.	To understand the various principles and rules of reaction mechanism and their stereochemical outcomes

### Course Outcomes

After the completion of this course, students will be:

1.	To learn different photophysical and photochemical fates of an organic compound upon photo-irradiation
2.	To learn the mechanisms of photochemical and free radical reactions
3.	To learn the different heterocycles, their synthesis and understand their reactivity
4.	To understand the mechanism of different pericyclic reactions and differentiate endo and exo additions, suprafacial and antarafacial shifts and conrotatory and disrotatory motions
5.	To apply the rules of organic reactions to determine the stereochemical outcome

## Syllabus

### Module I: Organic Photochemistry

(9 Lectures)

Singlet and triplet excited state, radiative and non-radiative transitions, potential energy surfaces, photoreduction, photoaddition, photorearrangement, photooxidation, aromatic substitution, Norrish Type I, Norrish Type II, excimers and exciplexes, photochemistry of alkenes, carbonyl, aromatic compounds.

### Module II: Free Radical Reaction

(10 Lectures)

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighboring group assistance, Reactivity for aliphatic and aromatic substrates, Reactivity in the attacking radicals, the effect of solvents on reactivity, Allylic halogenation, Oxidation of aldehydes to carboxylic acids, auto-oxidation, Sandmeyer reaction, free radical rearrangement, Hunsdiecker reaction.

### Module III: Pericyclic Reaction

(8 Lectures)

FMO & PMO approach, Electrocyclic reactions – conrotatory and disrotatory motions,  $4n$ ,  $4n+2$  and allyl systems, Cycloaddition Reaction: Antarafacial and suprafacial additions,  $4n$  and  $4n+2$  systems,  $2+2$  addition of ketenes, 1,3 dipolar cycloadditions and Cheletropic Reactions, Effect of Diene and dienophile stereochemistry, Endo rule in Diels-Alder Reaction, Reverse electron Demand Diels-Alder Reaction, Intramolecular Diels-Alder Reaction, Regioselective Diels-Alder Reactions, Sigmatropic rearrangements: Suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5-sigmatropic rearrangements, Claisen, Cope and aza-Cope rearrangements, Ene and Retro Ene Reactions.

**Module IV: Heterocyclic Chemistry****(9 Lectures)**

Heterocyclic synthesis: Principles of heterocyclic synthesis involving cyclization and cycloaddition (1,3-dipolar, hetero-diels alder and 2+2 cycloaddition reactions).

Heterocyclic chemistry of 3 and 4, 5 and 6 membered rings. Synthesis, medicinal applications and reactions of oxirane, aziridine, azetidinone ( $\beta$ -lactam), oxetane, pyridine, pyrylium salts and pyrones. Heterocyclic chemistry of benzo-fused derivatives: Synthesis, medicinal applications and reactions of benzofurans, benzothiophenes, quinolines, isoquinolines, quinolizines, Indolizines, benzopyrylium salts, coumarin, chromene, chromones.

**Module V: Asymmetric synthesis****(9 Lectures)**

Cram's rule, Felkin's rule, Prelog's rule, Karabatsos's rule and their application in organic synthesis (stereoselectivity in hydride reduction), Homogenous and heterogenous asymmetric catalysis.

**Text books:**

1. J. March, M. B. Smith, Advanced Organic Chemistry – Reactions, Mechanism and Structure, 7th ed., John Wiley, 2015.
2. S. M. Mukherjee, Pericyclic Reactions: A Mechanistic Study, 3rd ed., Macmillan, India, 2010.
3. I. L. Finar, Organic Chemistry, Vol. I & II, 5th ed., Longman Ltd., New Delhi, 2011.
4. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd ed., New Age Int., New Delhi, 1994.

**Reference books:**

1. T. H. Lowry and K. S. Richardson, Mechanisms and Theory in Organic Chemistry, 2nd ed., Harper and Row, New York, 1981.
2. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, Springer, New York 2006.
3. I. Fleming, Frontier orbitals and organic chemical reactions, John Wiley and sons, Student edition, 2009.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Assignment	√	√	
Quiz –I	√		
Quiz II		√	
End Sem Examination Marks	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	M	H	L
CO4	M	H	H	L
CO5	M	H	M	L

### **Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4, 5	CD1
CD2	Tutorials/Assignments	CO1, 2, 3	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3	CD6
CD7	Simulation	CO2	CD7



**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Organic photochemistry	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-7</b>	<b>L10-L21</b>	<b>2</b>	Free radical reactions	<b>T3, R2</b>	<b>1</b>	<b>-do-</b>
<b>8-9</b>	<b>L22-L27</b>	<b>3</b>	Pericyclic reactions	<b>T2, R3</b>	<b>1</b>	<b>-do-</b>
<b>10-12</b>	<b>L28-L36</b>	<b>4</b>	Heterocyclic chemistry	<b>T1, T3, R2</b>	<b>2</b>	<b>-do-</b>
<b>13-15</b>	<b>L37-L45</b>	<b>5</b>	Asymmetric synthesis	<b>T1, R4</b>	<b>3</b>	<b>-do-</b>

**Course code:** CH 411

**Course title:** Physical Chemistry-VIII: Equilibrium, Non-Equilibrium & Statistical Thermodynamics

**Pre-requisite(s):** B. Sc. (H) Chemistry

**Co- requisite(s):**

**Credits:** 3      L: 3      T: 0      P: 0

**Class schedule per week:** 03

**Class:** M. Sc. and I. Msc.

**Semester / Level:** M. Sc. II/ I. M. Sc. VIII

**Branch:** Chemistry

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basic principles of equilibrium and non-equilibrium thermodynamics.
B.	To familiarize with the fundamental concepts of statistical thermodynamics.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to calculate change in thermodynamic properties, equilibrium constants, partial molar quantities, chemical potential.
2.	Able to solve numerical problems based on non-ideal solutions, chemical potentials, thermodynamic properties.
3.	Able to measure the partition function of ideal and real gases.

## Syllabus

### Module I: Equilibrium Thermodynamics Basics

(8 lectures)

Introduction to thermodynamics: Concept of work and heat, first law of thermodynamics, enthalpy and heat capacities, concept of entropy, second law of thermodynamics, third law of thermodynamics-residual entropy. Maxwell's Relations and its applications and thermodynamic equations of state.

### Module II: Equilibrium Thermodynamics Applications

(9 lectures)

Free energy, free energy of mixing of gases and variation of free energy with temperature, pressure and volume (Gibbs-Helmholtz equations with its applications). Chemical potential, Gibbs-Duhem equation, determination of partial molar quantities, equilibrium constant, temperature dependence of equilibrium constant. Clapeyron & Clapeyron-Clausius equation, fugacity & activity of gas and liquid. Third law of thermodynamics: Determination of absolute entropy of solids, liquids & gases, Boltzmann entropy equation.

### Module III: Statistical Thermodynamics Basics

(8 lectures)

Concept of distribution, Thermodynamic probability and most probable distribution, Maxwell-Boltzmann statistics, Bose-Einstein statistics, Fermi-Dirac statistics. Ensemble averaging, Canonical, Grand canonical and micro canonical ensembles.

### Module IV: Statistical Thermodynamics Applications

(10 lectures)

*Ideal Gases:* Partition functions: Translational, rotational, Vibrational and electronic partition functions and calculation of thermodynamic properties in terms of partition functions for ideal monatomic and diatomic gas. Equilibrium constant of an ideal gas reaction in terms of partition function. *Real gases:* intermolecular potential and virial coefficients. Debye and Einstein theory of heat capacity of solids. Structure and thermal properties of liquids, Pair correlation functions. *Solids:* Thermodynamics of solids - Einstein and Debye models.  $T^3$  dependence of heat capacity of solids at low temperatures (universal feature). *Metals:* Fermi function, Fermi energy, free electron model and density of states, chemical potential of conduction electrons.

**Module V: Non-equilibrium thermodynamics****(10 lectures)**

Thermodynamic criteria for non-equilibrium state, Phenomenological laws and Onsager reciprocal relations, Conservation of mass and energy in closed and open system. Entropy production: Due to heat flow, involving chemical reactions. Entropy production and entropy flow in open system. Transformation properties of fluxes and forces. Electrokinetic phenomena. Stationary non-equilibrium state: Prigogine's principle. Irreversible thermodynamics for biological systems.

**Text books:**

1. D. A. McQuarrie and J. D. Simon, Molecular Thermodynamics, Viva Books Private Limited, 1st Indian edition, 2004.
2. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A molecular Approach, Viva, 1998.
3. C. Kalidas and M. V. Sangaranarayan, Non-Equilibrium Thermodynamics: Principles and Applications, McMillan India Ltd., 2002.
4. R. P. Rastogi and R. R. Misra, An Introduction to Chemical Thermodynamics, Vikas Publishing House Pvt. Ltd., 6th ed., 2000.
5. S. Glasstone, Thermodynamics for Chemists, East-West Press Pvt. Ltd. 2008.

**Reference books:**

1. P. W. Atkins, Physical Chemistry, 7th ed., Oxford University Press, New York, 2002.
2. I. N. Levine, Physical Chemistry, 5th ed., Tata McGraw Hill Pub. Co. Ltd., New Delhi. 2002.
3. F. W. Sears & G. L. Salinger, Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Narosa, 1986.
4. I. Prigogine, Introduction to Thermodynamics of Irreversible Processes. 3rd ed., Interscience, New York, 1978.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Assignments	√	√	
Quiz I	√		
Quiz II		√	
End Sem Examination Marks	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping of Course Outcomes onto Program Outcomes:**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	M	L
CO3	H	H	M	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3	CD1
CD2	Tutorials/Assignments	CO1, 2, 3	CD1, 2
CD3	Seminars	CO3, 4	CD3
CD4	Mini projects/Projects	CO1, 2, 3, 4, 5	CD4
CD5	Laboratory experiments/teaching aids	CO2, 3	CD5
CD6	Industrial/guest lectures	CO4	CD6, 7
CD7	Simulation	CO5	CD8

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L8</b>	<b>1</b>	Basics of Equilibrium Thermodynamics	<b>T1, T2,T3,R2</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	<b>L9-L17</b>	<b>2</b>	Applications of Equilibrium Thermodynamics	<b>T1,T2,T3 R2,R3</b>	<b>1</b>	<b>-do-</b>
<b>6-9</b>	<b>L18-L25</b>	<b>3</b>	Basics of Statistical Thermodynamics	<b>T2, T3,R2</b>	<b>1, 2</b>	<b>-do-</b>
<b>9-12</b>	<b>L26-L35</b>	<b>4</b>	Application of Statistical Thermodynamics	<b>T1,R4</b>	<b>3</b>	<b>-do-</b>
<b>12-15</b>	<b>L36-L45</b>	<b>5</b>	Basics of Non-equilibrium Thermodynamics	<b>T1,T2</b>	<b>2</b>	<b>-do-</b>

**Course code:** CH 412  
**Course title:** Analytical Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. II/ I. M. Sc. VIII  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basics of analytical Chemistry
B.	To understand several separation techniques
C.	To know about the classical analytical methods
D.	To learn the thermal and electrochemical techniques of analysis

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the basics of analytical Chemistry
2.	Separate the mixtures by different separation methods
3.	Able to determine the sample by volumetric and gravimetric analysis
4.	Determine the samples through different thermal and electrochemical techniques of analysis

## Syllabus

### Module I: Introduction to Analytical Chemistry (10 lectures)

Types of analysis-qualitative and quantitative. Classification of analytical methods- classical and instrumental, basis of their classification with examples. Statistical analysis and validation: Errors in chemical analysis. Classification of errors- systematic and random, additive and proportional, absolute and relative. Accuracy and precision. Mean, median, average deviation and standard deviation. Significant figures and rules to determine significant figures. Calculations involving significant figures. Confidence limit, correlation coefficient and regression analysis. Comparison of methods: F-test and T-test. Rejection of data based on Q test. Least squares method for deriving calibration graph. Validation of newly developed analytical method. Certified reference materials (CRMs). Numerical problems.

### Module II: Separation Techniques (10 lectures)

*Chromatography:* Definition and Classification. Techniques used in Paper, Thin Layer and Column chromatography. Applications in qualitative and quantitative analysis.

*Ion exchange:* Principle and technique. Types of ion exchangers. Ion exchange equilibria. Ion exchange capacity. Effect of complexing ions. Zeolites as ion-exchangers. Applications.

*Solvent extraction:* Principle and techniques. Distribution ratio and distribution coefficient. Factors affecting extraction efficiency: Ion association complexes, chelation, synergistic extraction, pH. Numericals based on multiple extractions. Role of chelating ligands, crown ethers, calixarenes and cryptands in solvent extraction. Introduction to Solid phase extraction (SPE) and Microwave assisted extraction (MAE), Applications.

### Module III: Classical Methods of Analysis (9 lectures)

*Volumetric analysis:* General principle. Theory of indicators. Types of titrations with examples- Acid-base, precipitation, redox and complexometric. Titration curves for monoprotic and polyprotic acids and bases. Indicators used in various types of titrations. Masking and demasking agents.

*Gravimetric analysis:* General principles and conditions of precipitation. Concepts of solubility, solubility product and precipitation equilibria. Steps involved in gravimetric analysis. Purity of precipitate: Co-precipitation and post-precipitation. Fractional precipitation. Precipitation from homogeneous solution. Particle size, crystal growth, colloidal state, aging and peptization phenomena. Ignition of precipitates.

**Module IV: Thermal Methods of Analysis**

**(7 lectures)**

Principle, methodology and applications: thermogravimetric and differential thermal analysis, differential scanning calorimetry; Thermo-mechanical and dynamic mechanical analysis; thermometric titrations

**Module V: Electrochemical Methods of Analysis**

**(9 lectures)**

Conductometry: Concepts of electrical resistance, conductance, resistivity and conductivity. Specific, molar and equivalent conductance and effect of dilution on them. Measurement of conductance. Kohlrausch's law, Applications of conductometry in determination of dissociation constant, solubility product. Conductometric titrations. High frequency titrations. Numerical problems.

Potentiometry: Circuit diagram of simple potentiometer. Indicator electrodes: hydrogen electrode, quinhydrone electrode, antimony electrode and glass electrode. Reference electrodes: Calomel electrode and Ag/AgCl electrode. Theory of potentiometric titrations. Acid-base, redox, precipitation and complexometric titrations. Nernst equation, standard electrode potential, Determination of cell potential,  $n$ ,  $K_f$  and  $K_{sp}$ . pH titrations. Buffers and buffer capacity. pH of buffer mixtures based on Henderson-Hasselbalch equation.

**Text books:**

1. G. D Christian, Analytical Chemistry. 5th ed., John – Wiley and Sons Inc., 1994.
2. D. A. Skoog, D. M. West and F. J. Holler, Fundamentals of Analytical Chemistry. 7th ed., Saunders College Publishing, 1996.
3. H. H. Willard, L. L. Merrit, J. A. Dean and F. A. Set, Instrumental methods of Analysis, CBS Publishers, 1996.

**Reference books:**

1. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5th ed., McGraw-Hill, New York, 1988.
2. A. J. Bard & L. R. Faulkner, Electrochemical methods, 2nd ed., Wiley, New York, 2000.
3. Vogel's text book of Quantitative Chemical analysis 5th edition, Ed., Jeffery et al. ELBS/Longman, 1989.
4. Encyclopedia of Analytical Chemistry: Ed. by R.A. Meyers Vol. 1-15, John Wiley, 2000.
5. D. M. Skoog, D. M. West and F. J. Holler, Fundamentals of Instrumental Analysis, 8th ed., Saunders College Publishing, 2004.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz -1		√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L



### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-4	L1-L09	1	Introduction to Analytical Chemistry	T1, R1,R3	1	PPT Digi Class/Chock-Board
4-7	L10-L18	2	Separation Techniques	T1,T2 R1,R3	1	-do-
7-10	L19-L27	3	Classical Methods of Analysis	T1, R2,R3	2	-do-
10-11	L28-L36	4	Thermal Methods of Analysis	T1	3	-do-
12-15	L37-L45	5	Electrochemical Methods of Analysis	T1	4	-do-

**Course code:** CH 413  
**Course title:** Inorganic Chemistry-V Lab  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      L:      T:      P: 4  
**Class schedule per week:** 04  
**Class:** M.Sc. and I M.Sc.  
**Semester / Level:** M. Sc. II/ I. M. Sc. VIII  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Semi micro qualitative analysis of mixtures containing two anions, two common cations and one rare earth elements: W, Mo, Ce, Th, Zr, V, U and Li.
2. Gravimetric determination of Fe in iron ore as  $\text{Fe}_2\text{O}_3$ .
3. Chemical Analysis of Alloy samples: Dissolution, sample preparation & Analysis. (any one)
  - a) Analysis of brass: Estimation of copper by gravimetry and zinc by EDTA titration.
  - b) Analysis of bronze: Estimation of copper by volumetry and tin by gravimetry
4. Inorganic Synthesis:
  - a) Nano-chemistry: Synthesis and characterization of manganese dioxide nanoparticles
  - b) Synthesis of pentaamminechlorocobalt(III) chloride.
  - c) Preparation of *cis* and *trans*-dichlorobis-(ethylenediamine)cobalt(III) chloride
  - d) Ligand synthesis for multimetal complex: Preparation of *bis*-(*N,N*-disalicylidene ethylenediamine)
  - e) Synthesis and characterization of *tris*-triphenylphosphinecopper(I) nitrate
  - f) Preparation of *bis*-(*N,N'*-disalicylaethylene-diamine)- $\mu$ -aquadichlorocobalt(II)

## Reference Books:

1. Vogel's Text book of Qualitative Chemical Analysis, J. Bassett, G. H. Jeffery and J. Mendham, ELBS, 1986.
2. Vogel's text book of Quantitative Chemical Analysis, 5th Edition, J. Bassett, G. H. Jeffery and J. Mendham, and R. C. Denny, Longman Scientific and Technical, 1999.
3. J. D. Woollins, Inorganic Experiments; VCH, Weinheim, 1994.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 414  
**Course title:** Theoretical & Computational Chemistry Lab  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      **L:** 0      **T:** 0      **P:** 4  
**Class schedule per week:** 04  
**Class:** M.Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. II/ I. M. Sc. VIII  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. A) Draw and clean the 2D chemical structure for given molecules (e.g.; Barbituric Acid, N-acetylneuraminic acid, Cholesterol) as per ACS format using ChemDraw Software. B) Perform the analysis of the drawn structure to report IUPAC name, molecular weight, exact mass and elemental analysis. C) Convert the 2D chemical structure into 3D structure using Chem3D software and demonstrate the various molecular models.
2. Draw the suitable conformers of 2,3-dibromobutane and demonstrate in Sawhorse, Newmann, and Fisher projection. Minimize the eclipsed and staggered conformer and evaluate the energies by molecular mechanics (MM) for both conformers.
3. Compute the physico-chemical properties such as log p, solubility, molar refractivity and NMR for a given molecule.
4. Draw the reaction mechanism for a given name reaction using ChemDraw tools in ACS (American Chemical Society) format.
5. Compute the partial atomic charges (extended Huckel) in phenol and display by color gradient.
6. Draw and demonstrate the HOMO-LUMO diagram using ethylene molecule. Minimize the energy of the given molecule and calculate HOMO-LUMO energy gap using Gaussian Software.
7. (a) Introduction about the computational chemistry software Schrodinger, understanding and use of its Graphical interface "Maestro" to prepare the molecular system for computer simulation. (b) Draw the 3D structure of a given chiral molecule (tamiflu) in Maestro workspace, clean the structure by short minimization using MM.
8. Generate the all stereochemical structure of a given molecules (tamiflu or zanamavir) using maestro interface of Schrodinger.
9. Conduct the molecular docking experiment for a given ligands with a large protein structure. Report the docking score and binding mode of ligands within the protein active site. Compare the docking result to conclude the remarks for its binding affinity.
10. Determine the single point energy of benzene (assume: singlet and uncharged) by density-function calculation with the B3LYP functional and a 6-31G\*\* basis set. Optimize the geometry of the output structure from experiment-9 using BLYP/6-31G\*\* level.
11. Run the calculation to demonstrate the electrostatic potential (ESP) of vinyl alcohol. Label atoms in the workspace with atomic properties derived from the ESP and examine the electrostatic potential (ESP) on the molecular surface.
12. Predict and describe the pKa values of organic bases such as methylamine, dimethyl amine and trimethyl amine using ChemOffice.
13. Draw and describe the 3D conformational features of *trans*-1,3-dimethyl cyclohexane. Draw, demonstrate and compare the electrostatic potential map of CH<sub>3</sub>-Cl and CH<sub>3</sub>-Li. Explain the significance of this experiment.

## Text books:

1. F. Jensen, Introduction to Computational Chemistry, Wiley, New York, 1999.
2. A. Szabo and N. S. Ostlund, Modern Quantum Chemistry, Introduction to Advanced Electronic Structure Theory, 1st ed., revised      Dover, 1989. More mathematical detail for many of the ab initio electronic structure methods.

**Reference book:**

1. D. A. McQuarrie, Quantum Chemistry, University Science Books, Mill Valley, CA, 1983.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 501  
**Course title:** Spectroscopic Elucidation of Molecular Structure  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To interpret spectra collected through different characterization tools
B.	To deduce the structure of molecules from given spectral data

### Course Outcomes

After the completion of this course, students will be:

1.	Learn fundamental principal of different characterization techniques
2.	Apply the basics of structural elucidation principles in deducing the molecular structure
3.	Analyse the given spectrum to decipher the molecular structure

## Syllabus

### UV-Visible & IR Spectroscopy (8 Lectures)

Electronic transitions, Chromophores, Auxochromes, Bathochromic and hypsochromic shifts, Solvent effects, Woodward –Fieser Rules for dienes, enones and aromatic compounds.

Vibrational Transitions, Important group frequencies, Factors affecting I.R. group frequency, Applications of I.R. Instrumentation and recording of spectra.

### Nuclear Magnetic Resonance Spectroscopy (10 Lectures)

<sup>1</sup>H-NMR: chemical shift, spin-spin interaction, shielding mechanism, chemical shift values and correlation for protons bonded to carbons and other nucleus, chemical exchange, effect of deuteration, complex spin-spin interaction between 2, 3, 4 and 5 nuclei, virtual coupling, stereochemistry, hindered rotation, simplification of complex spectra, nuclear magnetic double resonance, contact shift reagents, solvent effects, <sup>13</sup>C-NMR: General considerations, chemical shifts, coupling constants and examples 2D-NMR: spectroscopy-COSY, NOESY, DEPT. DEPT with 3 different angles, interpretation of 2D spectra and examples.

### Mass Spectrometry (9 Lectures)

Introduction, ion production, factors affecting fragmentation, ion analysis, ion abundance, mass spectro fragmentation in organic compounds, common functional groups, molecular ion peak, high resolution mass spectrometry, examples of mass spectral fragmentation of organic compounds w.r.t. their structure determination.

### Electron Spin Resonance Spectroscopy & Mossbauer Spectroscopy (11 Lectures)

Hyperfine coupling, Spin polarization for atoms and transition metal ions, spin orbit coupling an significance of g-tensors, applications to transition metal complexes having one unpaired electron including biological systems and to inorganic free radicals such as PH<sub>4</sub>, F<sub>2</sub><sup>-</sup> and (BH<sub>3</sub>)<sup>-</sup>.

Mossbauer Spectroscopy: Basic principles, spectral parameters and spectrum display, applications to the study of bonding and structures of Fe<sup>2+</sup> and Fe<sup>3+</sup> compounds, Sn<sup>2+</sup> and Sn<sup>4+</sup> compounds– nature of M-L bond, Co-ordination number, structure and detection of oxidation state.

**Spectra and Structure: Combined application****(7 Lectures)**

UV, IR, NMR and Mass spectral data to elucidate unknown compound structure.

**Text books:**

1. D. H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, McGraw-Hill Education; 6th ed. 2007.
2. R. M. Silverstein, F. X. Webster, D. J. Kiemle, Spectrometric Identification of Organic Compounds, 7th ed.; Wiley: Hoboken, NJ, 2005.
3. W. Kemp, Organic Spectroscopy, McMillan, Reprint 2009.

**Reference books:**

1. J. R. Dyer, Applications of Spectroscopy of Organic Compounds, Prentice Hall, Reprint 2010.
2. R. S. Macomber, A Complete Introduction to Modern NMR Spectroscopy, Wiley-Interscience; 1st ed., 1997.
3. H. Gunther, NMR Spectroscopy, Basic Principles, Concepts and Applications in Chemistry, 3rd ed., Wiley VCH, 2013.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>
<b>Quiz -1</b>	√		
<b>Quiz II</b>		√	
<b>End Sem Examination Marks</b>	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	M	L	H
CO3	H	M	L	H

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3	CD1
CD2	Tutorials/Assignments	CO1, 2, 3	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3	CD6
CD7	Simulation	CO2	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-2	L1-L09	1	UV-Vis and IR spectroscopy	T1, T2	1	PPT Digi Class/Chock -Board
3-6	L10-L18	2	NMR Spectroscopy	T1,T2,T3 R1,R3	1	-do-
7-9	L19-L27	3	Mass Spectrometry	T2, T3	1, 2	-do-
10-12	L28-L36	4	EPR and Mossbauer Spectroscopy	T3,R1	3	-do-
13-15	L37-L45	5	Structure determination from given combination of spectra	T1,T2,T3, R1,R2	2	-do-

**Course code: CH 502 (SPL-I)**

**Course title: Inorganic Chemistry-VIII: Solid state and Nuclear Chemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co- requisite(s):**

**Credits: 4**      L: 3      T: 1      P: 0

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. III/ I. M. Sc. IX**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the basics of nuclear chemistry
B.	To grow concept of nuclear structure
C.	To know about the nuclear reactions
D.	To know about the structure of the solids and their reactivities

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the basics of nuclear chemistry
2.	Able to explain the nuclear stability
3.	Able to predict the nuclear reactions
4.	Able to explain the structure of the solids and their reactivities

## Syllabus

### Module I: Basic Nuclear Chemistry

**(9 Lectures)**

Systematic of alpha, beta and gamma decays, Alpha decay, energy curve, spectra of alpha particles, Geiger-Nuttall law, theory of alpha decay, penetration of potential barrier, beta decay, range of energy relationship, beta spectrum, sergeants curve, Fermi theory of beta decay, matrix elements, allowed and forbidden transitions, curie plots, gamma decay, Nuclear energy levels, selection rule, isomeric transitions, Internal conversion, Auger effect.

### Module II: Nuclear Structure and Stability

**(9 Lectures)**

Nuclear Potential, Binding energy, empirical mass equation, The Nuclear Models: Shell model-salient features, forms of the nuclear potential, filling of orbitals, nuclear configuration, Liquid drop model, Fermi gas model, Collective model and Optical model.

### Module III: Nuclear reactions

**(9 Lectures)**

Introduction, production of projectiles, nuclear cross section, nuclear dynamics, threshold energy of nuclear reaction, Coulomb scattering, potential barrier, potential well, formation of a compound nucleus, Nuclear reactions, direct Nuclear reactions, heavy ion induced nuclear reactions, photonuclear reactions. Fission and Fusion reactions: Fission barrier and threshold, fission cross section, mass energy and charge distribution of fission products, symmetric and Asymmetric fission, decay chains and delayed neutrons.

### Module IV: The Structure of solids

**(9 Lectures)**

The types of matter, classification of solids, close packing of atoms; Voids in closest packings; Radius ratio rule, Structure of ionic Crystals; Ionic Crystals with stoichiometry MX, Ionic Crystals with stoichiometry MX<sub>2</sub>, spinel structure, perovskite structure. Perfect and Imperfect Crystals, intrinsic and extrinsic defects- Point defects, line and plane defects, Vacancies- Schottky and Frenkel defects. Thermodynamics of Schottky and Frenkel defects formation, Colour centres, Non-stoichiometry and



defects. Evolution of band structure, Brillouin zone, Effective mass of electron, Intrinsic semiconductors, Hall effect, Electrical conductivity of metals, alloys & semiconductors. Fermi levels in metals & semiconductors, Direct & indirect band gap semiconductors, Photo-conductivity, Properties of junctions: metal – metal, metal – semiconductor & semiconductor – semiconductor. Application: Diode system, Photocatalytic systems

#### **Module V: Solid State Reactions**

**(9 Lectures)**

Thermal decomposition reactions- Type I, Type II, Polymorphism, Enantiotropy & Monotropy, Order-disorder transitions, Buerger's Classification, Polytypism, Sintering, Zone refining, Crystal growth, Growth from solutions, Flame fusion method, Vapour deposition technique, Chemical transport reaction, Growth by condensation.

#### **Text books:**

1. H. J. Arnikaar, Essentials of Nuclear Chemistry, 4th ed. Wiley Eastern, 1987.
2. A. R. West, Solid State Chemistry and its Applications, 2nd ed., Student Edition, Wiley, 2014.

#### **Reference books:**

1. G. Friedlander, T. W. Kennedy, E. S. Macias and J. M. Miller, Introduction of Nuclear and Radiochemistry, 3rd ed., John Wiley, 1981.
2. H. J. M. Bowen, Chemical Applications of Radioisotopes, Methuen, 1969.
3. C. N. R. Rao, New Directions in Solid State Chemistry, 2nd ed., Cambridge University Press, 1997.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz –I	√	√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

### **Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-2</b>	L1-L09	<b>1</b>	Basic Nuclear Chemistry: Systematic of alpha, beta and gamma decays, Alpha decay, energy curve, spectra of alpha particles, Geiger-Nuttal law, theory of alpha decay	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	L10-L18	<b>2</b>	Nuclear Structure and Stability Nuclear Potential, Binding energy, empirical mass equation, The Nuclear Models	<b>T1, T3, R2</b>	<b>2</b>	<b>-do-</b>
<b>5-6</b>	L19-L27	<b>3</b>	Nuclear reactions Introduction, production of projectiles, nuclear cross section, nuclear dynamics, threshold energy of nuclear reaction, Coulomb scattering, potential barrier, potential well	<b>T1, T2, R1</b>	<b>3</b>	<b>-do-</b>
<b>7-10</b>	L28-L36	<b>4</b>	The Structure of solids The types of matter, classification of solids, close packing of atoms, Ionic Crystals with stoichiometry $MX_2$ , spinel structure, perovskite structure. Perfect and Imperfect Crystals, Schottky and Frenkel defects. Colour centres, Non-stoichiometry and defects.	<b>T1, R2</b>	<b>4</b>	<b>-do-</b>
<b>11-15</b>	L37-L45	<b>5</b>	Solid State Reactions: Thermal decomposition reactions- Type I, Type II, Polymorphism, Buerger's Classification, Polytypism, Sintering, Zone refining, Crystal growth, Growth from solutions	<b>T1, T2, R1</b>	<b>5</b>	<b>-do-</b>

**Course code:** CH 503(SPL-I)  
**Course title:** Molecular Spectroscopy  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To recognize the fundamental principles of optical and magnetic resonance and simple relations between experimentally observable spectroscopic quantities and molecule dependent parameters by introducing time dependent quantum mechanics.
B.	To show that spectroscopy connects matter with molecules through interaction of electromagnetic radiation.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to apply principles of microwave, infrared and electronic spectroscopies to identify the fingerprint region of small molecules.
2.	Able to identify the element present in the molecule along with oxidation state from their respective binding energies.
3.	Able to apply the concept of chemical shift and spin-spin coupling in both NMR and EPR spectroscopy to identify high resolution spectra of small organic molecules.
4.	Familiar with modern spectrometers and methods, which are applied in industrial and scientific laboratories in the field of synthesis and structural determination.

### Syllabus

#### Module I: Rotational spectroscopy

(9 lectures)

Classification of polyatomic molecules: Linear, symmetric rotor, spherical rotor and asymmetric rotor molecules. The Stark effect in hetero-nuclear diatomic molecules. Rotational Raman spectroscopy. Applications of microwave spectroscopy.

#### Module II: Vibrational spectroscopy

(9 lectures)

Infrared (IR) spectroscopy, Raman spectroscopy; Polyatomic molecules: Group vibrations, Number of normal vibrations of each symmetry species, Vibrational selection rules, Vibration-rotation spectroscopy, Anharmonicity. Techniques and instrumentation-Analysis by IR spectroscopy.

#### Module III: Electronic spectroscopy

(9 lectures)

Diatomic molecules. Selection rules. Breakdown of selection rules. Franck-Condon factors. Dissociation energies. Transition moments, assignment of electronic transitions of N<sub>2</sub>, H<sub>2</sub>O and formaldehyde using group theory. Qualitative ideas of solvent effects- viscosity, polarity, hydrogen bonding. Fluorescence and phosphorescence.

#### Module IV: Photoelectron spectroscopy

(9 lectures)

Ionization processes and Koopman's theorem, Ultraviolet photoelectron spectroscopy, X-ray photoelectron spectroscopy. Auger electron spectroscopy: introduction- instrumentation- classification of various transitions- quantification- applications. Electron energy loss spectroscopy: Franck and Hertz experiment- instrumentation - selection rules- theory- studies on molecules- surface states- high resolution spectroscopy- adsorption and catalysis- applications.

**Module V: Spin resonance spectroscopy****(9 lectures)**

The effect of magnetic fields on electron and nuclei, nuclear magnetic resonance (NMR): Bloch equations, Steady state (continuous wave) and Transient (pulsed) experiments, nuclear Overhauser effect, Polarization transfer, Selective Population Inversion. Electron spin resonance (ESR): g value, hyperfine structure, ESR of organic free radicals, solids, inorganic ions, simple free radicals in solutions. Mossbauer spectroscopy: principle & applications.

**Text books:**

1. P. W. Atkins, J. de Paula, Physical Chemistry, Oxford, London, 7th ed. 2002.
2. P. S. Sindhu, Fundamentals of Molecular Spectroscopy, New Age International (P) Ltd. Publishers, 2006.
3. C. M. Banwell, Molecular Spectroscopy, Tata McGraw Hill, 1998.
4. G. M. Barrow, Introduction to Molecular Spectroscopy, McGraw Hill, 1964.
5. M. Hollas, Modern Spectroscopy, Wiley; 4th ed., 2004.

**Reference books:**

1. A. Carrington and A. D. McLachlan, Introduction to Magnetic Resonance, Methuen, 1983.
2. J. D. Graybeal, Molecular Spectroscopy, McGraw Hill, 1993.
3. H. Friebolin, Basic One- and Two-Dimensional NMR Spectroscopy 5th ed., Wiley-VCH, 2010.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>
<b>Assignment</b>	√	√	√	
<b>Quiz –I</b>	√			
<b>Quiz II</b>		√	√	
<b>End Sem Examination Marks</b>	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	H	L
CO2	H	H	M	L
CO3	H	H	H	L
CO4	H	H	M	L

**Mapping of Course Outcomes onto Program Outcomes:**

Mapping Between COs and Course Delivery (CD) methods			
CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1, 2
CD3	Seminars	CO 1, 4	CD3
CD4	Mini projects/Projects	CO 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO1, 2, 3, 4	CD6
CD7	Simulation	CO 2, 3	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Microwave Spectroscopy	T1, T2 T3, T4	1, 4	PPT Digi Class/Chock -Board
4-6	L10-L18	2	Infrared and Raman Spectroscopy	T1,T3 R1,R3	1, 4	-do-
7-9	L19-L27	3	Absorption and Photoluminescence Spectroscopy	T3,T5, R2	1, 4	-do-
10-12	L28-L36	4	Photoelectron Spectroscopy	T4, T5	2	-do-
13-15	L37-L45	5	NMR and ESR Spectroscopy	T1, R1, R2, R3	3, 4	-do-

**Course code:** CH 504(SPL-I)  
**Course title:** Advanced Organic Synthesis  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand protection and deportation of different functional groups
B.	To know about important hydroboration, oxidation and reduction reagents
C.	To understand the hydroboration, oxidation and reduction mechanism
D.	To learn about some important name reaction

### Course Outcomes

After the completion of this course, students will be:

1.	Able to consider protection/deportation of functional groups during organic synthesis
2.	Able to perform and compare the hydroboration, oxidation and reduction reagents
3.	Able to explain the hydroboration, oxidation and reduction mechanisms
4.	Able to use the knowledge of name reaction for research and development purpose

### Syllabus

#### Module I: Protection and deprotection

(8 Lectures)

Principle of protection and deprotection of alcohol, amine, carbonyl and carboxyl groups

#### Module II: Hydroboration reactions

(10 Lectures)

Introduction, synthetic application of organoboranes: isomerization, formation of C-C bonds, aldehydes, ketones, trialkylcarbinols, reactions of alkenylboranes and trialkylalkynyl borates, free-radical reactions of organoborane.

#### Module III: Reagents for Oxidation

(9 Lectures)

SeO<sub>2</sub>, CrO<sub>3</sub>, CrO<sub>2</sub>Cl<sub>2</sub>, LTA, t-BuOOH, mCPBA, PdCl<sub>2</sub>, HgSO<sub>4</sub>, KMnO<sub>4</sub>, OsO<sub>4</sub>, OsO<sub>4</sub>/RuO<sub>4</sub>, H<sub>2</sub>O<sub>2</sub>, C<sub>6</sub>H<sub>5</sub>CO<sub>3</sub>H, CF<sub>3</sub>CO<sub>3</sub>H, I<sub>2</sub>/Py, HIO<sub>4</sub>, PCC, PDC, Des-Martin periodinane, IBX, NBS, AgNO<sub>3</sub>, Ag<sub>2</sub>CO<sub>3</sub>, Ag<sub>2</sub>O, AgO, MnO<sub>2</sub>, NaIO<sub>4</sub> cat. Ozone, DDQ, DDQ/PbO<sub>2</sub>.

#### Module IV: Reduction

(9 Lectures)

Catalytic hydrogenation and hydrogenolysis of various functional groups by Pt<sub>2</sub>O, Pd/C, raney nickel, Homogeneous hydrogenation by transition metal complexes {Rh, Ru}, dissolving metal {Li, Na in Liq. NH<sub>3</sub>, Zn/HCl or CH<sub>3</sub>COOH}, non-metallic reducing agent {hydrazine, Et<sub>3</sub>SiH, Ph<sub>2</sub>SiH<sub>2</sub>, formic acid}, Metal hydrides-based Reduction: LiAlH<sub>4</sub>, alkoxyaluminate, DIBAL-H, NaBH<sub>4</sub>, NaBH<sub>3</sub>CN, LiBH<sub>4</sub>, Zn(BH<sub>4</sub>)<sub>2</sub>, NaBH<sub>4</sub>/CeCl<sub>3</sub>, alkoxy/alkyl borohydrides, super-hydride, selectrides, n-Bu<sub>3</sub>SnH

#### Module V: Selected Name reactions

(9 Lectures)

Biginelli reaction, Hantzsch reaction, Passerini reaction, Ugi reaction, McMurry olefination, Suzuki, Heck and Sonogashira coupling, Stille coupling, Mitsunobu reaction, Nef reaction, Ring closing metathesis (RCM) - Grubb's reaction, Larock Indole synthesis.

**Text books:**

1. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 2nd ed., Oxford Press, 2012.
2. I. L. Finar, Organic Chemistry, Vol. I & II, 5th ed., Longman Ltd., New Delhi, 2011.
3. R. S. Monson, Advanced Organic Synthesis, Academic Press, New York, 2012.

**Reference books:**

1. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th ed., 7th Indian Reprint, Pearson Education, 2005.
2. Jerry March, Advanced Organic Chemistry, Wiley, 7th ed., 2013
3. Carey and Sundberg, Advanced Organic Chemistry, Springer, 5th ed.; 2000

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>
<b>Quiz –I</b>	√	√		
<b>Quiz II</b>			√	
<b>End Sem Examination Marks</b>	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome



### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	M	L
CO2	H	H	M	L
CO3	H	H	M	L
CO4	H	H	M	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-2	L1-L09	1	Protection and deprotection	T1, T2	1	PPT Digi Class/Chock-Board
3-5	L10-L18	2	Hydroboration reactions	T1,T2,T3 R1,R3	1	-do-
6-8	L19-L27	3	Reagents for oxidation	T2, T3, R2, R3	1, 2	-do-
9-12	L28-L36	4	Reduction	T3,R1, R2,R3	3	-do-
13-15	L37-L45	5	Selected name reactions	T1,T2,T3, R1,R2, R3	2	-do-

**Course code: CH 505 (SPL-II)**

**Course title: Inorganic Chemistry-IX: Bio Inorganic Chemistry**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co- requisite(s):**

**Credits: 4      L: 3      T: 1      P: 0**

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. III/ I. M. Sc. IX**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To grow knowledge on elements of life
B.	To study the role of oxygen in biology and its reactivity
C.	To know about the Hydrolase and Oxido-Reductase Enzymes
D.	To study the role of metals in medicine

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the role of different elements in biology
2.	Able to explain the oxygen management and oxygen transport mechanism in biology
3.	Able to explain role of Hydrolase and Oxido-Reductase Enzymes
4.	Able to explain the role of metals in drug

## Syllabus

### Module I Basic Bio-inorganic Chemistry

**(9 Lectures)**

Elements of life, the natural selection of elements, metallo-biomolecules– enzymes and proteins, their differences, Metal ion storage and transport: Ferritin, metallothioneins, cerruloplasmin; Siderophores– enterobactin, transferin;  $\text{Na}^+$ ,  $\text{K}^+$  pump,  $\text{Ca}^{2+}$  transport.

### Module II Oxygen management and oxygen transport

**(9 Lectures)**

Kinetics of biological and non-biological oxygenation, Reactive Oxygen Species (ROS): Super oxide dismutase - Occurance, types, active site structure and mechanism of catalytic activity, Catalase, Peroxidase - Occurance, types, active site structure and mechanism of catalytic activity Cytochrome c Oxidase, Cytochrome P– 450- Occurance, types, active site structure and mechanism of catalytic activity. Natural Oxygen carriers: Heme Type: Myoglobins and Hemoglobins, Properties of heme and iron-porphyrins, The heme iron–dioxygen bond, Mechanism of dioxygen binding and model systems. Di-iron Type: Hemerythrins and Myohemerythrins : Early history and distribution of hemerythrins, Protein structure , The di-iron site and formulation of the  $\text{O}_2$  binding reaction, Mechanism of dioxygen binding, Autoxidation, Cooperative hemerythrins, Dicopper Type: Hemocyanins: Protein structure and superstructure, The dicopper site, Mechanism of dioxygen binding.

### Module III Hydrolase and Oxido-Reductase Enzymes

**(9 Lectures)**

Zn Carbonic Anhydrase, Zn Carboxy peptidase, Fe Acid Phosphatase, Ni Urease, Alcohol dehydrogenase- Occurance, types, active site structure and mechanism and model system. catalytic activity of Cu proteins for biological oxidation: Tyrosinase, Galactose oxidase, Catecholase, phenoxazinone synthase.

**Module IV Model Systems in Bioinorganic Chemistry (9 Lectures)**

Chemistry of Vitamin B<sub>12</sub>, Iron– Sulphur proteins, Cytochromes, Nitrogenase- biological nitrogen fixation, molybdenum nitrogenase, Nitrogenase model systems, Hydrogenase and model systems, Metal complexes in transmission of energy- Chlorophylls & Photosynthetic Water Oxidation.

**Module V Metals in Medicine (9 Lectures)**

Metal Toxicity and Homeostasis, Chelation Therapy, Vanadium-Based Diabetes Drugs, Pt based Anti-Cancer Drugs, Mechanism of cisDDP Antitumor Activity, Anti-arthritis drugs, Imaging Agents: Technetium Imaging Agents, Gadolinium MRI Imaging Agents, Gold containing drugs used in the therapy of Rheumatoid Arthritis, Lithium in psychopharmacological drugs.

**Text books:**

1. I. Bertini, H. B. Gray, S. J. Lippard, J. S. Valentine, Bioinorganic Chemistry, University Science Books, Mill Valley, CA, 1994.
2. W. Kaim, B. Schwederski, A. Klein, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide, Wiley, 1994.
3. L. Stryer, J. M. Berg, J. L. Tymoczko, 5th ed., W. H. Freeman & Co Ltd, 2002.

**Reference books:**

1. R. R. Crichton, Biological Inorganic Chemistry, 2nd ed., Elsevier, 2012.
2. R. M. Roat-Malone, Bioinorganic Chemistry: A Short Course, Wiley, 2002.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

<u>Direct Assessment</u>	
Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Quiz –I	√	√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-2</b>	L1-L09	<b>1</b>	Elements of life, the natural selection of elements, metallo-biomolecules– enzymes and proteins, their differences, Metal ion storage and transport	<b>T1, T2, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	L10-L18	<b>2</b>	Oxygen management and oxygen transport, Reactive Oxygen Species	<b>T1, T3, R2</b>	<b>2</b>	<b>-do-</b>
<b>5-6</b>	L19-L27	<b>3</b>	Hydrolase and Oxido-Reductase Enzymes, Zn Carbonic Anhydrase, Zn Carboxy peptidase, Fe Acid Phosphatase, Ni Urease, Alcohol dehydrogenase-	<b>T1, T2, R1</b>	<b>3</b>	<b>-do-</b>
<b>7-10</b>	L28-L36	<b>4</b>	Model Systems in Bioinorganic Chemistry, Chemistry of Vitamin B <sub>12</sub> , Iron– Sulphur proteins, Cytochromes, Nitrogenase- biological nitrogen fixation	<b>T1, R2</b>	<b>4</b>	<b>-do-</b>
<b>11-15</b>	L37-L45	<b>5</b>	Metal Toxicity and Homeostasis, Chelation Therapy, Vanadium-Based Diabetes Drugs, Pt based Anti-Cancer Drugs, Mechanism of cisDDP Antitumor Activity, Anti-arthritis drugs, Imaging Agents	<b>T1, T2, R1</b>	<b>5</b>	<b>-do-</b>

**Course code:** CH 506 (SPL-II)  
**Course title:** Advanced Electrochemistry  
**Pre-requisite(s):** B.Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To learn electrode kinetics, corrosion and corrosion control.
B.	To know the principle and applications of electroanalytical, Spectro-electrochemical and spectroscopic techniques.
C.	To learn about the electrochemical energy systems used as power sources and for energy storage.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to calculate electrochemical kinetics parameters, exchange current density, Tafel slope.
2.	Familiar with the basic concepts of corrosion, factors which influence the corrosion and gain the knowledge about the control of corrosion in real situation.
3.	Familiar with electrochemical techniques like cyclic voltammetry, polarography, chrono methods, electrochemical impedance spectroscopy.
4.	Familiar with the reversible and irreversible cells and their applications in various fields and able to distinguish batteries, fuel cells and capacitors.

### Syllabus

#### Module I: Electrode Kinetics

(9 lectures)

Mass transfer by Diffusion and Migration – models of electrode reactions – current potential characteristics–general mass transfer equation. Kinetics of an electrode reaction, Butler-Volmer equation, diffusion overpotential. Exchange current density, Tafel plot. Polarizable and non-polarizable interfaces. Irreversible electrode processes.

#### Module II: Corrosion

(9 lectures)

Different types of corrosion; Evans diagram, Pourbaix diagram; Corrosion current and Corrosion potential; Measurement of corrosion rate; Stern Geary equation; Mixed potential theory and prevention of corrosion.

#### Module III: Electroanalytical Techniques

(10 lectures)

*Potential Step Methods:* Types of techniques, step under diffusion control, Ilkovic equation–polarographic analysis–sampled current voltammetry, reversible, irreversible processes, multicomponent systems. *Chrono Methods:* Chronoamperometry, chronocoulometry. *Pulse polarographic methods:* *Potential Sweep Methods:* Cyclic Voltammetry; *Bulk Electrolysis Techniques:* Classification of methods–Controlled Potential methods: current – time behaviour, electrogravimetry, electroseparation–Coulometric measurements: controlled current methods: characteristics, coulometric methods–Electrometric end point detection: classification, potentiometric, amperometric methods.

#### Module IV: Spectro-electrochemical and spectroscopic techniques

(7 lectures)

Impedance Spectroscopy, Scanning Electrochemical Microscopy, Electrochemical AFM and STM, Electrochemical Quartz Crystal Microbalance.

**Module V: Electrochemical Energy Systems****(10 lectures)**

Electrochemical power sources - theoretical background on the basis of thermodynamic and kinetic considerations. Primary cells, secondary cells- magnesium and aluminium based cells magnesium reserve batteries, Li-ion batteries. Fuel cells - classification - chemistry of fuel cells - detailed description of hydrogen/oxygen fuel cells - methanol - molten carbonate solid polymer electrolyte and biochemical fuel cells. Photoelectrochemical cells, Electrochemical supercapacitors for energy storage.

**Text books:**

1. J.O'M. Bockris & A. K. N. Reddy, Modern Electrochemistry, Vol. 1 & 2A and 2 B, Plenum Press, New York, 2000.
2. A. J. Bard and L. R. Faulkner, Electrochemical methods, Wiley & Sons, 2nd ed., 2001.
3. S. Glasstone, Introduction to Electrochemistry, East West Press, reprint 2007.

**Reference books:**

1. D. R. Crow, The Principle of electrochemistry, Chapman Hall, 4th ed. 1994.
2. H. Kissinger, Electroanalytical Techniques, John wiley, 1998.
3. P. H. Reiger, Electrochemistry, Prentice Hall, 1987.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>
<b>Assignment</b>	√	√	√	
<b>Quiz –I</b>	√			
<b>Quiz II</b>		√	√	
<b>End Sem Examination Marks</b>	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	H	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	H	H	H	L

**Mapping Between COs and Course Delivery (CD) methods:**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO 2, 3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO1, 2, 3, 4	CD6
CD7	Simulation	CO1	CD7

**Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Electrode Kinetics	T1, T2 T3	1	PPT Digi Class/Chock-Board
3-5	L10-L18	2	Corrosion	T1,T3 R1	2	-do-
6-10	L19-L27	3	Different Electroanalytical Techniques	T1,T2, R2	3	-do-
11	L28-L36	4	Spectroelectrochemical Techniques	T1, T2	3	-do-
12-15	L37-L45	5	Electrochemical Energy Systems	T1, T2, R2, R3	4	-do-



**Course code:** CH 507 (SPL-II)  
**Course title:** Selected Topics in Organic Synthesis  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T:1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To know about advance spectroscopy of complex molecules
B.	To understand details on neighbouring group participation with mechanism
C.	To get idea about asymmetric synthesis using various catalyst
D.	To learn about retrosynthetic principle and approach

### Course Outcomes

After the completion of this course, students will be:

1.	Able to understand and identify the advance spectroscopy of complex molecules
2.	Able to explain the neighbouring group participation process and its mechanism
3.	Able to use the knowledge of asymmetric synthesis during the use of various catalyst
4.	Able to consider retrosynthetic approach during research and development

## Syllabus

### Module I: Advanced Stereochemistry

(9 Lectures)

Optical isomerism in compounds without any stereocenters (allenes, biphenyls), Enantiomerism in allenes, alkylidene cycloalkane, spiranes- configurational nomenclature, correlation of axial dissymmetry and centrodissymmetry, Stereochemistry of natural products, strychnine, podophyllotoxin, Conformation and reactivity of fused polycyclic systems: perhydrophenanthrenes.

### Module II: Neighboring Group Participation

(9 Lectures)

Concept of neighboring group participation with mechanism, neighboring group participation by  $\pi$  &  $\sigma$  bonds, classical and non-classical carbocations, Intramolecular displacement by hydrogen, Oxygen, nitrogen, sulphur and halogen. Anchimeric assistance using Alkyl, cycloalkyl, Aryl participation, participation in bicyclic system, migratory aptitude, intimate and solvent separated ion-pair, transannular, pinacole and carbocation rearrangements and related rearrangements in neighboring group participation, NGP in elimination and addition.

### Module III: Catalytic Asymmetric Synthesis

(9 Lectures)

Sharpless epoxidation and dihydroxylation; asymmetric cyclopropanation; asymmetric hydrogenation, Enzyme catalyzed asymmetric synthesis, CBS reduction, Reactions using Chiral Lewis Acids and Bronsted Acids, Hydrosilylation of Carbon-Carbon Double bonds and Related Reactions, Synthesis via C-H Activation: Introduction, types of C-H activation, oxidation of alkanes, addition of C-H bond to C-C double bonds, C-H activation in natural product synthesis.

### Module IV: Principles of Retrosynthesis

(9 Lectures)

Methodologies in organic synthesis-basic ideas on synthons and synthetic equivalents, disconnection approach, functional group transformations and inter-conversions of simple functionalities, Disconnection Approaches, Functional Group Interconversions (FGI). Concept of synthetic efficiency: one pot, multi-component and atom economical reactions. linear and convergent synthesis.

**Module V: Retrosynthetic analysis****(9 Lectures)**

One group disconnections, Reactions examples One group C-C and C-X disconnection, Umpolung of reactivity and protecting groups. Two group C-C disconnections, Diels-Alder reaction, 1,3-difunctionalised compounds,  $\alpha$ ,  $\beta$ -unsaturated carbonyl compounds, control in carbonyl condensation, 1,5-difunctionalised compounds. Michael addition and Robinson annelation, Retrosynthetic analysis and synthetic design of Tamiflu and Reserpine.

**Text books:**

1. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications; New Age International Publishers, 2018
2. M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanism and Structure, 7ed, Wiley, 2015.
3. W. Carruthers, I. Coldham, Some modern methods of Organic Synthesis, 4th ed., Cambridge Univ. Press, 2015.
4. S. Warren, Organic Synthesis: The Disconnection Approach, Wiley 2007

**Reference books:**

1. E. L. Eliel, Stereochemistry of Organic Compounds, Wiley, 2008
2. S. Warren, P. Wyatt Workbook for Organic Synthesis: The Disconnection Approach, 2nd ed., Wiley, 2010.
3. Norman and Coxon, Principle of Organic Synthesis, 3rd ed., CRC Press, 1993.
4. I. Ojima, Catalytic Asymmetric Synthesis, 3rd ed, John Wiley & Sons, New Jersey, 2010.
5. V. Sunjic, V. P. Perokovic; Organic Chemistry from Retrosynthesis to Asymmetric Synthesis, Springer, 2016

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz –I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>TextBook /References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	L1-L09	<b>1</b>	Advanced Stereochemistry	<b>T1, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock -Board</b>
<b>3-5</b>	L10-L18	<b>2</b>	Neighboring Group Participation	<b>T2, R3</b>	<b>1</b>	<b>-do-</b>
<b>5-7</b>	L19-L27	<b>3</b>	Catalytic Asymmetric Synthesis	<b>T1, T2 R4</b>	<b>2</b>	<b>-do-</b>
<b>7-9</b>	L28-L36	<b>4</b>	Principles of Retrosynthesis	<b>T4, R2, R5</b>	<b>3</b>	<b>-do-</b>
<b>9-12</b>	L37-L45	<b>5</b>	Retrosynthetic analysis	<b>T4, R2, R5</b>	<b>3</b>	<b>-do-</b>

**Course code: CH 508**

**Course title: Advanced Characterization Lab**

**Pre-requisite(s): B. Sc. (H) Chemistry**

**Co-requisite(s):**

**Credits: 2      L: 0      T: 0      P: 4**

**Class schedule per week: 04**

**Class: M. Sc. and I. M. Sc.**

**Semester / Level: M. Sc. III/ I. M. Sc. IX**

**Branch: Chemistry**

**Name of Teacher:**

## **Syllabus**

- I: Examples of organic sample characterization by UV-VIS, IR, NMR, Mass, CHN, mp and single crystal diffraction techniques.
- Experiment 1: Synthesis and characterization of sugar intermediates using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.
- Experiment 2: Synthesis of Nucleo-base analogs and characterization using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.
- Experiment 3: Synthesis of Benzanilide and characterization using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.
- II: Examples of bimolecular and polymeric materials characterization using Intense Viscosity Measurement, Molecular Weight Determination and Distribution using GPC, Light Scattering Technique, FTIR, NMR, SEM, XRD
- Experiment 1: Determination of  $T_g$  and  $T_m$  of Polyvinyl chloride and methylmethacrylate polymer using TGA/DSC.
- Experiment 2: Study of surface morphology of polymeric material /hybrid materials using XRD and SEM.
- Experiment 3: Finding out molecular weight of PMMA using light-scattering/GPC.
- III: Examples of inorganic sample characterization
- Experiment 1: Thermogravimetric analysis of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
- Experiment 2: Synthesis & characterization of Fluorescent Zn complexes by spectrofluorometer.
- Experiment 3: Study of surface morphology of inorganic materials using XRD and SEM.

## **Reference book:**

1. V. R. Gowariker, N. V. Viswanathan & J. Sreedhar, Polymer Science, New Age International (P) Ltd. Publishers, 1986.
2. W. Kemp, Organic Spectroscopy, Palgrave, Reprint 2009.
3. Suryanarayana, C.; Norton, M. G. X-Ray Diffraction - A Practical Approach, Springer Publishers, 1998.
4. Lyman, C. E. et al., K.-R. Scanning Electron Microscopy, X-Ray Microanalysis, and Analytical Electron Microscopy, Springer Publishers, 1990.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 509  
**Course title:** Inorganic Chemistry (SPL) Lab  
**Pre-requisite(s):** B.Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      L:      T:      P: 4  
**Class schedule per week:** 04  
**Class:** M.sc. and I M.Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Determination of conductivity of 1:1, 1:2 and 1:3 complexes.
2. Kinetics of Hg(II) catalysed reaction of  $[\text{FeCN}_6]^{4-}$  with 1,10-*ortho* phenonthroline and its application in the determination of trace quantity of Hg(II).
3. Study of the conductance of  $\text{H}[\text{Co}(\text{DMGH})_2\text{Cl}_2]$  in freshly prepared aqueous solution and its change with time for studying the rate of aquation.
4. pH metric determination of Proton- Ligand and Metal-Ligand stability constants.
5. Colorimetric study of the kinetics of the reduction of azidopentaminecobalt(III) chloride by aqueous Fe(II) ion.
6. Colorimetry: Simultaneous determination of chromium and manganese in a solution by visible spectroscopy.
7. Spectrofluorometric determination of lanthanide elements in dilute solution.
8. Quantitative determination of DNA–Ligand binding using fluorescence spectroscopy.
9. Determination of magnetic moment of the lanthanides by Gouy's method.
10. Use of ligand field tetragonality on the ground state spin of Ni(II) complexes.
11. Determination of formal potential of electronically non-innocent ligands.
12. Determination of formal potential of metal complexes.

## Reference books:

1. M. V. Cases, Principles of analytical chemistry, Springer, 2000.
2. D. Harvey, Modern Analytical Chemistry; Mcgraw-Hill, 2000.
3. A. J. Bard and I. Rubinstein, Electroanalytical Chemistry, CRC Press, 1998.
4. Electroanalytical Chemistry: A Series of Advances: Volume 24, A. J. Bard and C. Zoski, CRC Press, 2017.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 510  
**Course title:** Physical Chemistry (SPL) Lab  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. To determine pH of a buffer solution using quinhydrone electrode.
2. Oscillatory reaction: Chemical oscillation & pattern formation in B-Z system.
3. To study the phase diagram of two components forming a simple eutectic.
4. To determine the molecular weight of a polymer from viscosity measurements.
5. To determine magnetic susceptibility by Guoy balance.
6. To determine the surface area of alumina by BET surface area determination method.
7. To determine the solubility product by conductivity and potentiometric methods.
8. Stability constants of complexes by the use of pH meter, potentiometric method.
9. Reversibility of an electrochemical reactions and determination of concentration of a given reducible ion-Polarography.
10. To determine the Tafel constants, the corrosion current and the linear polarisation resistance from polarisation curves.
11. Electrochemical impedance spectroscopy (EIS) study and formation of equivalent circuit diagram.
12. To determine the effect of change of temperature, concentration of reactant and catalyst and ionic strength of the media on the velocity constant of hydrolysis of an ester.

### Text books:

1. B. Viswanathan, and P. S. Raghavan, Practical Physical Chemistry, Viva Books, 2010.
2. J. B. Yadav, Advanced Practical Physical Chemistry, 22<sup>nd</sup> edition, Goel publishing House, Krishna Prakashan Media Ltd. 2005.
3. V. Venkatesan, R. Veeraswamy and A.R. Kulandaivelu, Basic Principles of Practical Chemistry, 2nd ed., Sultan Chand and Sons Publication, New Delhi. 1997.
4. D. Harvey, Modern Analytical Chemistry; Mcgraw-Hill, 2000.

### Reference books:

1. B. P. Levitt, Findlays Practical Physical Chemistry, 9th ed., Longman, London, 1985.
2. G. R. Chatwal and S. K. Anand, Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi, 2000.
3. A. M. Halpern and G. C. McBane, Experimental Physical Chemistry: A Laboratory Text Book, 3rd ed., W. H. Freeman, 2006.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

**Course code:** CH 511  
**Course title:** Organic Chemistry (SPL) Lab  
**Pre-requisite(s):** B.Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:**2      L: 0      T: 0      P: 4  
**Class schedule per week:** 04  
**Class:** M.Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. III/ I. M. Sc. IX  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

1. Synthesis of alcohol from the reaction of a Grignard reagent and a ketone.
2. Synthesis of an alkene from dehydration of the alcohol prepared in previous step.
3. Multi-step reactions, (Cyclohexanone to methyl cyclohexane) using i) Grignard reaction ii) Dehydration iii) High-pressure hydrogenation.
4. Anthranilic acid from phthalic anhydride.
5. Synthesis of Nylon 6 starting from cyclohexanone.
6. Characterization of an organic compound through CHN, Mass, FTIR, NMR and single crystal X-ray diffraction.

## Reference Books:

1. A. I. Vogel, Quantitative Organic Analysis, Part 3, Pearson, 2012.
2. F. G. Mann, & B. C. Saunders, Practical Organic Chemistry, Pearson Education, 2009.
3. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Practical Organic Chemistry, 5th ed., Pearson, 2012.
4. V. K. Ahluwalia and R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2000.
5. V. K. Ahluwalia and S. Dhingra, Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press, 2000.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)



**Course code:** CH 513 (SPL-III)  
**Course title:** Inorganic Chemistry-X: Inorganic Photochemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. IV/ I. M. Sc. X  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the photolytic excited state
B.	To know the techniques to study the excited state
C.	To learn the photochemistry of polypyridyl complexes and porphyrins
D.	To know the application of inorganic photochemistry

### Course Outcomes

After the completion of this course, students will be:

1.	To explain photochemical excited state
2.	To determine the properties of the excited state
3.	To explain the photochemical properties of polypyridyl complexes and porphyrins
4.	To explain the application of inorganic photochemistry

## Syllabus

### Module I Photophysical properties of excited state

(9 Lectures)

Absorption spectra and electronic transitions, Assignment of electronic transitions, Charge transfer transition, Radiative decay, Non-radiative decay and the energy gap law, Classification of the excited state- MLCT, MC & LC excited state, Reactivity pattern of the excited state, Electronic excited state of  $d^3$  and  $d^6$  complexes, Solvent effects and dipole moment of the excited state, Acid- base reactions of the excited states.

### Module II Photochemical reactions and techniques for the study of excited state (9 Lectures)

Bimolecular quenching of the excited state, Energy and electron transfer quenching, Energetics, Photoredox reactions of metal complexes - Thermal electron transfer process: Classical treatment and self exchange type, Energy transfer reactions of the excited state, Excited state acid-base reactions, Photoinduced electron transfer, Photoinduced energy transfer (Forster and Dexter mechanism), Characterization of the excited state by steady state methods and Time-Resolved methods (Flash Photolysis), Time resolved conductivity, Electron spin resonance, Photoselection, Study photo-redox and energy transfer reactions, Study of the photosubstitution reactions.

### Module III Photochemistry of the Polypyridyl complexes and porphyrins (9 Lectures)

Polypyridyl ligands as chelating agents, Free ligand and metal complexes excited state, Ground and excited state redox properties, General trends in polynuclear and ortho-metallated complexes, Polypyridyl complexes of Fe, Ru, Os, Cr and Cu Photochemical applications of Polypyridyl complexes: Catalysed photodecomposition of  $H_2O$  to  $H_2$ , and  $O_2$ , Catalysed photoreduction of CO and  $CO_2$ ,  $Ru(bpy)_3^{2+}$  as dye for DSSC.

### Module IV Photochemistry of Porphyrins

(9 Lectures)

Introduction to porphyrin, Types of porphyrin and their general features, Classification based on peripheral substitution, Reduced porphyrins, Electronic spectroscopy of metalloporphyrin- Classification based on absorption and emission spectral feature, Description on metalloporphyrin ground and excited

state, Different types of excited states of porphyrins. Resonance Raman spectra of metalloporphyrins. Hypso porphyrins: luminiscent type- Cu Porphyrin, Ag Porphyrin, Phosporescent type- Au Porphyrins, Pt Porphyrins, Pd Porphyrins, Rh Porphyrins, Ru Porphyrins, Os Porphyrins; Radiationless Hypso Porphyrins: Fe and Co Porphyrins, Hyper porphyrine: d type- Cr and Mn Porphyrins, p Type-Metalloid porphyrins; Pseudo normal Porphyrins-Lanthanide porphyrins..

#### **Module V Application of Inorganic Photochemistry**

**(9 Lectures)**

Environment cleaning: Photocatalytic reactions of volatile hydrocarbons, Photocatalytic activity of  $\text{TiO}_2$  in cleaning air pollutants, Photocatalyst based air purifying materials.

Porphyrin and photosynthesis, Active site structure of Chlorophyl, Accessory Pigments and Extended Range of Light Absorption, Exciton Transfer; Central Photochemical Event: Light-Driven Electron Flow, The Pheophytin-Quinone Reaction Center, Functional modules of photosynthetic machinery- Z Scheme, Biomimetic energy production- Artificial photosynthesis, Photosynthetic cell, Dye Sensitised Solar Cell, Tandem Cell.

#### **Text books:**

1. K. Kalyanasundaram, Photochemistry of Polypyridine and Porphyrin Complexes; Academic Press Limited: London, 1992.

#### **Reference books:**

1. M. Kaneko, I. Okura, Photocatalysis: Science and Technilogy, Springer
2. E. A. B. Ebsworth, D. W. H. Rankin, S. Cardock, Structural methods in Inorganic Chemistry; 2nd ed., Wiley-Blackwell, 1991.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

#### **Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

##### **Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a commitee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz –I	√	√		
Quiz-II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

- 1. Student Feedback on Faculty**
- 2. Student Feedback on Course Outcome**

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-2</b>	L1-L09	<b>1</b>	Photophysical properties of excited state	<b>T1, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	L10-L18	<b>2</b>	Photochemical reactions and techniques for the study of excited state	<b>T1, R2</b>	<b>2</b>	<b>-do-</b>
<b>7-8</b>	L19-L27	<b>3</b>	Photochemistry of the Polypyridyl complexes and porphyrins	<b>T1, R1</b>	<b>3</b>	<b>-do-</b>
<b>8-13</b>	L28-L36	<b>4</b>	Photochemistry of Porphyrins	<b>T1</b>	<b>4</b>	<b>-do-</b>
<b>13-15</b>	L37-L45	<b>5</b>	Application of Inorganic Photochemistry	<b>T1, R1</b>	<b>5</b>	<b>-do-</b>

**Course code:** CH 514 (SPL-III)  
**Course title:** Chemical Applications of Group Theory  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. IV/ I. M. Sc. X  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To apply the great orthogonality theorem to derive simple point groups and illustrate its use in the applications in crystal field theory, pericyclic reactions and molecular spectroscopy.
----	---

### Course Outcomes

After the completion of this course, students will be:

1.	Able to determine the symmetry operations of any small and medium-sized molecule and apply point group theory to the study of electrical, optical and magnetic properties and selection rules for absorption.
----	---

### Syllabus

#### Module I: Molecular Vibrations

(9 lectures)

Group theory and normal modes of vibrations of polyatomic molecules. Procedure for determining the irreducible representation of the vibrational modes for H<sub>2</sub>O, NH<sub>3</sub> molecules. Selection rules for fundamental vibration transition.

#### Module II: Molecular Orbital (MO) Theory & its Application in Organic Chemistry

(9 lectures)

Symmetry factoring of secular equations, carbocyclic system, LCAO-MO  $\pi$ -bonding for naphthalene & formaldehyde. Electronic excitation, Selection Rule and Configuration interaction, Three-centre bonding, Symmetry-based selection rule for cyclization reaction.

#### Module III: MO Theory for Inorganic & Organometallic Compounds

(9 lectures)

Transform properties of atomic orbitals, hybridization scheme for  $\sigma$  &  $\pi$  bonding orbitals; MO theory for AB<sub>n</sub>-type of molecules and regular octahedral and tetrahedral molecules.

#### Module IV: Ligand Field Theory

(9 lectures)

Electronic structure of free atoms and ions; Splitting of levels and terms in chemical environment, Construction of energy level diagrams; Estimation of orbital energy; Selection rules and polarization; Double groups.

#### Module V: Crystallographic Symmetry

(9 lectures)

Two-dimensional space symmetries; Three-dimensional and their symmetries; Crystal symmetry; Interrelating lattice symmetry, crystal symmetry & diffraction symmetry; Additional symmetry elements & operations; Space groups and X-ray crystallography.

#### Text books:

1. F. A. Cotton, Chemical Applications of Group Theory, 3rd ed., Wiley Eastern Limited, 1985.
2. V. Ramakrishnan and M. S. Gopinathan: Group Theory in chemistry, Vishal Publication, 1986.

#### Reference books:

1. P. Atkins, R. Friedman, Molecular Quantum Mechanics, 4th ed., Oxford University Press, 2005.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1
Assignment	√
Quiz -1	√
Quiz II	√
End Sem Examination Marks	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	H	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO 1	CD1
CD2	Tutorials/Assignments	CO 1	CD1, 2
CD3	Seminars	CO 1	CD3
CD4	Mini projects/Projects	CO 1	CD4
CD5	Laboratory experiments/teaching aids	CO 1	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO 1	CD6
CD7	Simulation	CO 1	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L09	1	Group Theory and normal modes of vibration for polyatomic molecules	T1, T2,R1	1	PPT Digi Class/Chock -Board
3-5	L10-L18	2	Molecular Orbital (MO) Theory and its Application	T1, T2,R1	1	-do-
6-10	L19-L27	3	MO Theory for Inorganic Compound	T1, T2,R1	1	-do-
11	L28-L36	4	Ligand Field Theory	T1, T2,R1	1	-do-
12-15	L37-L45	5	Crystallographic Symmetry	T1, T2,R1	1	-do-

**Course code:** CH 515 (SPL-III)  
**Course title:** Interdisciplinary Organic Chemistry  
**Pre-requisite(s):** B. Sc. (H) Chemistry  
**Co- requisite(s):**  
**Credits:** 4      L: 3      T: 1      P: 0  
**Class schedule per week:** 04  
**Class:** M. Sc. and I. M. Sc.  
**Semester / Level:** M. Sc. IV/ I. M. Sc. X  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the structure and functions of Carbohydrate, peptides, proteins, flavonoids, terpenoids and steroids in biological system. How to differentiate reducing and non-reducing sugars.
B.	Study reactions involving peptide synthesis, biosynthesis of Steroids.
C.	To understand polymer chemistry including Properties of polymers, Methods of polymerization and processing.
D.	To design safer chemicals, safer solvents and auxiliaries, energy efficient reactions for Green synthesis.

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain structure and functions of Carbohydrate, peptides, proteins, flavonoids, terpenoids and steroids.
2.	Able to explain properties of polymers, their methods of preparation and processing.
3.	Able to design safer chemicals, safer solvents and auxiliaries, energy efficient reactions for Green synthesis
4.	Able to explain the principles of green chemistry

## Syllabus

### Module I: Carbohydrate chemistry

(10 Lectures)

Biological importance of monosaccharides (aldohexose-glucose, mannose, galactose; epimers; ketohexose-fructose;; aldopentose-ribose; deoxysugars-deoxyribose; fucose; rhamnose), polysaccharides (cellulose, glycogen, starch, chitin, agar), Glycoprotein, proteoglycan, glycosaminoglycan, muramic acid, sialic acid. Molish's test for carbohydrate, reaction of monosaccharides with nitric acid, bromine water, periodic acid and phenylhydrazine, osazone formation, reaction of deoxyribose with DPA and reaction of ribose with orcinol reagent; glycosidic linkage, disaccharides (sucrose-invert sugar, inversion of sucrose, maltose and lactose) reducing and non-reducing sugar (tests for reducing sugars, reaction with Benedict's reagent, Fehling's solution, Tollen's reagent, Seliwanoff test for ketose)

### Module II: Peptide Chemistry

(10 Lectures)

Example of biologically important peptides and their functions in brief (glutathione-peptide of non-protein origin), Merrifield solid-phase peptide synthesis using protection/ deprotection protocol (brief outline). Deprotection and racemization in peptide synthesis. Solution and solid phase techniques. Proteins: Definition & structure, primary, secondary, tertiary and quaternary structure (definition and example), structure of globular protein (albumin, globulin, haemoglobin & myoglobin – Structure, function and occurrence in brief) Behaviour of proteins in solutions, salting in and salting out, Denaturation and renaturation of proteins (example -RNase), absorbance of proteins, example of metalloprotein, lipoprotein.



**Module III: Natural Product Chemistry****(9 Lectures)**

Flavonoid Chemistry: Anthocyanins, Flavonols and flavones; Quinone chemistry. Terpenoids: Structure and Methods for Structure elucidation. Biosynthesis of Terpenoids: Gibberellins. Acyclic (Squalene), Lanosterol, Ursolic acid & Oleanolic acid. Alkaloid Chemistry: Opium, Ergot, Rauwolfia and Vinca alkaloids. Cyanogenic glycosides, Indoles and Chlorophylls. Steroid chemistry: Introduction & Biosynthesis of Steroids. Phytosterols, Saponins & Sapogenins, Cardiotonic glucosides, Steroidal alkaloids: Solanum and Kurchi alkaloids.

**Module IV: Polymer Chemistry****(8 Lectures)**

Methods of polymerization: Bulk, solution, suspension, emulsion, Addition, Melt and condensation. Properties of polymers: Viscosity, end-group analysis, hardness, abrasion resistance, crystallinity glassy state, glass transition temperature ( $T_g$ ) and melting point ( $T_m$ ). Additives in polymers: Plasticizers, stabilizers, antioxidants, fillers, pigments. Polymer processing: Compounding, calendaring, die/rotational/film casting, injection molding, extrusion molding, thermoforming, foaming and reinforcing.

**Module V: Green Chemistry****(8 Lectures)**

Introduction to the principles of green chemistry – prevention of waste, atom economy, less hazardous chemical syntheses, designing safer chemicals, safer solvents and auxiliaries, design for energy efficiency, reduce derivatives, renewable feedstock, catalysis, design for degradation, Green synthesis, clean routes, supercritical solvents, ionic liquids, Catalysis in green chemistry.

**Text books:**

1. I. L. Finar Organic Chemistry Vol. II., Stereochemistry and the Chemistry Natural Products, 5th ed., Longman Ltd., New Delhi, 2011.
2. A. Ravve, Principles of Polymer Chemistry, Plenum Press, New York, Springer 3<sup>rd</sup> Edition, May 2012.
3. V. R Gowarikar, Vishwanathan Srikanth, Polymer Chemistry, Wiley Eastern, Bombay, 2000.
4. V. K. Ahluwalia, Green Chemistry: Greener Alternatives to Synthetic Organic Transformations- Narosa Publishing House.

**Reference books:**

1. T.K. Lindhorst: Essentials of Carbohydrate Chemistry and Biochemistry, 3rd ed., Wiley-VCH, Weinheim 2007.
2. P. D. Bailey, An Introduction to Peptide Chemistry; Wiley-Blackwell; Revised ed. edition (22 April 1992)
3. S. V. Bhat, B. A. Nagasampagi, M. Shivakumar: Chemistry of Natural Products; Narosa Publishing House; Revised edition (27 September 2013)
4. V. K. Ahluwalia, Anuradha Mishra Polymer Science:, Ane Books Pvt. Ltd.
5. M. Lancaster, Green Chemistry: In Introductory Text, RSC Publishing, 2010

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√	√	
Quiz -I	√			
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	M	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	L	H

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	L1-L09	<b>1</b>	Carbohydrate Chemistry	<b>T1, R1</b>	<b>1</b>	<b>PPT Digi Class/Chock-Board</b>
<b>4-6</b>	L10-L18	<b>2</b>	Chemistry of Peptide and Proteins	<b>T1, R2</b>	<b>1</b>	<b>-do-</b>
<b>7-9</b>	L19-L27	<b>3</b>	Natural Product Chemistry	<b>T1, R3</b>	<b>2</b>	<b>-do-</b>
<b>10-12</b>	L28-L36	<b>4</b>	Polymer Chemistry	<b>T2, T3, R4</b>	<b>3</b>	<b>-do-</b>
<b>13-15</b>	L37-L45	<b>5</b>	Green Chemistry	<b>T4, R5</b>	<b>4</b>	<b>-do-</b>

## **OPEN ELECTIVES (OE\*) FOR PG PROGRAMME**

**Course code: CH 415**

**Course title: Molecular Structure by NMR & X-Ray Crystallography**

**Pre-requisite(s): B.Sc./ B. Pharm**

**Co- requisite(s):**

**Credits: 3      L: 3      T: 0      P: 0**

**Class schedule per week: 03**

**Class: M. Sc./ I. M. Sc/ M. E/ M. Pharm**

**Semester / Level: PG**

**Branch: Chemistry**

**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the theory and principle of NMR spectroscopy
B.	To know the applications of NMR spectroscopy
C.	To grow the knowledge on crystal structure
D.	To know the instrumental techniques on NMR spectroscopy and X ray crystallography

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain several parameters on NMR spectroscopy
2.	Able to interpret the nmr spectrum to find the molecular formula
3.	Able to explain different parameters of solid state and X-ray crystallography
4.	Able to experimentally determine the molecular structure by NMR and X-ray

### Syllabus

#### **Module-I: Introduction to Nuclear Magnetic Resonance Spectroscopy      (9 Lectures)**

Physical Basis of NMR Spectroscopy,  $^1\text{H}$  NMR: NMR Spectrum, Chemical Shift, Chemical Shift Scales, Integral, Chemical Shift and Structural Relation, Spin-Spin Splitting, Coupling constant, shielding mechanism, effect of deuteration, Anisotropic effects in alkene, alkyne, aldehydes and aromatics. Parameters in NMR of important spin 1/2 nuclei (  $^1\text{H}$ ,  $^{19}\text{F}$ ,  $^{13}\text{C}$ ,  $^{31}\text{P}$  etc.): (a) Chemical shift (b) Spin-spin coupling (J-coupling) (c) Relaxation mechanisms (d) Nuclear Overhauser Effect

#### **Module-II: $^{13}\text{C}$ -and 2D NMR:      (9 Lectures)**

Brief introduction to  $^{13}\text{C}$  NMR, chemical shifts, coupling constants and examples. 2D-NMR: spectroscopy-COSY, NOESY, DEPT. DEPT with 3 different angles, Basics of 2D NMR experiments (the basic 2D spectrum; 2D pulse sequences incorporating polarization transfer and coherence transfer experiments for enhancing spectral resolution and structural detail. Interpretation of 2D spectra and examples. Problems/Examples to solve unknown structure using spectral data of NMR, Mass, UV, & IR

#### **Module-III: Crystals and crystal structures      (9 Lectures)**

Crystal families and crystal systems, Morphology and crystal classes, The description of crystal structures, The cubic close-packed (A1) structure of copper, The body-centred cubic (A2) structure of tungsten, The hexagonal (A3) structure of magnesium, The halite structure, The rutile structure, The fluorite structure, The structure of urea, The density of a crystal

#### **Module-IV: Lattices, planes and symmetry      (9 Lectures)**

Unit cells, The reciprocal lattice, The reciprocal, Lattice planes and Miller indices, Hexagonal lattices and Miller-Bravais indices, Miller indices and planes in crystals, Directions, The symmetry of an object: Centre of symmetry, Axes of inversion, The symmetry of the Bravais lattices, The crystallographic point groups, Bragg's law, Symmetry and reflection intensities,

**Module-V: Instrumentation, Software and Structure solution (9 Lectures)**

NMR instrumentation; spectrometer components and their function, superconducting magnets, probe heads, NMR data processing: zero filling, window functions, etc. Spectral analysis in 1 dimension with examples, Weakly and strongly J-coupled spectra and their analysis. Pulse, FID, DELTA Software for spectrum generation. Single Crystal Diffractometer and Structure Solution, Structure determination using X-ray diffraction, Refinement, ORTEP diagram and Crystal Information File creation

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz -1		√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L9	1	Basics of NMR spectroscopy	T1, T2	1	PPT Digi Class/Chock -Board
4-6	L10-L18	2	Study of different types of NMR spectra	T1,T2,T3 R1,R3	1	-do-
7-9	L19-L27	3	Basics of X- ray crystallography	T2, T3	1, 2	-do-
10-12	L28-L36	4	Solid state and molecular symmetry	T3,R1	3	-do-
13-15	L37-L45	5	Structure determination form nmr and X-ray	T1,T2,T3, R1,R2	2	-do-

**Course code:** CH 416  
**Course title:** Electroanalytical Techniques  
**Pre-requisite(s):** B.Sc./ B. Pharm/ B.Tech  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M. E/ M. Pharm  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**  
**Course Objectives**

This course enables the students:

A.	To understand the theory and principle of electrochemistry
B.	To know the applications of electrochemistry
C.	To grow the knowledge on electroanalytical techniques
D.	To know the instrumental techniques on electrochemical analysis

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain different parameters on electrochemistry
2.	Able to interpret the electrochemical processes
3.	Able to design the electroanalytical techniques
4.	Able to analyze the sample by electrochemical processes

## Syllabus

### Module-I: Basics of electro-chemistry

(9 Lectures)

Overview of electrochemical concepts and methods; two and three-electrode cell, redox reactions; cell notation; standard potentials, free energy & equilibrium constants; the SHE; the Nernst equation; activity and formal potentials; reference electrodes, etc. Ohmic and non-Ohmic behaviors; Voltage; Impedance; The electric double layer; Electrocapillarity; Current, Diffusion transport; Current-Voltage relation.

### Module-II: Electrolysis

(9 Lectures)

Current-Voltage relation, Chemical modified electrodes etc., Electrogravimetric analysis at constant current, constant potential and at controlled potential, Coulometric analysis, Electrochemical Cells, Types of Electrochemical Cells, Electrolytic Cells, Galvanic Cells, Electrolytic Cell Vs Galvanic Cell, Electrolytic Cell, Multi cation presence in cell, Multi anions presence in cell, Importance of Salt Bridge, IUPAC Cell Representation, Oxidation Side, Salt Bridge, Reduction Side, Preferential Discharge Theory

### Module-III: Electrochemical characterization

(9 Lectures)

Standard rate constant; transfer coefficient; Tafel equation; Marcus theory; Butler-Volmer equation; Tafel plots; irreversible & quasi-reversible voltammetry, etc. Two types; general methods and calibration; redox and ion-selective electrodes, etc. Definition of reversibility; charging currents; convectionless methods; chronoamperometry; Cottrell equation; linear scan and cyclic voltammetry; polarography; pulse methods; convection methods; rotating disk and ring-disk voltammetry; microelectrodes, etc. Electrochemical Impedance Spectroscopy.

### Module-IV: Electrochemical sensors

(9 Lectures)

Potentiometric sensors, Potentiometric biosensors, Amperometric sensors, Conductometric sensors, Applications of Field-Effect Transistors sensors, Electroanalytical chemistry in neuroscience. Electrochemistry of redox proteins. Design of third generation electrochemical sensors. Electrochemical



DNA sensors. Electrochemical Impedance spectroscopy and their application. Electrochemical immunoassay: redox and enzyme labeled immunoassay. Electrochemiluminescence and immunoassay; Electrochemical quartz crystal microbalance and its applications.

**Module-V: Other electrochemical applications (9 Lectures)**

Electrical Energy Storage Device, Batteries, Fuel Cells, Corrosion, Corrosion protection, Technological aspects of electrochemistry, corrosion and stability of metals, electrochemical energy conversion, electricity storage.

**Textbooks:**

1. A. J. Bard and L. R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, John Wiley and Sons., 2<sup>nd</sup> ed. 2001.
2. D. Pletcher, *A First Course in Electrode Processes*, RSC Publishing, 2<sup>nd</sup> ed. 2009.

**Reference books:**

1. F. Scholz, *Electroanalytical methods*, Springer, 2002.
2. P. Monk, *Fundamentals of electroanalytical chemistry*, Wiley, 2001.
3. A.P.F. Turner I. Karube, I. G. Wilson, *Biosensors- Fundamentals and applications*. Oxford University Press, New York, 1987.
4. Brian R. Eggins, *Chemical Sensors and Biosensors, Analytical Techniques in the Sciences (ANTS)*, 2nd Edition, Wiley, 2002.
5. Gabor Harsanyi, *Sensors in Biomedical Applications - Fundamentals, Technology and Applications*, CRC Press, 2000.
6. Raluca-Ioana Stefan, *Electrochemical Sensors in Bioanalysis*, CRC Press, 2001.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

<b><u>Direct Assessment</u></b>	
<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz -1		√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
<b>1-3</b>	<b>L1-L9</b>	<b>1</b>	Basics of electro-chemistry	<b>T1, T2, R3, R4</b>	<b>1,2</b>	<b>PPT Digi Class/Chock-Board</b>
<b>3-6</b>	<b>L10-L18</b>	<b>2</b>	Electrolysis	<b>T1,T2,R1 R4,R5</b>	<b>1,2,3</b>	<b>-do-</b>
<b>7-9</b>	<b>L19-L27</b>	<b>3</b>	Electrochemical characterization	<b>T1,T2, R2, R3</b>	<b>2, 4</b>	<b>-do-</b>
<b>10-12</b>	<b>L28-L36</b>	<b>4</b>	Electrochemical sensors	<b>T1,T2,R1, R6</b>	<b>3,4</b>	<b>-do-</b>
<b>13-15</b>	<b>L37-L45</b>	<b>5</b>	Other electrochemical applications	<b>T1,T2,R1, R2,R5</b>	<b>4</b>	<b>-do-</b>

**Course code:** CH 417  
**Course title:** Chemistry of Metalloenzymes  
**Pre-requisite(s):** B.Sc./ B. Pharm/ B.Tech  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M. E/ M. Pharm  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**

## Course Objectives

This course enables the students:

A	To understand the basic role of metals in biology
B	To know the role and mechanism of metalloenzymes in different biological catalytic process- e.g., acid -base reaction, Reactive oxygen Species (ROS) deactivation, oxidation-reduction process etc.
C	To understand the mechanism of photosynthetic energy production

## Course Outcomes

After the completion of this course, students will be:

1.	Able to describe the importance of metals in biology
2.	Able to elucidate the mechanism of several biological catalysis
3.	Able to explain the process of photosynthetic energy production

## Syllabus

### Module-I: Basics of Bioinorganic Chemistry (9 Lectures)

Fundamentals of coordination chemistry – metal ions and their coordination behavior, ligands, electronic configurations. Elements of life, the natural selection of elements, Mapping the elements with the binding sites in biological systems, Metalloproteins and metalloenzymes -general perspectives, Amino acids and their mode of coordination, preferred geometries of metal ions in metalloproteins, Other Bioligands – Porphyrins, Nucleobases and ATP

### Module-II: Enzymes dealing with oxygen and reactive oxygen species (ROS) (9 Lectures)

Oxidase: cytochrome c oxidase – structure, mechanism, electron transfer pathways and synthetic models; Amine oxidase, Galactose oxidase, Catechol oxidase

Oxygenases: Heme mono oxygenase - Cytochrome P450, Non-heme dioxygenase, tyrosinase, Catalase, superoxide dismutase and glutathione, peroxidase

### Module-III: Photosynthetic oxygen evolution: (9 Lectures)

The Central Photochemical Event: Light-Driven Electron Flow; Photosystem I and II; Integration of photosystems I and II in chloroplasts- “Z” scheme, Water oxidation catalyst - Active site structure, mechanism and model systems,

Concept of Artificial photosynthesis for renewable energy production

### Module-IV: Acid-base, Isomerisation and alkyl group transfer catalysis:(9 Lectures)

Zn- carbonic anhydrase, carboxypeptidase, Alkaline phosphatase; Mg - ribulose biphosphate carboxylase, Fe - Acid phosphatases, aconitase, B<sub>12</sub>- dependent Isomerase and methyl transferase

### Module-V: Biological Cycles (9 Lectures)

Biological nitrogen fixation: Nitrogenase, Mechanistic study, Iron–Sulfur Clusters, Fe–Protein Structure, MoFe–Protein Structure.

Biological hydrogen production: Mechanism and active site structure of Hydrogenase-Fe only hydrogenase, Ni-Fe Hydrogenase

**Text books:**

1. I. Bertini, H. B. Gray, S. J. Lippard, J. S. Valentine, Bioinorganic Chemistry, University Science Books, Mill Valley, CA, 1994.
2. W. Kaim, B. Schwederski, A. Klein, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide, Wiley, 1994.
3. L. Stryer, J. M. Berg, J. L. Tymoczko, 5th ed., W. H. Freeman & Co Ltd, 2002.

**Reference books:**

1. R. R. Crichton, Biological Inorganic Chemistry, 2nd ed., Elsevier, 2012.
2. R. M. Roat-Malone, Bioinorganic Chemistry: A Short Course, Wiley, 2002.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>
<b>Assignment</b>	√	√	
<b>Quiz –I</b>		√	
<b>Quiz II</b>			√
<b>End Sem Examination Marks</b>	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3,	CD1
CD2	Tutorials/Assignments	CO1, 2, 3,	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3,	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3,	CD6
CD7	Simulation	CO2,	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L9	1	Basics of Bioinorganic Chemistry	T1, 2,T3,R2	1	PPT Digi Class/Chock-Board
4-6	L10-L18	2	Enzymes dealing with oxygen and reactive oxygen species (ROS)	T1,T2,T3 R2, R3	1	-do-
7-9	L19-L27	3	Photosynthetic oxygen evolution	T2, T3, R2	1, 2	-do-
10-12	L28-L36	4	Acid–base, Isomerisation and alkyl group transfer catalysis	T1, R4	3	-do-
13-15	L37-L45	5	Biological Cycles:	T1,T2	2	-do-

**Course code:** CH418  
**Course title:** Membrane Science  
**Pre-requisite(s):** B.Sc./ B. Pharm/ B.Tech  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M. E/ M. Pharm  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**

This course enables the students:

A.	To understand the concepts and applications of membrane and separation process
B.	To strengthen the fundamental concepts of separation and its applications
C.	To apply basic chemistry/science skills, conduct experiments in teams, analyze the results, and communicate these results, in a safe, professional and ethical manner leading to development of separation sciences through membranes

### Course Outcomes

After the completion of this course, students will be:

1.	Able to understand concept of membranes for Separation Processes
2.	Able to classify membranes and their mechanism of function
3.	Able to know applications of membranes for gas separation
4.	Able to know applications of membranes for liquid separation
5.	Able to comprehend the working principles of OSN processes

## Syllabus

### Module I: Separation Process: Membranes for Separation Processes (9 lectures)

Introduction of various membrane separation processes such as gas permeation, pervaporation, reverse osmosis, microfiltration, electrodialysis, membrane reactor, etc. Membrane Preparation: Selection of polymer, solvent and nonsolvent. Methods for preparation of membranes. Basic facilities for preparation of membranes. Rate governed and equilibrium membrane separation processes- Fundamentals, Types of membranes, Modules, Flow patterns, Preparation and characterization of membranes, Melt pressing, Film stretching, Sol-gel peptization, Interfacial polymerization etc. Measurement of pore size and solute rejection properties.

### Module II: Membrane Transport (9 lectures)

Reverse osmosis transport. Specification of membranes and predictability of RO membrane performance for aqueous solution systems. Reverse Osmosis- Design and operating parameters, Various transport models, Kedem-katchalsky model, Spiegler-kedem model, Solution diffusion model, Concentration polarization and flux decline, Design of an RO module, Forward Osmosis Membrane gas transport. Design of composite membranes for gas separation/Resistance Theory. Dialysis- Principle of dialysis, Dialysis systems, Mass transfer in 4 dialysis, Modeling of solute transport in hemodialyzer, Advantages of diffusion dialysis, Application of diffusion dialysis, Electrodialysis.

### Module III: Membrane gas Separation (9 lectures)

Membranes for gas separation, Fundamental mechanism of gas transport, Knudsen diffusion, Molecular sieving, Solution diffusion, Dual sorption model, Factors affecting gas permeation, Complete mixing model, Solution of equations, Equations for multicomponent mixtures, Cross- flow model, Countercurrent Model, Polarisation Phenomena, Membrane Modules and Membrane Systems Methods to reduce fouling, Module types. Module calculations and design.

**Module IV: Liquid Membrane:****(9 lectures)**

Benefits of liquid membrane, Bulk liquid membrane, Emulsion liquid membrane, Thin sheet supported liquid membrane, Hollow fibre supported liquid membrane, Applications Facilitated Transport:- Mechanism of facilitated transport, Coupled Transport, Carrier agents, Competitive facilitated transport with two permeants, active and passive transport, Some potential applications of facilitated transport. Membrane Reactor- Membrane bioreactor, Membrane distillation. Theoretical considerations on mass transfer. Membrane devices and transport correlations. Concentration profile in hollow fibre lumen.

**Module V: Organic Solvent Nanofiltration (OSN) Processes****(9 lectures)**

Ultra & Nano filtration, OSN-Background, Membrane Formation and Characterisation, Equipment and Scale Up, Fine Chemicals and Pharma, Process Design, OSN – Refining and Bulk Chemicals, Membrane Transport Models for OSN. Nanofiltration- Transport mechanism in NF membranes, Parameters affecting the performance of NF membranes, Fouling model, determination of various resistances.

**Text Books:**

1. Membrane Handbook Eds. by W. S. W. Ho and K. K. Sirkar
2. Membrane technology and applications, Baker, R.W., 2nd ed., John Wiley 2004
3. Synthetic membranes: Science, Engineering and Applications, Eds. by P. B. Bunge, H. K. Lonsdale and M. N. Depinho.
4. Ultrafiltration and Microfiltration Handbook, (2nd Edition), Munir Cheryan, CRC Press.
5. Basic Principles of Membrane Separation, Mudler J, (2nd Edition), Springer.

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Self- learning such as use of NPTEL materials and internet
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50



Assessment Components	CO1	CO2	CO3	CO4	CO5
Assignment	√	√	√	√	
Quiz –I	√	√			
Quiz II			√	√	
End Sem Examination Marks	√	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	H	L
CO5	H	H	L	L

**Mapping Between COs and Course Delivery (CD) methods**

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5	CD1
CD2	Tutorials/Assignments	CO2, CO3	CD1
CD3	Seminars	CO3, CO4	CD1 and CD2
CD4	Mini projects/Projects	CO1, CO2, CO3, CO4, CO5	CD3 and CD4
CD5	Laboratory experiments/teaching aids	CO2, CO3	CD5
CD6	Industrial/guest lectures	CO4	CD6
CD7	Self- learning such as use of NPTEL materials and internets	CO5	CD7
CD8	Simulation	CO1 CO2	CD8

### Lecture wise Lesson planning Details.

WeekNo.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1 - L9	1	Types of membranes, mechanisms involved	1,2	1	PPT Digi Class/Chalk -Board
4-6	L10-18	2	Membrane transport systems	1,2	2	-do-
7-9	L19-27	3	Membranes for gas separation	1,2,3	3	-do-
8-12	L27-36	4	Liquid membranes	1,2,3	4	-do-
13-15	L37-45	5	Organic solvent nanofiltration processess	1,2,3	5	-do-

**Course code:** CH419  
**Course title:** Environmental Monitoring and Control  
**Pre-requisite(s):** B.Sc./ B. Pharm/ B.Tech  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M. E/ M. Pharm  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**

This course enables the students:

A.	To understand the concepts and applications of environmental chemistry
B.	To strengthen the fundamental concepts of environmental chemistry and then builds an interface with their applications.
C.	To apply basic chemistry/science skills, conduct experiments in teams, analyze the results, and communicate these results, in a safe, professional and ethical manner leading to better environmental conditions

### Course Outcomes

After the completion of this course, students will be:

1.	Able to understand elements of ecology
2.	Able to understand and analyse air pollution monitoring and control practices
3.	Able to understand and analyse water pollution monitoring and control practices
4.	Able to understand Soil, Radiation and Noise pollution
5.	Able to comprehend waste management practices

### Syllabus

#### Module I: Ecology & Environment

(9 lectures)

Basic concepts of ecology & ecosystem, Structure and function of an ecosystem, Energy & Nutrient flow, Segments of environment, Environmental factors, Environmental transformation and degradation processes.

#### Module II: Air pollution monitoring and control

(9 lectures)

Sampling and analysis of air pollutants, Units of pollutants, emission standards from industrial sources, control of air pollutants from mobile and stationary emission sources, Various control methods for particulate emission: gravitational settling chambers, cyclone separators, baghouse filters, electrostatic precipitators and wet scrubbers. Control of gaseous emissions, absorption by liquids, adsorption by solids, combustion. Control of Sox, NO<sub>x</sub>, CO, Hydrocarbons from mobile and stationary emission sources. Indoor air quality

#### Module III: Water quality and control

(9 lectures)

Municipal and industrial water quality, Drinking water standards-PHED and WHO, Sampling techniques and preservation of samples, Physical examination, chemical characterization and Biological investigation, Control measures: Primary, secondary and advanced treatments, Coagulation, flocculation, sedimentation, Industrial water treatment: softening, corrosion and scale prevention

#### Module IV: Radiation, Noise and Odour: Measurement and control

(9 lectures)

Radiation hazards: Types of radiation, sources, effects, control and disposal of nuclear waste. Noise: Sources of Noise, types of noise, noise measurement, mapping, Control measures-Anechoic chambers, Industrial noise abatement measures, Sources of odour, sampling, measurement

#### Module V: Soil pollution and Solid waste management

(9 lectures)

Soil Pollution: Analysis of micro and macro nutrients in soil, Trace element analysis, pesticide analysis Sources, Classification and composition of MSW, Properties of MSW, MSW management, Waste minimization, Life cycle assessment, benefits, waste reduction techniques, Reuse and recycling, Biological MSW treatment, Thermal treatment, Landfill, Integrated waste management, Case studies

**Text books:**

1. Environmental Pollution Control Engineering by C.S. Rao.
2. Practical Environmental Analysis by Miroslav Radojevic and Vladimir N. Bashkin, RSC.
3. Environmental Pollution Analysis by S. M. Khopker, New Age International Corporations.
4. An Introduction to Environmental Science & Engineering by Gilbert M. Masters. 5. Chemical analysis of ecological materials by S. E. Allen.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Self- learning such as use of NPTEL materials and internet
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√	√	
Quiz -I	√			
Quiz II		√	√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	H	L

Mapping Between COs and Course Delivery (CD) methods			
CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5	CD1
CD2	Tutorials/Assignments	CO2, CO3	CD1
CD3	Seminars	CO3, CO4	CD1 and CD2
CD4	Mini projects/Projects	CO1, CO2, CO3, CO4, CO5	CD3 and CD4
CD5	Laboratory experiments/teaching aids	CO2, CO3	CD5
CD6	Industrial/guest lectures	CO4	CD6, CD7
CD7	Self- learning such as use of NPTEL materials and internets	CO5	CD8
CD8	Simulation	CO1 CO2	CD8

### **Lecture wise Lesson planning Details.**

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1 - L9	1	Ecology, Biogeochemical cycles, Fate of pollutants	1,2	1	PPT DigiClass/Chalk-Board
4-6	L10-18	2	Air pollution monitoring & control	1,2	2	-do-
7-9	L19-27	3	Water pollution monitoring & control	1,2,3	3	-do-
8-12	L27-36	4	Soil, noise & radiation pollution	1,2,3	4	-do-
13-15	L37-45	5	Solid waste management	1,2,3	5	-do-

**Course code:** CH420  
**Course title:** Research Methodology and Data Analysis  
**Pre-requisite(s):** B.Sc./ B. Pharm/ B.Tech  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M. E/ M. Pharm  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

### **Module I : Probability Distributions (6 Lectures)**

Poisson Distribution, Normal distribution, Lognormal distribution, Student's t- distribution, Chi-squared distribution, Cauchy distribution and Pareto distribution  
 Calculation of population mean for normal distribution  
 Geometric mean and geometric standard deviation for lognormal distribution  
 Calculation of percentiles of a particular distribution.

### **Module II : Sampling Designs (12 Lectures)**

Random Sampling, Stratified Random Sampling, Systematic Sampling, Two-Stage Sampling, Composite and Three-Stage Sampling, Double Sampling, Guidelines for effective sample size determination, Sampling distributions of Means, Difference of means, Proportion, Variances, estimation of parameters, Point and Interval estimates. Confidence interval estimation of – Means, Difference of means, Proportion, and Variance, estimation of Upper Confidence Limits (UCL) and Lower Confidence Limits (LCL) Formulae of UCL for Normal and Lognormal Distribution, Analysis of environmental data using ANOVA, Method of Censoring Data: Method Detection Limits, Methods to estimate mean and standard deviation in presence of below detection level (BDL) data.

### **Module III: Time Series Analysis and Extreme Value Theory (10 Lectures)**

Introduction  
 Correlogram analysis  
 Autocorrelation and partial autocorrelation function  
 Trend and moving average analysis  
 Introduction to autoregressive and moving average models  
 Yule walker equations  
 Application of univariate models for daily average pollutant concentration series.  
 Introduction to extreme values  
 Applications-Forecasting floods, Environmental pollution  
 Identifying outlying observations  
 Families of distributions  
 Analysis of extreme value data  
 Extremes of data containing trends  
 Parameter estimation  
 Extremes of small samples  
 Reliability computations for extreme value distributions.

### **Module IV: Tests of Hypotheses and Environmental Data (7 Lectures)**

Hypotheses testing procedures  
 Type I and Type II Errors  
 Level of significance  
 Parametric tests – Tests of significance for large samples  
 Special tests of significance for small samples  
 Generation of environmental data Type and objectives of environmental studies

Stochastic processes in the environment

**Module V: Regression and Correlation Analysis and Data Analysis (10 Lectures)**

Student's t-test, Goodness-of-fit tests

Chi-Squared test

Kolmogorov-Smirnov test

Nonparametric test- Sign test

Wilcoxon Signed-Rank test, Kruskal-Wallis test, Runs test;

Measurement Uncertainty, Bias, Precision and Accuracy

Variability and Errors in environmental pollution data

Outlier detection – Different tests for outlier detection

Quality assurance and quality control

Control charts: Description and Theory

Analysis of trend in the environmental data: Detecting and estimating trend, trends and seasonality

**Reference**

1. Berthouex Paul Mac and Linfield C. Brown, "Statistics for Environmental Engineers", Lewis Publisher, 1994
2. Murray R. Spiegel, John Schiller, and R. Alu Srinivasan, Probability and Statistics, Second Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2004
3. Catillo Enrique, Extreme Value Theory in Engineering, Academic Press, Inc., Hart-Court Brace Jovanovich, Publishers.
4. Box G.E.P and Jenkins G.M., Time Series Analysis, Forecasting and Control, San Francisco, Holden day, 1976
5. Robert R. Kinnison, Applied Extreme Value Statistics, Battelle Press, Macmillan Publishing Company, 1985.

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Self- learning such as use of NPTEL materials and internet
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√	√	
Quiz -I	√			
Quiz II		√	√	
End Sem Examination Marks	√	√	√	√

#### Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

#### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	M	H	L	L
CO2	H	H	M	L
CO3	H	H	H	M
CO4	H	M	H	L

Mapping Between COs and Course Delivery (CD) methods			
CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5	CD1
CD2	Tutorials/Assignments	CO2, CO3	CD1
CD3	Seminars	CO3, CO4	CD1 and CD2
CD4	Mini projects/Projects	CO1, CO2, CO3, CO4, CO5	CD3 and CD4
CD5	Laboratory experiments/teaching aids	CO2, CO3	CD5
CD6	Industrial/guest lectures	CO4	CD6, CD7
CD7	Self- learning such as use of NPTEL materials and internets	CO5	CD8
CD8	Simulation	CO1 CO2	CD8



**Lecture wise Lesson planning Details.**

<b>Week No.</b>	<b>Lect. No.</b>	<b>Ch. No.</b>	<b>Topics to be covered</b>	<b>Text Book / References</b>	<b>COs mapped</b>	<b>Methodology used</b>
1-3	L1 - L9	1	Probability Distributions	1,2	1	PPT DigiClass/Chalk-Board
4-6	L10-18	2	Sampling Designs	1,2	2	-do-
7-9	L19-27	3	Time Series Analysis and Extreme Value Theory	1,2,3	3	-do-
8-12	L27-36	4	Tests of Hypotheses and Environmental Data	1,2,3	4	-do-
13-15	L37-45	5	Regression and Correlation Analysis and Data Analysis	1,2,3	5	-do-

**Course code:** CH 421  
**Course title:** Nuclear and Radiation Chemistry  
**Pre-requisite(s):** B.Sc./ B. Pharm/ B.Tech  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M. E/ M. Pharm  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**

This course enables the students:

A.	To understand the concepts and applications of radioactivity and nuclear chemistry
B.	To strengthen the fundamental concepts of chemistry and then builds an interface with their applications.
C.	To apply basic chemistry/science skills, conduct experiments in teams, analyze the results, and communicate these results, in a safe, professional and ethical manner

### Course Outcomes

After the completion of this course, students will be:

1.	Able to understand radioactivity and nuclear reactions.
2.	Able to classify elements of radiation chemistry
3.	Able to know applications of radioactivity and depict the concept of kinetics
4.	Able to analyse trace elements and compounds and understand the risks involved
5.	Able to comprehend the working of nuclear power plants

## Syllabus

### Module I: Radioactivity

(7 lectures)

Recapitulation: types of radioactive decay, Nuclear reactions: types of nuclear reactions, nuclear cross section, spallation, nuclear fusion nuclear fission-theory of nuclear fission; chain reaction, decay kinetics, radiation detection and measurement separation of isotopes, (G. M. and Scintillation Counter).

### Module II: Elements of radiation chemistry:

(8 lectures)

Interaction of ionising radiation with matter, units for measuring radiation absorption and radiation energy, radiation dosimetry, radiolysis of water and aqueous solutions.

### Module III: Applications of radioisotopes-

(10 lectures)

General principles of using radioisotopes, applications of radiotracers in various applications like energy tapping, dating of objects, neutron activation analysis, isotopic labeling studies, nuclear medicine-<sup>99m</sup>Tc radiopharmaceuticals

Physicochemical constants - diffusion coefficient, surface area, solubility, stability constant.

Chemical pathways - kinetic studies, inorganic reactions, organic reaction, biosynthesis, polymerization.

### Module IV: Trace analysis of elements and compounds

(12 lectures)

neutron activation analysis, isotope dilution analysis. Isotopes used in nuclear fission reactions. Radioisotopes used in noninvasive imaging techniques in nuclear medicine.

### Module V: Nuclear power plants:

(8 lectures)

critical mass; nuclear reactors-fast breeder reactors, fuels used in nuclear reactors moderators, coolants Commissioning, working, closure of power plants, Location, on site sampling, analysis, nuclear reactors in India Environmental issues, Future prospects.

**Text Books:**

1. Essentials of Nuclear Chemistry, H. J. Arnikar, 4th Edition Wiley Eastern (1987).
2. Chemical Applications of Radioisotopes, H. J. M. Bowen. Buttler and Tanner (1969).
3. Introduction of Nuclear and Radiochemistry, G Friedlander, T. W. Kennedy, E. S. Macias and J. M. Miller, 3rd Edition, John Wiley (1981).

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>	<b>CO5</b>
Quiz (s)	√	√	√	√	
Assignment	√	√	√	√	
End Sem Examination Marks	√	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

<b>Course Outcome #</b>	<b>Program Outcomes</b>			
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>
<b>CO1</b>	<b>M</b>	<b>H</b>	<b>L</b>	<b>L</b>
<b>CO2</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>L</b>
<b>CO3</b>	<b>H</b>	<b>M</b>	<b>H</b>	<b>M</b>
<b>CO4</b>	<b>H</b>	<b>M</b>	<b>H</b>	<b>L</b>
<b>CO5</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>M</b>

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5	CD1
CD2	Tutorials/Assignments	CO2, CO3	CD1
CD3	Seminars	CO3, CO4	CD1 and CD2
CD4	Mini projects/Projects	CO1, CO2, CO3, CO4, CO5	CD3 and CD4
CD5	Laboratory experiments/teaching aids	CO2, CO3	CD5
CD6	Self- learning such as use of NPTEL materials and internet	CO5	CD6
CD7	Simulation	CO1 CO2	CD7

### Lecture wise Lesson planning Details.

WeekNo.	Lect.No.	Ch. No.	Topics to be covered	TextBook / References	COs mapped	Methodology used
1-2	L1 - L7	1	Radioactivity, Nuclear reactions	1,2	1	PPT Digi Class/ Chalk-Board
3-5	L8-15	2	Elements of radiation chemistry	1,2	2	-do-
6-8	L16-25	3	Applications of radioisotopes	1,2,3	3	-do-
9-12	L26-37	4	Trace analysis of elements	1,2,3	4	-do-
13-15	L38-45	5	Nuclear power plants	1,2,3	5	-do-

**Course code:** CH 422  
**Course title:** Fuel Chemistry-1  
**Pre-requisite(s):** B.Sc./ B. Tech.  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M. Tech  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the knowledge of energy resources and fossil fuels
B.	To make a framework of renewable and non-renewable energy sources
C.	To gain the knowledge of working principle of various fuels systems
D.	To ensure the proper utilization of various fuels for both domestic and industrial application

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the basic of fuel chemistry
2.	Able to know the importance of various fuels for development of social and industries
3.	Able to explain working principle and efficiency of different fuels
4.	Able to validate the parametric evaluation of various hydrocarbon fuels

## Syllabus

### Module-I: Energy Resources

(9 Lectures)

Renewable and Non-Renewable Energy Resources, Basic of Biomass and Fossil fuels Resources, Introduction of Solar, Wind, Hydro, Tidal, Ocean Thermal Energy Resources, Clean Energy Resources and Monitoring of Environment.

### Module-II: Fuels

(9 Lectures)

Introduction, Classification of Fuels, Solid Liquid, Gaseous Fuels, Fuels and Combustion, Combustion stoichiometry, Representative parameters of conventional Resources, Calorific Value, Structure and Properties Relationship of Hydrocarbon fuels, Volatility, Melting, Density, Viscosity, Solubility, Flash Point and the Combustion temperature, Lower Heating Value and Higher Heating Value.

### Module-III: Solid Natural Fuels

(9 Lectures)

Introduction and Principle of Classification, Fuel Characteristics of Solid Fossil Fuels (Woods & Coals) in terms of their Constituents, Calorific Value, Ash, Moisture, Ignition and Combustion.

### Module-IV: Solid Fossil Fuels (Coal)

(9 Lectures)

Introduction, Uses and Utilization, Classification of Coal, Fuel Characteristics of Coal, Fundamentals of Coal Combustion, Coal Combustion Techniques, Coal Tar Distillation, Coal Liquefaction, Direct Liquefaction, Indirect liquefaction, Coal gasification, combustion stoichiometry, Flue Gas, Producer Gas, Water Gas.

### Module-V: Coal Carbonization & Characterization

(9 Lectures)

Introduction to Coal Carbonization, Coke Formation, Pre-Carbonization Techniques, Coal Gasification & Liquefaction, Chemical Composition and their Uses, Coal Metamorphism, Categorizing of coal, Size

analysis, Proximate analysis, Ultimate analysis, Gross calorific value, Net calorific value, Free Swelling Index, Estimation of Total Moisture.

**Text Books:**

1. Combustion, Irvin Glassman, 2nd ed., Academic Press
2. Fuels Combustion and Furnaces, John Griswold, Mc-Graw Hill Book Company Inc.
3. Fuels and Combustion: Samir Sarkar, University Press (India) Pvt Limited, India
4. Elements of Fuels, Furnaces and Refractories: O P Gupta, Khanna Publishers, India

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

<b>Assessment Tool</b>	<b>% Contribution during CO Assessment</b>
<b>Assignment</b>	<b>10</b>
<b>Seminar before a committee</b>	<b>10</b>
<b>Three Quizzes</b>	<b>10+10+10</b>
<b>End Sem Examination Marks</b>	<b>50</b>

<b>Assessment Components</b>	<b>CO1</b>	<b>CO2</b>	<b>CO3</b>	<b>CO4</b>
<b>Assignment</b>	√	√		
<b>Quiz -1</b>		√		
<b>Quiz II</b>			√	
<b>End Sem Examination Marks</b>	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

### Mapping between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L9	1	Basics of energy resources	T1, T3	1	PPT Digi Class/Chock-Board
3-8	L10-L18	2	Fundamental of fuel chemistry	T1,T2,T4	1	-do-
8-9	L19-L27	3	Basics of Solid Natural Fuels	T2, T3	1, 2	-do-
9-10	L28-L36	4	Fossil Fuels and Coal combustion	T3,R1	3, 4	-do-
10-12	L37-L45	5	Coal Carbonization and Characterization	T1,T2,T3, R1,R2	2	-do-

**Course code:** CH 423  
**Course title:** Fuel Chemistry-2  
**Pre-requisite(s):** B.Sc./ B. Tech.  
**Co- requisite(s):**  
**Credits:** 3      L: 3      T: 0      P: 0  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M. E./M. Tech  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**

### Course Objectives

This course enables the students:

A.	To understand the knowledge of petroleum liquid fuels
B.	To know the basic of gaseous fuels
C.	To gain the knowledge of processing and utility standard of petroleum liquid and solid fuels
D.	To ensure the proper utilization of various liquid and gaseous fuels for both domestic and industrial applications

### Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the basic of petroleum liquid and gaseous fuels
2.	Able to know the compositional characteristics of various liquid/gaseous fuels for application
3.	Able to explain efficiency based characterization of different liquid/gaseous fuels
4.	Able to validate the parametric standard of liquid/gaseous fuels

## Syllabus

### Module-I: Liquid and Gaseous Fuels

(9 Lectures)

Basic Introduction of Liquid Fuels, Gaseous Fuels, Natural Gas and Light Hydrocarbons gaseous fuels, Fuels containing Biomass/Biogas and Hydrogen energy.

### Module-II: Liquid Fuels

(9 Lectures)

Liquid Fuels Resources, Classifications, Characterization Method of crude oils, Refinery Techniques and Operations, Industrial process design, Utilization of Petroleum Products, Synthetic liquid fuels.

### Module-III: Gaseous Fuels

(9 Lectures)

Different Types of Gaseous Fuels, Resources and Characteristics of Gaseous Fuels, Principles of Manufacturing of Gaseous Fuels from Coal and Oil, Kinetics and Mechanism of Gasification, Production of Industrial Fuel Gases, Rich Gases such as SNG, Purification, Storage and Transportation of Gaseous Fuels.

### Module-IV: Liquid lubricants

(9 Lectures)

Introduction, Principle and Basic mechanism of action of additives, Antioxidants, Detergents and Dispersants, Anti- Corrosion Additives, Anti-Foam Additives, Emulsifiers, Viscosity Modifiers, Viscosity- Temperature Curve, Anti-Wear and Lubricity Additives, Extreme Pressure Additives, biocides.



**Module-V: Significance Fuel additives****(9 Lectures)**

Effect of Fuels and Lubricants on Environment, Properties Regenerated Lubricating Oil and Recycling Technology for Used Oil.

**Text and Reference Books:**

1. Modern Petroleum Technology, Vol 1, Upstream, Ed. by Richard A. Dave, IP, 6th ed., John Wiley & Sons. Ltd.
2. Modern Petroleum Technology, Vol 2, Downstream, Ed. by Alan G. Lucas, IP, 6th ed., John Wiley & Sons. Ltd.
3. Modern Petroleum Technology, Vol 1, Upstream, Ed. by Richard A. Dave, IP, 6th ed., John Wiley & Sons. Ltd.
4. Modern Petroleum Refining Processes, B.K. Bhaskar Rao, 4th ed., Oxford & IBH Publishing Co. Pvt. Ltd

<b>Course Delivery methods</b>
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Self- learning such as use of NPTEL materials and internets
Simulation

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Assignment	10
Seminar before a committee	10
Three Quizzes	10+10+10
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Assignment	√	√		
Quiz -1		√		
Quiz II			√	
End Sem Examination Marks	√	√	√	√

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

### Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes			
	PO1	PO2	PO3	PO4
CO1	H	H	L	L
CO2	H	H	H	L
CO3	H	H	H	L
CO4	M	H	H	L

### Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1,CD2
CD3	Seminars	CO 2, 3	CD3
CD4	Mini projects/Projects	CO3, 4	CD4
CD5	Laboratory experiments/teaching aids	CO 1, 2, 3	CD5
CD6	Self- learning such as use of NPTEL materials and internets	CO1, 2, 3, 4	CD6
CD7	Simulation	CO2, 4	CD7

### Lecture wise Lesson planning Details.

Week No.	Lect. No.	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Methodology used
1-3	L1-L9	1	Basics Liquid and Gaseous Fuels	T1, T4	1	PPT Digi Class/Chock-Board
3-6	L10-L18	2	Fundamental of Liquid Fuels	T1,T2,T3	1	-do-
6-8	L19-L27	3	Basics of Gaseous Fuels	T2, T2	1, 2	-do-
8-10	L28-L36	4	Liquid lubricants	T1,R4	3, 4	-do-
10-12	L37-L45	5	Significance Fuel additives	T3, T4	2	-do-

**Course code:** CH 424  
**Course title:** Fuel Chemistry Lab  
**Pre-requisite(s):** B.Sc./ B. Tech.  
**Co- requisite(s):**  
**Credits:** 1.5    L: 0    T: 0    P: 1.5  
**Class schedule per week:** 03  
**Class:** M. Sc./ I. M. Sc/ M.E./M. Tech  
**Semester / Level:** PG  
**Branch:** Chemistry  
**Name of Teacher:**

## Syllabus

- Determination of Flash and Fire points of Liquid fuels
- Determination of Viscosity of Petroleum Liquid Fuels using Redwood Viscometer
- Spectroscopic characterization of Liquid Fuels
- Determination of Carbon residue Liquid fuels-A
- Determination of Carbon residue Liquid fuels-A
- Determination of Cloud and Pour point of Liquid fuels
- Determination of Proximate Analysis of coal
- Determination of Ultimate Analysis of coal
- Determination of Calorific value: of Gaseous fuels using Junkers Gas Calorimeter
- Determination of Calorific value of coal using bomb calorimeter
- Pyrolysis & Degradation of Coal Sample.
- Determination of Aniline point of given fuels.

Assessment Tool	% Contribution
Progressive Evaluation	60 (Day to day performance: 30, Quiz: 10, Viva: 20)
End Sem Examination	40 (Experiment Performance: 30, Quiz: 10)

### Text Books & Reference Books:

1. Fuels and Combustion: Samir Sarkar, University Press (India) Pvt Limited, India.
2. Elements of Fuels, Furnaces and Refractories: O P Gupta, Khanna Publishers, India
3. Fuels, Furnaces and Refractories: R C Gupta, PHI Learning Private Limited, India
4. A Text Book of Engineering Chemistry by Shashi Chawla, Dhanpat Rai & Sons, India.

**DEPARTMENT OF APPLIED CHEMISTRY**  
**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI**

Name of the course:	<b>Integrated M. Sc. (Chemistry)</b>
Duration:	10 semesters
Intake:	20
Eligibility:	10+2 with Physics, Chemistry, Maths/Biology with 60% mark as average of marks in four subjects (ECPM/B) (50% for SC/ST category)
Exit Option:	Candidates may be allowed to exit from the programme after successfully completing their VI Semester. However the candidate has to submit in writing their intention to exercise this option at the time of registration of IV Semester. Such candidates would be given B.Sc. Degree with Chemistry (Hons./Major).

**COURSE AIMS & OBJECTIVE**

The proposed course aims to provide students with a broad theoretical background in Inorganic, Organic & Physical Chemistry, with emphasis on Analytical Techniques. Particular attention is given to Industrial applications of chemistry so that students are completely equipped to move into careers in academic, industrial and commercial organizations. The course curriculum is interdisciplinary in nature involving applied chemistry, applied physics, mathematics and biological sciences. Our institute has a good number of experts in these areas along with basic instrumentation facilities. The content of the course provides an understanding of different aspect of chemistry. The lecture based course will cover the various aspects of pure & applied chemistry. In lab experiments the emphasis is laid on green chemistry and industrial chemistry elaborating the need for waste minimization, substitution of non toxic chemicals for toxic ones and increasing the use of semi-micro, micro and computational techniques. Laboratory courses have been designed to provide an exhaustive and hands on experience on working with various sophisticated instruments. Final semester is dedicated to thesis/dissertation work giving students experience in solving a real-life problem under the supervision of faculty members involved in pursuing research and development projects, usually related to industrial problems.

**Employment Potential:**

To provide properly qualified man power for academic institutions, R&D and quality control laboratories of chemical / pharmaceutical industries & forensic labs. This will also fulfill the needs of the students regarding the limited exposure to modern instrumental techniques in various graduate and postgraduate courses, thus enabling them for employment in chemical, pharmaceutical industries, R & D laboratories, academic institution, forensic labs etc. More over this course can be helpful to the students to be self employed as it not only allows for an in-depth subject specific knowledge and opportunities to specialize in a number of areas at the leading-edge of the subject but also encourages students to develop problem solving and reflective working practices.

## COURSE STRUCTURE

1st Semester	Subject Code	Subject	L-T-P	Credits	(C)/ (B)
	<b>ISP 1001</b>	Physics I (General Properties of Matter and Waves & Oscillations)	3-1-0	4	C
	<b>ISC 1001</b>	Chemistry I	3-0-0	3	C
		Mathematics I (Analytical Geometry and Calculus)	3-1-0	4	C
	<b>CS</b>	Unix & C-Programming	3-0-2	4	B
		English	2-1-0	3	B
	<b>ISP1002</b>	Physics Lab I	0-0-2	1	C
		Chemistry Lab I	0-0-2	1	C
		Co Curricular Activity	0-0-2	1	B
		<b>Total Credits</b>		<b>21</b>	<b>C-13 B-7</b>
2 <sup>nd</sup> Semester	<b>ISP 2001</b>	Physics II (Basic Electromagnetic Theory)	3-0-0	3	C
	<b>ISC 2002</b>	Chemistry II	3-1-0	4	C
		Mathematics II (Matrix Algebra & Complex Variables)	3-0-0	3	C
		Data Structure	3-0-2	4	B
		Environmental Science	3-0-0	3	B
	<b>ISP 1004</b>	Physics Lab II	0-0-2	1.5	C
		Chemistry Lab II	0-0-2	1.5	C
		Co Curricular Activity	0-0-2	1	B
		<b>Total Credits</b>		<b>21</b>	<b>C-13 B-8</b>
3 <sup>rd</sup> Semester	<b>ISP 3001</b>	Physics III (Modern Physics)	3-0-0	3	C
	<b>ISC 2003</b>	Chemistry III	3-0-0	3	C
		Maths III (Ordinary Differential Equations with Special Functions)	3-1-0	4	C
	<b>CS</b>	Java Programming & Web Technology	3-0-2	4	B
		Biological Science	3-0-0	3	B
		Physics Lab-III	0-0-2	1.5	C
		Chemistry - Lab III	0-0-2	1.5	C
		Co Curricular Activity	0-0-2	1	B
		<b>Total Credits</b>		<b>21</b>	<b>C-13 B-8</b>
4 <sup>th</sup> Semester		Physics IV (Modern Optics)	3-0-0	3	C
	<b>ISC 2004</b>	Chemistry IV	3-0-0	3	C
		Maths IV (Integral Transform & Partial Differential Equations)	3-1-0	4	C
		Value Education, Human Rights and Legislative Procedure	3-0-0	3	B
	<b>ISP 4003</b>	Solid State Physics	3-1-0	4	C
	<b>ISP 4002</b>	Physics Lab-IV	0-0-3	1.5	C
		Chemistry Lab IV	0-0-3	1.5	C
		Co Curricular Activities	0-0-2	1	B
		<b>Total Credits</b>		<b>21</b>	<b>C-17 B-4</b>

	Code	Subject	L-T-P	Credits	(C)/ (B)
<b>5<sup>th</sup> Semester</b>		Physical Chemistry I	3-1-0	4	C
		Organic Chemistry I	3-1-0	4	C
		Organic Chemistry II	3-0-0	3	C
		Inorganic Chemistry I	3-0-0	3	C
		Inorganic Chemistry II	3-0-0	3	C
		Inorganic Chemistry Lab -I	0-0-3	1.5	C
		Organic Chemistry Lab -I	0-0-3	1.5	C
		<b>Total Credits</b>		<b>20</b>	<b>C-20</b>
<b>6<sup>th</sup> Semester</b>		Physical Chemistry II	3-0-0	3	C
		Physical Chemistry III	3-0-0	3	C
		Organic Chemistry III	3-0-0	3	C
		Inorganic Chemistry III	3-0-0	3	C
		Foreign Language	2-0-1	2	B
		Industrial Chemistry	3-0-0	3	C
		Physical Chemistry Lab -I	0-0-3	1.5	C
		Industrial Chemistry Lab	0-0-3	1.5	C
		<b>Total Credits</b>		<b>20</b>	<b>C 18 B 2</b>
<b>7<sup>th</sup> Semester</b>		Advanced Physical Chemistry	3-1-0	4	C
		Organic Reaction Mechanisms	3-1-0	4	C
		Metal Chemistry	3-0-0	3	C
		Environmental Chemistry	3-0-0	3	C
		IPR	3-0-0	3	B
		Computational Chemistry Lab	0-0-3	1.5	C
		Organic Chemistry lab II	0-0-3	1.5	C
		<b>Total Credits</b>		<b>20</b>	<b>C 17 B 3</b>
<b>8<sup>th</sup> Semester</b>		Theoretical Chemistry	3-0-0	3	C
		Synthetic Organic Chemistry	3-1-0	4	C
		Advanced Analytical Techniques	3-0-0	3	C
		Advanced Inorganic Chemistry	3-1-0	4	C
		Environmental Monitoring and Control	3-0-0	3	C
		Inorganic Chemistry Lab II	0-0-3	1.5	C
		Physical chemistry Lab II	0-0-3	1.5	C
		<b>Total Credits</b>		<b>20</b>	<b>C-20</b>
<b>9<sup>th</sup> Semester</b>		Bio-Inorganic & Organometallic Chemistry	3-1-0	4	C
		Advanced Organic Chemistry	3-1-0	4	C
		Elective I	3-0-0	3	C
		Elective II	3-0-0	3	C
		Breadth Paper: PG Lever (Oth Dept.)	3-0-0	3	B
		Advanced Characterization Lab	0-0-3	1.5	C
		Elective Lab	0-0-3	1.5	C
		<b>Total Credits</b>		<b>20</b>	<b>C 17 B 3</b>
<b>10<sup>th</sup> Semester</b>		<b>Thesis /Dissertation</b>		<b>10</b>	
		<b>TOTAL CREDIT</b>		<b>194</b>	

### Syllabus of Chemistry I-X

#### ISP 1001 Physics I - General Properties of Matter and Waves & Oscillations (3-1-0-4)

##### Module 1

[6]

Systems of particles: Centre of mass, Linear momentum, Conservation of linear momentum, System with varying mass: A Rocket; Potential energy and conservation of energy, Conservative and non-conservative forces, Force as gradient of potential energy; Particle collisions: Elastic and inelastic collision.

##### Module II

[6]

Angular momentum of a particle and system of particles, Angular momentum of rigid body rotating about a fixed axis, Conservation of angular momentum, Torque, Rotation about a fixed axis. Moment of inertia and its calculation

##### Module III

[5]

The world and gravitational force, Newton's law of gravitation, Gravitation near earth's surface, Gravitation inside earth, Gravitational potential energy, Planets and satellites: Kepler's Laws.

##### Module IV

[5]

Torsion of a cylinder, Bending moment, Cantilever, Beam supported at both ends, Beams clamped at both ends, Reciprocity theorem; Elastic energy in different types of deformation.

##### Module V

[6]

Molecular forces, Surface tension and surface energy, Angle of contact, Excess pressure over a curved liquid surface, Capillarity, Shape of liquid drops. Ripples, Streamline and turbulent motion, Reynold's number; Poiseuille's equation. Stoke's law, Rotating cylinder and rotating disc methods for determining the coefficient of viscosity, Euler's equation for liquid flow; Bernoulli's theorem and its applications.

##### Module VI

[8]

Simple harmonic motion, Motion of simple and compound pendulum, Damping, Forced vibration and resonance, Wave equation in one dimension, Phase velocity, Group velocity, Dispersion. Types of wave, Transverse and longitudinal waves. Speed of a travelling waves, Wave speed on a stretched string, Energy and power of a travelling string wave, The principle of superposition for waves, Interference of waves, Stationary waves, Sound waves, speed of sound Intensity of sound. Measurement of intensity; The Doppler effect, Shock waves

#### Text Books:

1. Fundamental of Physics, Halliday D., Resnick R. and Walker J., Wiley India
2. Sears and Zemansky's University Physics, Young H.D., Freedman R.A., Ford A.L., Pearson
3. General properties of Matter, Newman and Searle
4. Properties of Matter: C. J. Smith

#### Reference Books:

1. Mechanics, D.S.Mathur.
2. Mechanics, Shukla R.K. and Srivastava A.
3. Physics Course vol. I, Berkley
4. Textbook of sound, Wood A. B.
5. Waves and Oscillations, French

## Chemistry-I

Credit: 3 (3-0-0)

### Module I: Atomic Structure & Periodic Properties

[5]

Atomic Structure, Electronic Configuration, Atomic and ionic radii, ionization energy, electron affinity and electronegativity, trends in periodic table and applications in predicting and explaining the chemical behaviour.

### Module II: Chemical Bonding

[7]

Covalent Bond – Valence bond theory and its limitations, various types of hybridization and shapes of simple inorganic molecules and ions. Valence shell electron pair repulsion (VSEPR) theory to  $\text{NH}_3$ ,  $\text{H}_3\text{O}^+$ ,  $\text{SF}_4$ ,  $\text{ClF}_3$ ,  $\text{ICl}_2$  and  $\text{H}_2\text{O}$ . MO theory, homonuclear diatomic molecules, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference. Weak Interactions – Hydrogen bonding, Van der Waals forces.

### Module III Gaseous & Liquid States of Matter

[8]

Postulates of kinetic theory of gases, deviation from ideal behavior, van der waals equation of state. Law of corresponding states. Molecular velocities: Root mean square, average and most probable velocities. Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter. Liquification of gases (based on Joule Thomson- effect) Intermolecular forces, structure of liquid. Structural differences between solids, liquids and gases. Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic and cholestric phases. Thermography and seven segment cell.

### Module IV Introductory Organic Chemistry

[7]

IUPAC nomenclature: Alkanes, cyclo-alkanes, alkenes, alkynes, halogen compounds, alcohols, ethers, aldehydes, ketones, carboxylic acids, nitro compounds. Hybridization and Geometry of Molecules: methane, ethane, ethylene, acetylene. Electronic Effects: Inductive, resonance, hyper conjugation and steric effect. Cleavage of bonds: homolytic and heterolytic C-C bond fission. Reaction Intermediates and their stability: carbocations, carbanions and free radicals.

### Module V: Basic Organic Synthesis and Principles

[8]

Alkanes: preparation by reduction of alkyl halides, Wurtz reaction and Kolbe's electrolytic methods with mechanism; Alkenes: preparation by dehydration of alcohols, dehydrohalogenation of alkylhalides, dehalogenation of vicdihalides and by Kolbe's electrolytic method. Alkynes: Preparation by dehydrohalogenation of vic-dihalides and gem-dihalides, dehalogenation of tetrahalides and Kolbe's electrolytic method. Reactions: addition reactions with hydrogen, halogens, hydrogen halide (markownikoffs rule, peroxide effect), hydroboration, ozonolysis, hydroxylation with  $\text{KMnO}_4$ , allylic substitution by NBS. Conjugated Dienes; Electrophilic addition of dienes: 1,2, & 1,4 addition, Diels . Alder reaction

### Books Recommended:

1. Organic Chemistry, Morrison and Boyd, Prentice Hall.
2. Advanced Organic Chemistry, Bahl, B S, Bahl A.
3. Physical Chemistry by **P. W. Atkins**, Elbs
4. Basic Inorganic Chemistry by **F. A. Cotton & Wilkinson**, John Wiley
5. Inorganic Chemistry by **J. E. Huhey**, Harpes & Row



## IMC 1001 Mathematics I - Analytical Geometry and Calculus (3-1-0- 4)

### Module I

**Analytical Geometry (2D & 3D):** Polar equation of conics. Cones, cylinders and conicoids, Central conicoids, normals and conjugate diameters. [6]

### Module II & III

**Differential Calculus:** Successive differentiation of one variable and Leibnitz theorem, Taylor's and Maclaurin's expansion of functions of single variable. Functions of several variables, partial derivatives, Euler's theorem, derivatives of composite and implicit functions, total derivatives, Jacobian's. Taylor's and Maclaurin's expansion of functions of several variables, Maxima and minima of functions of several variables, Lagrange's method of undetermined multipliers, Curvature and asymptotes, concavity, convexity and point of inflection, Curve tracing. [12]

### Module IV

**Integral Calculus:** Improper integrals, convergence of improper integrals, test of convergence, Beta and Gamma functions and its properties, Differentiation under integral sign, differentiation of integrals with constant and variable limits, Leibnitz rule. [6]

### Module V

Evaluation of double integrals, Change of order of integrations, change of coordinates, evaluation of area using double integrals, Evaluation of triple integrals, change of coordinates, evaluation of volumes of solids and curved surfaces using double and triple integrals. Mass, center of gravity, moment of inertia and product of inertia of two and three-dimensional bodies and principal axes. [6]

### Module VI

**Vector Calculus:** Scalar and vector fields, Level surfaces, differentiation of vectors, Directional derivatives, gradient, divergence and curl and their physical meaning, vector operators and expansion formulae, Line, surface and volume integrations, Theorems of Green, Stokes and Gauss, Application of vector calculus in engineering problems, orthogonal curvilinear coordinates, expressions of gradient, divergence and curl in curvilinear coordinates. [6]

### Books:

1. M. D. Weir, J. Hass and F. R. Giordano: Thomas' Calculus, 11<sup>th</sup> edition, Pearson Educations, 2008
2. Dennis G. Zill, Warren S. Wright: Advanced Engineering Mathematics, 4<sup>th</sup> edition, Jones and Bartlett Publishers, 2010
3. E. Kreyszig : Advanced Engineering Mathematics, 8<sup>th</sup> Edition John Wiley and sons 1999.
4. T. M. Apostol : Calculus Vols I and II, 2<sup>nd</sup> Edition, John Wiley and sons, 1967 and 1969.
5. Murray R Spiegel, Theory and problems of Vector Analysis and an Introduction to Tensor Analysis, McGraw Hill, Schaum's Outline Series

## **CS                      UNIX and C Programming                      (3-0-2-4)**

### **MODULE – I**

Fundamentals of Unix Operating System, Login & Password, Different Commands, Unix directory, Structure and working with directories, Vi-editor, History and Importance of C, Sample programming, Basic Structure and execution of C programmes, Constants, Variables, and Data Types and various type of declarations, Different type operators and Expressions, Evaluation of Expressions, Operator Precedence and Associability, Mathematical Functions.

### **MODULE –II**

Managing Input and Output operations, Decision Making and Branching Decision Making and Looping.

### **MODULE – III**

One – dimensional Arrays and their declaration and Initialisations, Two-dimensional Arrays and their initialisations, Multidimensional Arrays, Dynamic Arrays, String Variables, Reading and Writing Strings, Arithmetic Operations on characters, Putting Strings together, Comparison of Two Strings, String – handling functions, Table and other features of Strings.

### **MODULE –IV**

Need and Elements for user –defined Functions, Definition of Functions, Return values and their types, Function calls and Declaration, Arguments and corresponding return values, Functions that return multiple values, Nesting of functions, Recursion, Passing arrays and strings to functions, The Scope, Visibility and Life time of variables.

### **MODULE –V**

Defining Structure, Declaring Structure Variable and Accessing Structure Members, Initialisation of Structure, Comparing Structure Variables, Operation on Individual Members, Arrays of Structures, Structures within structures, Structures and Functions, Unions, Size of Structures, Bit Fields.

### **MODULE – VI & VII**

Understanding Pointers, Accessing the Address of a Variable, Declaration and Initialisation of Pointer Variables, Accessing a Variable through its Pointer, Chain of Pointers, Pointer Expressions, Pointer Increments and Scale Factor, Pointers and Arrays, Pointers and Arrays, Pointers and Character Strings, Arrays of Pointers, Pointers and Function Arguments, Functions Returning Pointers, Pointers to Functions, Pointers and Structures, File Management in C.

### **Text Book :**

E. Balagurusamy – Programming in ANSI C, 3rd Edn. , TMH, New Delhi ; 2004

### **Reference:**

A. N. Kanthane – Programming with ANSI and TURBO C, Pearson Education, New Delhi; 2004  
Y. Kanetkar – Let us C, 4th Edition, BPB Publication , New Delhi; 2002.

## ENGLISH (2-1-0-3)

### **MODULE 1:**

1. Short stories
  - A) The castaway – Rabindra nath Tagore
  - B) Mr. know all - somerset Maugham
2. Essays
  - a) Life's Philosophy – Jawaharlal Nehru
  - b) Ideas that have helped mankind – Bertrand Russell
3. Vocabulary
  - a) One word substitution
  - b) Idioms & Phrases
  - c) Pairs of word
  - d) Synonyms & Antonyms
4. Comprehension

### **MODULE 2:**

1. Communication
  - a) Definition & Meaning
  - b) Effective communication
  - c) Barriers to communication
  - d) Verbal & Non- Verbal communication
2. Official correspondence
  - a) Memorandum
  - b) Notice, Agenda, Minutes
  - c) Invitation letter for Seminar etc.
  - d) Refusal & Acceptance letter
3. Drafting C.V. & writing Application
4. Paragraph writing

#### **Reference books:**

1. Selected short stories , Prof. Damodar Thakur(ed)- Mcmillan India Ltd.
2. Modern Masters – An Anthology of English prose; Bord of editors- Orient longman
3. Student's Companion- W D Best - Rupa & Co.
4. Effective Business Communication- Asha Kaul- Prentice Hall of India
5. Business Communication- Satya Swaroop Debasish, Bhagban Das- Prentice hall of India

**ISP 1002                      Physics Lab-1            (0-0-2-1)**

1. Error analysis using vernier calipers, screw gauge, and spherometer
2. Determination of Young's modulus, modulus of rigidity and Poisson's ratio of material of a wire using Searle's method.
3. Determination of Young's modulus of material of a metallic bar by bending of beam method.
4. To study the standing waves on a stretched string and verify the relation between tension, frequency and number of loops.
5. To determine the frequency of ac mains supply using sonometer.
6. Determination of viscosity of liquid using Poiseuille's method.
7. Determination of surface tension of a liquid by capillary tube method.
8. Determination of acceleration due to gravity using compound pendulum

## Chemistry Lab-1 (0-0-2-1)

1. Demonstration & concept of good lab practices including safety, glassware handling, chemical nature understanding, chemical handling, chemical/glassware waste management, Error Analysis, notebook maintenance.
2. Calibration and handling of balances, pipettes and burettes, basic principles & experiments related to sample & reagent preparation: practical concept of Molarity, Molality, Normality, equivalence, weight %, vol.%, Preparation of standard solutions, Dilution 0.1 M to 0.001 M solutions.
3. Calibration of Thermometer
  - a. 80-82 C (Naphthalene), 113.5-114 C (Acetanilide)
  - b. 132.5-133 (Urea), 100 C (Distilled Water)
4. Determination of Melting Point  
Naphthalene 80-82 C, Benzoic Acid 121.5-122 C  
Urea 132.5-133 C, Succinic Acid 184.5-185  
Cinnamic Acid 132.5-133, Salicylic Acid 157.5-158 C  
Acetanilide 113.5-114 C, m-Dinitrobenzene 90 C  
p-Dichlorobenzene 52 C, Aspirin 135 C
5. Determination of Boiling Point
  - a. Ethanol 78 C, Cyclohexane 81.4 C, Toluene 110.6 C
6. Crystallization
  - a. Phthalic acid from hot water (using fluted filter paper and stemless funnel)
  - b. Acetanilide from boiling water
  - c. Naphthalene from ethanol
  - d. Benzoic acid from water
7. Distillation
  - a. Simple distillation of ethanol-water mixture using water condenser
  - b. Distillation of nitrobenzene and aniline using air condenser
8. Macro analysis (qualitative) of cations and anions (known samples)

### Books Suggested:

1. Vogel's Textbook of Practical Organic Chemistry
2. Experiments in General chemistry, C. N. R. Rao and U. C. Agarwal
3. Vogel's Textbook of Practical Organic Chemistry (5th Edition)
4. Vogel's Inorganic Practical Chemistry

## Co-curricular Activity (0-0-2-1)

## ISP 2001      Physics II - Basic Electromagnetic Theory (3-0-0-3)

### Fields:

[6]

Vector and scalar fields, physical and mathematical concepts of gradient, divergence and curl, Gauss's theorem and Stokes' theorem.

### Electrostatics:

[9]

Coulomb's law, Gauss's law in integral and differential form, electric potential and relation with  $E$ , electrostatic energy density, dielectrics, Relation between  $E$ ,  $D$  and  $P$  vectors, dielectric susceptibility, boundary conditions on  $E$  and  $D$ .

### Magnetism:

[9]

Motion of charged particles in electric and magnetic fields, Biot-Savart law, Ampere's law in integral and differential form, applications, Hall effect.

Types of magnetism – diamagnetism, paramagnetism and ferromagnetism, Weiss field, domains, magnetic permeability and susceptibility, Relation between  $B$ ,  $H$  and  $M$  vectors, boundary conditions on  $B$  and  $H$ , hysteresis.

### Electromagnetic theory:

[12]

Faraday's law of electromagnetic induction in integral and differential form, Inductance, magnetic energy density, continuity equation for charge, displacement current, Maxwell's equations in free space, electromagnetic wave equation for plane waves in dielectric medium and free space, relation between  $E$ ,  $B$ , and  $k$ , Poynting vector, radiation pressure.

### Text books:

1. Fundamental of Physics: Halliday, Resnick & Walker (6<sup>th</sup> Edition)
2. Engineering Electromagnetics: William Hayt, John Buck, McGraw-Hill Companies (7<sup>th</sup> Edition)

### Reference books:

1. Introduction to Electrodynamics: David J Griffiths, 3rd Ed.
2. Electricity and Magnetism: Jackson

## Chemistry II ( 3-1-0-4)

### Module- I Colloidal State

[5]

Definition of colloid, classification of colloids. Solids in liquids (sols): properties – kinetic, optical and electrical: stability of colloids, protective action Hardy-Schulze law, gold number. Liquids in solids (gels): classification, preparation and properties, inhibition, general application of colloids.

### Module-II Chemical kinetics and Catalysis

[6]

Introduction to chemical kinetics Theories of chemical kinetics: effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy, Simple collision theory based on hard sphere model transition state theory (equilibrium hypothesis) Expression for the rate constant based on equilibrium constant and thermodynamic aspects. Catalysis, characteristics of catalysed reactions, classification of catalysis, miscellaneous examples.

### Module III: s- and p- Block Elements

[5]

Comparative study, diagonal relationships, salient features of hydrides, solvation and complexation tendencies, an introduction to alkyls and aryls.

Chemical properties of the noble gases, chemistry of xenon, structure and bonding xenon compounds Role of Mg, Na, K, Ca ions in biology.

### Module IV: Acids and Bases

[4]

Arrhenius, Bronsted-Lowry, solvent system, Lewis and HSAB concept of acids and bases.

### Module V Aromatic Compounds & Aromaticity

[5]

Aromatic hydro carbons and aromaticity, resonance in benzene, Huckel's  $(4n+2)$  rule and its simple applications. Acidic character of phenols - explanation on the basis of resonance stabilization. Electrophilic substitution reactions in aromatic compounds. General mechanisms of nitration, halogenation, sulphonation, Friedel-Craft's acylation and alkylation, ortho/para/meta directive influence with examples.

### Module VI Elimination & Substitutions Reactions

[5]

SN1 and, SN2 reaction mechanism: effects of structure, substrate, solvent, nucleophile and leaving groups. Mechanisms of E1 and E2 reactions, Hoffmann and Sayetzeffs rules cis and trans eliminations, Elimination Vs substitution.

### Module VII Stereochemistry

[6]

Introduction, Concept of Isomerism, Classification of Stereoisomers, Optical isomerism, Chirality & Elements of symmetry, Wedge formula, Fischer projection, Newmann projection. Relative and absolute configurations, sequence rules, D & L, R & S systems of nomenclature. Understanding with examples for Enantiomers, mesoform, erythro/threo forms, diastereoisomers, inversion, retention, and racemization. Conformational understanding with an example of ethane, n-butane, Cyclohexane and Decalin.

### Books Recommended:

1. Fundamentals of Organic Chemistry Solomons, John Wiley
2. Introduction to Organic Chemistry, Streitwiesser, Hathcock and Kosover, Macmillan.
3. Physical Chemistry Vol. 1-5, by K.L Kapoor
4. Physical Chemistry: A Molecular Approach by McQuarrie & Simon Viva
5. Concise Inorganic Chemistry by J D Lee, Amazon.
6. Comprehensive Co-ordination Chemistry by G. Wilkinson, R. D. Gillars & J. A. McCleverty, Pergamon
7. Chemistry of the Elements by N. N. Greenwood & Earnshaw, Pergamon

**IMC 2001 Maths II - Matrix Algebra & Complex Variables (3-0-0-3)**

**Module I**

**Inequalities-** A.M., G.M. Cauchy Schwartz inequality, Weirstrass's inequality, Holder's inequality. Simple Continued Fractions [3]

**Module II**

**Infinite serie --** Convergency and divergency of Infinite series. Comparison test, D' Alembert's Ratio test, Raabe's test, logarithmic test, Cauchy's root test, Higher Logarithmic ratio Test, Gauss's Test, Alternating series, Leibnitz test, absolute and conditional convergence, power series, uniform convergence. [6]

**Module III**

**Matrix Algebra:** Orthogonal, Hermitian, skew- Hermitian and unitary matrices, Elementary row and column transformations, rank and consistency conditions and solution of simultaneous equations, linear dependence and consistency conditions and solution of simultaneous equations, linear dependence and independence of vectors, Linear and orthogonal transformations, Eigen values and Eigen vectors, properties of Eigen values, Cayley-Hamilton theorem, reduction to normal forms, quadratic forms, reduction of quadratic forms to canonical forms, index, signature, Matrix calculus & its applications in solving differential equations. [9]

**Module IV**

**Theory of equations-** Descartes's rule of Signs. Relation between roots and coefficients of a polynomial equation, transformation of equation, reciprocal equation, symmetric function of roots, solution of cubic polynomial by Cardon's method, solution of bi-quadratic equations by Ferrari's and Descarte's method. [6]

**Module V & VI**

**Complex variables:** Introduction to complex variables. Functions of a complex variable. Limit, continuity, differentiability and analyticity of complex functions. Cauchy-Remann equations. Complex Integration, Cauchy's theorem and Cauchy's Integral formula, Morera's Theorem, Power series, Taylor's, Laurent's Theorems, Cauchy's inequality, Liouville's theorem, fundamental theorem of algebra. Calculus of residues, Contour integrals, Conformal mappings, and Bilinear Transformations. [12]

**Text Books:**

1. M. D. Weir, J. Hass and F. R. Giordano: Thomas' Calculus, 11<sup>th</sup> edition, Pearson Educations, 2008.
2. Complex Variables and applications- R.V. Churchill and J.W. Brown, 7th edition, 2004, McGraw-Hill.
3. A.D. Wunsch, Complex Variables with Applications, 3rd edition, Pearson Education, Inc.
4. M J Ablowitz and A S Fokas, Complex Variables Introduction and Applications Cambridge Texts, 2nd Ed.
5. Higher Algebra- **S Branard & J M Child**, Maxford Books (2003)
6. Introduction to Matrices and Linear Transformations: Third Edition- Daniel T. Finkbeiner, Dover Publications, 2011
7. Higher Algebra-Hall & Knight - Arihant Prakashan.



**CS                      Data Structures                      (3-0-2-4)**

**MODULE – I [5 lectures]**

**Algorithms and Analysis of Algorithms:** Definition, Structure and Properties of Algorithms, Development of an Algorithm, Data Structures and Algorithms, Data Structure – Definition and Classification, Efficiency of Algorithms, Apriori Analysis, Asymptotic Notations, Time Complexity of an Algorithm using  $O$  Notation, Polynomial Vs Exponential Algorithms, Average, Best and Worst case Complexities, Analyzing Recursive Programs

**MODULE – II [5 lectures]**

**Arrays, Stacks and Queues:** Array Operations, Number of Elements in an Array, Representation of Arrays in Memory, Applications of Array, Stack-Introduction, Stack Operations, Applications of Stack, Queues-Introduction, Operations on Queues, Circular Queues, Other Types of Queues, Applications of Queues.

**MODULE – III [5 lectures]**

**Linked List, Linked Stacks and Linked Queues:** Singly Linked Lists, Circularly Linked Lists, Doubly Linked Lists, Multiply Linked Lists, Applications of Linked Lists, Introduction to Linked Stack and Linked Queues, Operations on Linked Stacks and Linked Queues, Dynamic Memory Management and Linked Stack, Implementations of Linked Representations, Applications of Linked Stacks and Linked Queues.

**MODULE – IV [6 lectures]**

**Trees, Binary Trees, BST, AVL Trees and B Trees:** Trees: Definition and Basic Terminologies, Representation of Trees, Binary Trees: Basic Terminologies and Types, Representation of Binary Trees, Binary Tree Traversals, Threaded Binary Trees, Applications, BST & AVL Trees: Introduction, BST: Definition and Operations, AVL Trees: Definition and Operations, B Trees: Introduction, m-way search trees: Definition and Operations, B Trees: Definition and Operations.

**MODULE – V [5 lectures]**

**Sorting:** Introduction, Shell Sort, Quick Sort, Heap Sort.

**MODULE – VI [4 lectures]**

**Searching:** Introduction, Binary Search, Transpose Sequential Search, Interpolation Search.

**Text Book:**

1. G A V Pai – Data Structures and Algorithms: Concepts, Techniques and Applications, 2<sup>nd</sup> Edn, Tata McGraw-Hill, 2008
2. Horowitz E.Sahni, S., Susan A., Fundamentals of Data Structures in C, 2<sup>nd</sup> Edition, University Press, 2010

**Reference Books:**

1. J. P. Tremblay, P. G. Sorenson – *An Introduction to Data Structures With Applications*, 2<sup>nd</sup> Edn, McGraw-Hill, Inc. New York, NY, USA.
2. Seymour Lipschutz – *Data Structures*, 6<sup>th</sup> Edn, 9<sup>th</sup> Reprint 2008, Tata McGraw-Hill.
3. Adam Drozdek – *Data Structures and Algorithms in C++*, Thomson Learning, New Delhi – 2007.
4. J. Feller, B. Fitzgerald -*Understanding Open Source Software Development*, Pearson Education Ltd. New Delhi

**ISC                      Environmental Science                      (3-0-0-3)**

**Module I** **[6]**

**Introduction to Environment Pollution:** Environmental Awareness, concept of an ecosystem, structure and function of an ecosystem, energy and nutrient flow biogeochemical cycle, sources, pathways and fate of environmental pollutants.

**Module II** **[8]**

**Air Pollution:** Composition, major sources of air pollution, their detrimental effects, stationary emission sources, some control methods, eg. cyclon separators, wet scrubbers electrostatic precipitators etc.

Automobile emission control, smog, green house effect, ozone depletion, global warming and acid rains etc.

**Module III** **[6]**

**Water Pollution:** Water resources, sources of water pollution, various pollutants their detrimental effects.

Portability limits as per WHO & PHED specification, treatment of municipal supply water, slow sand filters, rapid sand filter, disinfections, their advantage & disadvantages, break point chlorination.

**Module IV** **[5]**

**Industrial Water:** Specification for boiler feed water, internal and external treatment, ion exchange electro dialysis and reverse osmosis.

**Module V** **[5]**

**Sewage Treatment:** Composition aerobic & anaerobic treatment, chemical & biological oxygen demand.

**Module VI**

A brief Introduction to Noise Pollution & Radioactive Pollution [3]

**Module VII**

Soil pollution and solid waste management [3]

**Book Recommended:**

De.A.K.Environmental Chemistry, Wiley Eastern Ltd,  
Miller T.G.Jr., Environmental Science, Wadsworth publishing House, Meerut  
Odum.E.P.1971. Fundamental of Ecology. W.B. Saunders Co.U.S.A.

**ISP 1004**

**Physics Lab-II**

**(0-0-2-1.5)**

1. Determination of resistance per unit length and an unknown resistance using C. F. Bridge.
2. Determination of thermal conductivity of a bad conductor using Lee's disc method.
3. To determine the electrical equivalent of heat.
4. To determine the band gap energy of a given semiconductor by four-probe method.
5. B-H curve and hysteresis loss.
6. To study series and parallel resonant L. C. R. circuit.
7. To measure voltage and frequency of a sinusoidal waveform using a CRO and to find unknown frequencies by producing Lissajous figures.
8. To determine the emf and internal resistance of a cell using a stretched wire potentiometer.
9. (a) To study deviation of light through a prism and obtain the angle of minimum deviation using Raytrace software.  
(b) To study the relationship between position of an object and its image produced by a convex lens and to find the resulting magnification.

## Chemistry Lab-II (0-0-2-1.5)

### 1. Volumetric analysis

- (a) Determination of acetic acid in commercial vinegar using NaOH
- (b) Estimation of calcium content in chalk as calcium oxalate by permanganometry.
- (c) Estimation of hardness of water by EDTA.
- (d) Estimation of copper using thiosulphate

### 2. Synthesis and analysis

- (a) Preparation of Ni-DMG complex,  $[\text{Ni}(\text{DMG})_2]$
- (b) Gravimetric analysis of Ni as Ni-DMG complex
- (c) Qualitative inorganic analysis of mixtures containing not more than 4 radicals from the following:
  - Cation Radicals:  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{+2}$ ,  $\text{Sr}^{+2}$ ,  $\text{Ba}^{+2}$ ,  $\text{Al}^{+3}$ ,  $\text{Cr}^{+3}$ ,  $\text{Mn}^{+2}$ ,  $\text{Fe}^{+3}$ ,  $\text{Co}^{+3}$ ,  $\text{Ni}^{+3}$ ,  $\text{Cu}^{+2}$ ,  $\text{Zn}^{+2}$ .
  - Anion Radicals:  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{BrO}_3^-$ ,  $\text{I}^-$ ,  $\text{SCN}^-$ ,  $\text{S}^{2-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{S}_2\text{O}_3^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{BO}_3^{3-}$ ,  $\text{CrO}_4^{2-}$ ,  $\text{Cr}_2\text{O}_7^{2-}$ ,  $\text{Fe}(\text{CN})_6^{4-}$ ,  $\text{Fe}(\text{CN})_6^{3-}$ .
  - Insoluble Materials:  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{Cr}_2\text{O}_3$ ,  $\text{SnO}_2$ ,  $\text{SrSO}_4$ ,  $\text{BaSO}_4$ ,  $\text{CaF}_2$ .
  - Experiment A: Preliminary Tests for acid and basic radicals in given samples.
  - Experiment B: Wet tests for Acid and Basic radicals in given samples.
  - Experiment C: Confirmatory tests.

### Practical Book:

- 1. G. Svehla: Vogel's Qualitative Inorganic Analysis.
- 2. J. Mendham, R. C. Denny, J. D. Barnes, M. J. K. Thomas: Vogel's Text Book of Quantitative Chemical Analysis.
- 3. Vogel's Textbook of Quantitative Chemistry.
- 4. Synthesis & characterization of Inorganic Compounds by W. L. Jolly, Prentice Hall.

## Co-curricular Activity (0-0-2-1)

### ISP 3001    Physics III - Modern Physics (3-0-0-3)

1. **Atomic structure:** Bohr and Sommerfeld model of hydrogen atom, Effect of finite nuclear mass, Idea of discrete energy levels and electron spin, Significance of four quantum numbers and concept of atomic orbital.  
[6]
2. **Vector atom Model:** One valence electron atom: Orbital magnetic dipole moment, Orbital, spin and total angular moment, Stern–Gerlach experiments, Larmor precession, Vector model of atom, Electronic configuration and atomic states, Spin-orbit interaction and fine structure, Intensity of spectral lines, General selection rules. Magnetic moment of the electron, Lande g factor, Zeeman Effect, Doublet structure of alkali spectra.  
[6]
3. **Multi electron Atom:** Pauli's exclusion principle, shell structure, Hund's rule, Atomic ground state and periodic table.  
[6]
4. **Molecular spectra:** The molecular bond, Electron sharing, Types of molecular energy state and molecular spectra, molecular orbital method, MO treatment of hydrogen molecule and molecular ion, diatomic molecular orbital, Molecular orbital energy level diagrams, Molecular Symmetry.  
[6]
5. **Special theory of relativity:** Postulates, Galilean transformations, Lorentz transformations, length contraction, time dilation, velocity addition, mass change and Einstein's mass energy relation.  
[6]
6. **Introduction to X-ray:** Electromagnetic radiations, continuous spectrum, characteristic spectrum, production of x-rays, detection of x-rays, properties of x-ray, safety precautions. X-ray diffraction, the Bragg law, filters.  
[6]

#### Textbooks:

Modern Physics, Arthur Beiser, Tata McGraw-Hill Edition (2008)

Modern Physics, R. A. Serway, C. J. Moses & C. A. Moyer, Thomson books (2007).

#### Reference books:

Richtmeyer, Kennard, Cooper

## [6]

[6]

[5]

[6]

[7]

[6]

19

**IMC 3001 Maths III - Ordinary Differential Equations with Special Functions (3-1-0-4)**

**Module I**

**Differential Equations:** Linear Differential equation of 1st order. Differential Equations of first order and higher degree, Linear independence and dependence of functions. Higher order differential equations with constant coefficient, Rules of finding C.F. and P.I., Method of variation of parameter. Cauchy and Legendre's linear equations, Simultaneous linear equations with constant coefficients. [6]

**Module II**

Linear differential equations of second order with variable coefficients; Removal of first derivative (Normal form), Change of independent variable, Applications of higher order differential equations. [6]

**Module III**

Total Differential equations and conditions of integrability. Initial value problems, Existence and Uniqueness theorem. Series solution around an ordinary point and a regular singular point, the method of Frobenius. [6]

**Module IV & V**

**Special Functions:** Bessel, Legendre and Hypergeometric equations, Confluent Hypergeometric equation, Self adjoint eigen value problems, Green's functions, Second order boundary value problems, Sturm Liouville problems. [12]

**Module VI**

**Fourier Series:**

Periodic functions, Euler's formulae, Dirichlet's conditions, expansion of even and odd functions, half range Fourier series, Parseval's formula, complex form of Fourier series. [6]

**Text Book:**

1. Simmons G.F., Differential Equations with Applications and Historical Notes, TMH, 2nd ed., 1991.

**Reference Books:**

2. Dennis G. Zill, Warren S. Wright, Advanced Engineering Mathematics, 4<sup>th</sup> edition, Jones and Bartlett Publishers, 2010
3. Edwards & Penney, Differential Equations and Boundary value problems, Pearson Education, 3<sup>rd</sup> ed.
4. Shepley L. Ross, Differential Equations, Wiley India Pvt. Ltd, 3<sup>rd</sup> ed.
5. Birkhoff & Rota, Ordinary Differential Equations, Wiley India Pvt. Ltd., 4<sup>th</sup> ed.
6. Zill, Differential Equations, Thomson Learning, 5th ed., 2004

## CS JAVA Programming & Web Technology (3-0-2-4)

### MODULE – I

Introduction to Java Applications, Memory Concepts, Arithmetic, Decision making, Equality and Relational Operators. Introduction to Java Applets, Drawing strings and lines.

Control Statements: if, if ... else, selection statements, while statement, compound assignment operators, increment decrement operators, for ... statement, do.... While, switch, break and continue, labelled break and continue, logical operators.

Methods in java: declarations, argument promotions, scope of declarations, method overloading, Recursion.

Arrays: declaring and creating references and reference parameters, passing arrays to methods, multi dimensional arrays.

### MODULE – II

Object based programming, classes, class scope, controlling access to members, this keyword and its use, constructors, overloading constructors, composition, garbage collection, static class members, final instance variables, creating packages, package access, Data abstraction and encapsulation.

### MODULE – III

Inheritance and polymorphism: super class and subclass, protected members, Relation ship between super and sub class. Inheritance hierarchy, abstract classes and methods, final methods and classes, nested classes, Type wrappers.

### MODULE – IV

Exception handling, Java exception hierarchy, rethrowing an exception, finally clause, stacks unwinding, chained exception, declaring new exception types.

Multithreading: Life cycle of a thread, priorities and scheduling, creating and executing threads synchronization.

### MODULE – V

Files and streams, hierarchy, files and streams, File class, Sequential access file manipulation, random access file handling, Introduction to String class and its members.

### MODULE – VI

World Wide Web, Client / Server architecture, Web browser, Web server, creating a web site and mark up languages, HTML, document structuring tags in HTML, Special tags in HTML.

### MODULE – VII

Introduction to DHTML, scripting languages, java script: objects, methods, events & event handling, Document object model.

### Text Book:

1. Dietel,Dietel - Java How to program , 5<sup>th</sup> edition; Pearson Education , New Delhi.
2. S. Raj Kamal – Internet and Web Technology, Tata McGraw Hill, New Delhi, 2002.

### Reference:

1. C. Horstmann,G. Cornell - Core Java 2 Vol I & Vol II ; Pearson Education , New Delhi.
2. Balagurusamy -Programming in Java, 2<sup>nd</sup> Edition; Tata McGraw Hill Publication; New Delhi.
3. Patrick Naghton & H. Schildt – The Complete Reference Java 2, Tata McGraw Hill Publication, New Delhi.



PS 1301

Biological Sciences

(3-0-0-3)

Module I

**Cytology:** Plant cell & its structure, Mitosis & meiosis, Different types of plant tissues & their functions. (4)

Module II

**Genetics:** Mendelism, Chromosomal aberration, Polyploidy. (7)

Module III

**Morphology & Histology of different parts of the plants:** root, stem, bark, leaf, flower, fruit, and seed. (6)

Module IV

**Classification of plants:** in brief. (2)

Module V

**General survey of Animal Kingdom:** Structure and life history of parasites as illustrated by amoeba, entamoeba, trypanosoma, plasmodium, taenia, and ascaris.

**General Structure and Life History of Insects** (in relation to humans & medicinal crops): Mosquito, Housefly, Mites, Tse – Tse fly, Silkworm. (5)

Module VI

**General overview of Physiology and various terminologies used in physiology and pharmacology.** (5)

Module VII

**Cell & Tissue :** Structure of cell, its components and their functions, Mechanism of Transport through the Cell membrane. (5)

**Books Recommended:**

1. Dutta : “Text Book of Botany,”
2. Maheshwari : “Text Book of Botany,”
3. Gupta : “Genetics,”
4. Hess : “Plant Physiology,”
5. Trueman : “Elementary Biology,”
6. Vidharathi : “Text Book of Biology,”
7. Guyton & Hall: “Textbook of Medical Physiology,” WB Saunders Company,
8. Chatterjee: “Human Physiology,” Vols I & II, Medical Allied Agency, Calcutta,

**ISP 3002    Physics Lab – III (0-0-2-1.5)**

1. To study the force experienced by a current carrying conductor placed in a magnetic field (Lorentz force) using a mechanical balance.
2. Determination of boiling point of a liquid by platinum resistance thermometer.
3. Determination of wavelength of sodium yellow line by Newton's rings.
4. Determination of wavelength of mercury lines by diffraction grating.
5. To study polarization by reflection and determine Brewster's angle.
6. Determination of wavelength of sodium yellow line by Fresnel's Biprism
7. Michelson Interferometer with sodium vapour lamp.
8. To determine the slit width of a given aperture by laser diffraction method.

## Chemistry Lab-III (0-0-2-1.5)

1. Mixed melting point determination
  - a. Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)
2. Decolorisation and Crystallization using Charcoal
  - a. Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration.
  - b. Crystallization and decolorisation of impure naphthalene (100 g of naphthalene mixed with 0.3 g Congo Red using 1 g decolorizing carbone) from ethanol
3. Sublimation (Simple and Vacuum)  
Camphor, Naphtalene, Phthalic Acid and Succinic Acid
4. Qualitative Analysis
  - a. Element detection and Functional group determination (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and aniline) in simple organic compounds and mixture analysis.
5. Thin Layer Chromatography: Determination of R<sub>f</sub> values and identification of organic compounds.
  - a. Separation of green leaf pigments (spinach leaves may be used).
  - b. Preparation and separation of 2,4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2- and 3-one using toluene and light petroleum (40:60).
  - c. Separation of mixture of dyes using cyclohexane and ethyl acetate (8.5: 1.5)
6. One step organic synthesis:
  - a. R<sub>f</sub> determination, crystallization, melting point determination.
  - b. UV and IR spectroscopic analysis.

### Books Suggested:

1. Vogels Textbook of Practical Organic Chemistry
2. Experiments in General chemistry, C. N. R. Rao and U. C. Agarwal
3. Experimental Organic Chemistry Vol 1 and 2, P R Singh, D S gupta, K S Bajpai, Tata McGraw Hill
4. Laboratory Manual in Organic Chemistry, R. K. Bansal, Wiley.

## Co-curricular Activity (0-0-2-1)

**ISP 4001                      Physics IV - Modern Optics                      (3-0-0-3)**

**Physical Optics**

**Interference:** Conditions for sustained interference, Theory of interference, Two-Beam Interference, Interference in parallel and wedge shaped films, Achromatic fringes, Color of thin films. Newton's rings and Michelson interferometer and their applications. Multiple beam interference in parallel film and Fabry-Perot interferometer. [12]

**Diffraction:** Fresnel's diffraction, Zone plate, diffraction due to straight edge. Fraunhofer diffraction due to single and double slits, plane transmission grating and its resolving power. [6]

**Polarization :** Polarization of light, Malus's law, polarization by reflection, Brewster's law, Analysis of linearly and circularly polarized light, Polarization by double refraction and Huygen's theory, Nicol prism, Retardation plates, Optical activity and Fresnel's theory, Biquartz polarimeter [8]

**Lasers and Holography:**

Lasers: Einstein coefficients, Threshold condition for LASER action, Rate equation for three level laser system, Characteristics of laser radiation. He-Ne and Nd-YAG Laser.

Holography: Principle of holography, recording and reconstruction method and its theory as interference between two plane waves, Applications of Holography. [10]

**Textbooks:**

1. Jenkins and White ; Fundamentals of Optics
2. Ghatak; Optics

**Reference books:**

3. Hecht & Zajak; Optics
4. An introduction to Laser Theory and Application – M.N.Avdhanulu
5. Perspective of Modern Physics, A. Beiser (AB), Mc Graw Hill Int

## ISC Chemistry IV (3-0-0-3)

### Module I Phase Equilibrium

[6]

Statement and meaning of the terms – phase, component and degree of freedom, phase equilibria of one component system – water, phase equilibria of two component system – solid equilibria, simple eutectic – Pb-Ag system, desilverisation of lead.

### Module II Electrochemistry

[6]

Electrical transport, Migration of ions and Kohlrausch law, Arrhenius theory of electrolytic dissociation, Application of conductivity measurements, conductometric titrations. Types of reversible electrodes Electrode reactions, Nernst equation, derivation of cell E. M. F. and single electrode potential, standard hydrogen electrode – reference electrodes, electrochemical series and its significance. Electrolytic and Galvanic cells – reversible and irreversible cells. EMF of a cell and its measurement. Potentiometric titrations.

### Module III Coordination Compounds

[6]

Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes.

### Module IV Nuclear chemistry

[5]

Radioactivity: Characteristics of radioactive decay, Decay kinetics, types of decay,  $\alpha$ ,  $\beta$ ,  $\gamma$ - emissions, artificial radioactivity. Nuclear fission and fusion; Nuclear Reactors: Classification of reactors, reactor power, and application of radioactivity, nuclear waste Management.

### Module V Carboxylic Acids & its derivatives

[5]

Acidity of Carboxylic Acids, Effects of Substituent's on Acid Strength. Preparation and reactions of carboxylic acids. Hell-Volhard-Zelinsky reaction. Synthesis of acid chlorides, esters and amides. Reduction of carboxylic acids. Mechanism of decarboxylation, effect of heat and dehydrating agents, Mechanisms of esterification and hydrolysis (acidic and basic).

### Module VI Spectroscopic Characterization of Organic Molecules

[4]

Basic principles of UV-VIS and, FTIR, spectroscopy. Brief application of spectroscopic characterization of organic molecules.

### Module VII Biomolecules

[4]

Classifications and nomenclature of monosaccharides, Mechanism of osazone formation, Interconversion of glucose and fructose, formation of glycosides, Cyclic structure of D(+)-glucose, Mechanism of mutarotation, Classification, structure and stereochemistry of amino acids, isoelectric point, Brief introduction to peptide and proteins, Classical peptide synthesis, introduction and constituents of nucleic acids, the double helical structure of DNA.

### Books Recommended :

1. Modern Electrochemistry – Vol – I & II, by **J. O. M. Bockris & A. K. N. Reddy**, Plenum.
2. Organic Chemistry, F.A. Carey, McGraw-Hill Inc.
3. Organic Chemistry, Morrison and Boyd, Prentice Hall.
4. Concise Inorganic Chemistry by **J D Lee**, Amazon.
5. Comprehensive Co-ordination Chemistry by G. Wilkinson, R. D. Gillars & J. A. McCleverty, Pergamon
6. Principles of Bio-inorganic Chemistry by S. J. Lippard & J. M. Berg, University Science Books.

## IMC 4001 Maths IV - Integral Transform & Partial Differential Equations (3-1-0-4)

### Module I

**Laplace Transform** : Definition of Laplace Transform, Linearity property, condition for existence of Laplace Transform; First & Second Shifting properties, Laplace Transform of derivatives and integrals; Unit step functions, Dirac delta-function. Differentiation and Integration of transforms, Convolution Theorem, Inversion. Periodic functions. Evaluation of integrals by L.T., Solution of boundary value problems. [6]

### Module II

**Fourier Transform**: Fourier Integral formula, Fourier Transform, Fourier sine and cosine transforms. Linearity, Scaling, frequency shifting and time shifting properties. Self reciprocity of Fourier Transform. Convolution theorem. Application to boundary value problems. [6]

### Module III & IV

**Integral Equations**: Integral Equations: Basic concepts, Volterra integral equations, Relationship between linear differential equations and Volterra equations, Resolvent kernel, Method of successive approximations, Convolution type equations, Volterra equation of first kind, Abel's integral equation, Fredholm integral equations, Fredholm equations of the second kind, the method of Fredholm determinants, Iterated kernels, Integral equations with degenerate kernels, Introduction to Singular integral equations. [12]

### Module V & VI

**Partial Differential Equations**: Formation of P.D.E, Equations solvable by direct integration, Linear and non-linear equations of first order, Lagrange's equations, and Charpit's method, Homogeneous and non-homogeneous linear P.D.E. with constant coefficients, Rules for finding C.F. & P.I. Linear and quasi linear equations, Partial Differential Equations of second order with constant and variable coefficients, Classification and reduction of second order equations to canonical form, Cauchy's, Neumann and Dirichlet's problems, Solution of Laplace and Poisson's equations in two and three dimensions by variable separable method, Solution of wave equation and unsteady heat equation in homogeneous, non-homogeneous cases. [12]

### Text Books:

1. The use of integral Transforms -**I.N. Sneddon**, TATA McGraw-Hill
2. Elements of Partial Differential Equations-**I.N. Sneddon** -Dover Publications
3. Simmons G.F., Differential Equations with Applications and Historical Notes, TMH, 2nd ed., 1991.

### Reference Books:

4. Zill, Differential Equations, Thomson Learning, 5th ed., 2004
5. **F H Miller**, Partial Differential Equations -- J. Wiley & Sons, Inc.
6. **F H Miller**, Partial Differential Equations -- J. Wiley & Sons, Inc.

## **IHU Value Education, Human Rights and Legislative Procedure (3-0-0-3)**

### **Module I [7]**

Concept of value and value education: Social Values and Individual Attitudes, Work Ethics, Indian Vision of Humanism, Moral and Non-moral Valuation, Standards and Principles, Value Judgments.

### **Module II [5]**

Theories of value development: Rural Development in India, Co-operative Movement and Rural Development.

### **Module III [5]**

Human Rights, UN declaration, Role of various agencies in protection and promotion of rights.

### **Module IV [8]**

Indian Constitution: Philosophy of Constitution, Fundamental Rights and Fundamental Duties, Legislature, Executive, and Judiciary: Their Composition, Scope and Activities.

### **Module V [11]**

The Legislature: Function of Parliament, Constitution of Parliament, Composition of the Council of the States, Composition of the House of People, Speaker.

Legislative Procedure: Ordinary Bills, Money Bills, Private Member Bills; Drafting Bills; Moving the Bills, Debate, Voting, Approval of the President/Governor.

Vigilance: Lokpal and Functionaries

#### **Books:**

1. Value education and human rights: R.P.Shukla, Sarup & Sons.
2. Human Rights, Education, & Global Responsibilities, Vol 3, James Lynch, Celia Modgil, Sohan Modgil 1992, The Falmer press.
3. Human Rights, Volume 4: U.N. Gupta, Atlantic Publishers And Distributers
4. **Human rights:** an interdisciplinary approach, Michael Freeman, Wiley-Blackwell,

## ISP 4003      Solid State Physics (3-1-0-4)

**Crystal structure:** Lattice, Basis, Translational vectors, Primitive unit cell, Symmetry operations, Bravais lattices, SC, BCC and FCC structures, Packing fraction, Miller indices, Lattice planes and directions, Reciprocal lattice; Bragg's law and Bragg's Diffraction condition in direct and reciprocal lattice, Ewald's construction, Debye Scherer method, Analysis of cubic structure by powder method. [7]

**Crystal bonding:** Different types of bonding- ionic, covalent, metallic, van der Waals and hydrogen bonding; cohesive energy. [3]

**Lattice Vibrations:** Vibration modes of continuous medium; concept of Phonons; Lattice specific heat; Classical theory, Einstein's theory and Debye's theory of specific heat. [4]

**Free Electron Theory:** Classical free electron theory (Drude model) and its draw back; Quantum theory of free electrons: Schrodinger's wave equations and its applications in particle in box; Physical significance of wave function; Fermi energy, Fermi level, Fermi-Dirac distribution function and effect of temperature; Hall Effect, Origin of energy gap, Energy bands in Solids, Distinction between metal, semiconductor and insulator [7]

**Semiconductors** Introduction to Metal, Semiconductors and insulator; Types of semiconductors: intrinsic and extrinsic semiconductors; junction devices (diode, transistors, LED,). [4]

**Dielectrics:** Concepts of dielectrics, Dipole moment; Basic concepts and types of polarization, A.C. effects, Ferro-electricity, Piezo electricity, Ferro and piezo electric materials. [4]

**Magnetism:** Electron spin and magnetic moment; Origin of magnetism; Types of Magnetism: Dia-, para-, ferro-, ferri-, and antiferromagnetism; Langevin theory of Dia- and paramagnetism, Curie's law; Magnetic domains & hysteresis, Magnetic materials, Magnetic storage devices, Memory materials [4]

**Superconductivity:** Introduction, effect of magnetic field, Meissner effect, Isotope effect, Penetration depth (London Equations). [3]

### Text books:

1. Introduction to Solid State Physics:C. Kittel, Wiley Eastern ltd., New Delhi - 1988.
2. A. J. Dekker: Solid state Physics

### Reference books:

1. Solid State Electronics Engineering Materials, S. O. Pillai, Wiley Eastern ltd. New Delhi, 1992.
2. Solid State Physics: Ashcroft & Mermin



### **ISP 4002      Physics Lab IV      (0-0-2-1.5)**

1. Study of Hall affect.
2. To study variation of magnetic field along the axis of Helmholtz Galvanometer and to determine reduction factor.
3. Febry Perot Interferometer
4. Mach-Zhender Interferometer using a He-Ne laser.
5. Determination of Planck's constant by means of LED's
6. To draw the input and output characteristics of a p-n-p transistor.
7. Solar cell experiment.
8. Determination of Stefan's constant.

### **Chemistry Lab IV      (0-0-2-1.5)**

1. To determine the cell constant of a conductivity cell.
2. To determine the molar conductivity of weak mono – basic acid over a given range of concentration.
3. To determine Pka value of the given organic acid by **pH** measurement.
4. Determine  $\lambda_{\text{max}}$  for  $\text{KMnO}_4$  by colorimetric measurements
5. Determine the surface tension of a liquid by stalagmometer method
6. Determine the Viscosity of a given liquid by Oswald's Viscometer.
7. To study the distribution of benzoic acid between benzene and water at room temperature and hence show the molecular state of benzoic acid in benzene.
8. Determine the heat of neutralization of  $\text{HCl}$  by  $\text{NaOH}$ .
9. Study the hydrolysis of an ester in presence of  $\text{HCl}$ .

1. Findley's Practical Physical Chemistry, B. P. Levitt, Longman.

### **Co-curricular Activity      (0-0-2-1)**

**Semester-V**

**Physical Chemistry I**

**(Credit – 3-1-0)**

**Module I: Phase Equilibria**

Derivation of Gibbs Phase Rule, Phase equilibria of one component system of CO<sub>2</sub> & Sulfur, two component system of Bi–Cd. Solid solutions – compound formation with congruent m.pt. Mg–Zn & incongruent m.pt. (NaCl–H<sub>2</sub>O, Ferric chloride – water & copper sulfate water), Freezing mixtures, acetone-dry ice.

Liquid-liquid mixtures: ideal liquid mixtures, Raoult's and Henry's Law, Non Ideal systems, azeotropes, HCl–Water and ethanol–water systems. Partially miscible liquids–Phenol–water.

**Module II Electrochemistry**

Nernst distribution law – thermodynamic derivation, applications. Concentration cell, with and without transport, liquid junction potential, application of concentration cells, solubility product and activity coefficient, potentiometric titrations, definition of pH and pK<sub>a</sub>, determination of pH using Hydrogen, quinhydrone and glass electrodes by potentiometric methods. Buffers: Mechanism of buffer action, Henderson–Hasselbalch equation, hydrolysis of salts, corrosion: types, theories and methods of control.

**Module III Thermodynamics**

Third law, Nernst Heat theorem, statement and concept of residual entropy, evaluation absolute entropy from heat capacity data, Gibbs and Helmholtz functions, G & A functions as thermodynamic quantities, A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, variation of G & A with P, V & T.

Books recommended:

1. The Elements of Physical Chemistry, P. W. Atkins, Oxford
2. Physical Chemistry, G. M. Barrow, McGraw Hill
3. Physical Chemistry through problems: S. K. Dogra & S. Dogra, Wiley Eastern Ltd.

Corey House reactions and decarboxylation of carboxylic acids, Mechanism of free radical halogenation of alkanes, Cycloalkanes: Nomenclature, methods of preparations, chemical reactions, Bayer's strain theory and its limitations, Ring strain in cyclopropane and cyclobutanes, Theory of strain in rings. The case of cyclopropane ring: banana bonds.

Regio-selectivity: Saytzeff rule, Hoffmann elimination, physical properties and relative stabilities of alkenes. Chemical reactions of alkenes: hydroboration-oxidation, oxymercuration-reduction, Epoxidation, hydration, polymerization of alkenes, Substitution at the allylic and vinylic positions of alkenes. Cycloalkenes: conformation, synthesis, and chemical reactions. Dienes: nomenclature, isolated, conjugated and cumulated dienes: structure, method of formation, polymerization, chemical reaction-1,2 and 1,4 additions, diels-alder reaction. Alkynes: hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization

The aryl group, Aromatic nucleus and side chain, Side chain reactions of benzene derivatives, Birch reduction, Methods of formation and chemical reactions of alkylbenzenes, alkynylbenzenes and biphenyl.

Methods of formation alkyl halide, Mechanisms of nucleophilic substitution reactions of alkyl halides, substitution at the allylic and vinylic positions of alkenes, Mechanisms of elimination reactions of alkyl halides. Methods of formation of aryl halides, nuclear and side chain reactions. The addition-elimination and the elimination-addition, mechanisms of nucleophilic aromatic substitution reactions.

Monohydric alcohols: methods of formation (Grignard reagent), reduction of aldehydes, ketones, carboxylic acids and esters. Hydrogen bonding, Acidic nature, Reactions of alcohols. Dihydric alcohols: methods of formation, chemical reactions of vicinal glycols, oxidative cleavage  $[\text{Pb}(\text{OAc})_4$  and  $\text{HIO}_4$ ] and pinacol-pinacolone rearrangement. Trihydric alcohols: methods of formation, chemical reactions of glycerol.

Nomenclature, structure and bonding, Preparation of phenols, physical properties and acidic character, Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion, Reactions of phenols - electrophillic aromatic substitution, acylation and carboxylation, Mechanisms of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Hauben-Hoesch, Lederer-Manasse and Reimer-Tiemann reaction.

1. **Organic Chemistry**<sup>\*</sup>, I. L. Finar, Vol. I & II, 5th Edition (1975), Longman Ltd., New Delhi.
2. **Organic Chemistry**, Morrison and Boyd, Prentice Hall.
3. **Organic reaction and mechanism-structure and reactivity** by Jerry March
4. **Introduction to Organic Chemistry**, Streitwiesser, Hathcock and Kosover, Macmillan.
5. *A Guide Book to Mechanism in Organic Chemistry*<sup>\*</sup>, P. Sykes, Orient Longman Ltd.
6. **Fundamentals of Organic Chemistry**, Solomons, John Wiley.

**Semester-V**

**Organic Chemistry-II (Credit – 3-1-0)**

**Module I      Ethers and Epoxides**

Nomenclature and methods of formation, physical properties, Chemical reactions: cleavage and autoxidation, Zeisel's method. Synthesis of epoxides. Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

**Module II      Aldehydes and Ketones:**

Synthesis of aldehydes and ketones from acid chlorides, 1,3-dithianes, nitriles and carboxylic acids, Physical properties. Mechanism of nucleophilic additions to carbonyl group: Perkin and Knoevenagel condensations, Condensation with ammonia and its derivatives. Wittig reaction. Mannich reaction, Use of acetals as protecting group. Baeyer-Villiger oxidation, Meerwein-Ponndorf Verley, Clemmensen, and  $\text{NaBH}_4$  reductions, Halogenation of enolizable ketones, An introduction to  $\alpha$ ,  $\beta$  unsaturated aldehydes and ketones.

**Module III      Carboxylic acid and Derivatives**

Preparation and Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction, Mechanisms of esterification and hydrolysis (acidic and basic). Reduction of carboxylic acids, Mechanism of decarboxylation, effect of heat and dehydrating agents, methods of formation and chemical reactions of unsaturated monocarboxylic acids, Dicarboxylic acids, haloacids, hydroxy acids- Malic, tartaric & citric acid and acid anhydrides. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution.

**Module IV      Nitrogen Compounds**

Preparation and Chemical reactions of nitroalkanes and nitroarenes, Mechanisms of nucleophilic Substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid. Halonitroarenes: reactivity, structure and nomenclature, physical properties, Stereochemistry of amines. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds, Gabriel-Phthalamide reaction, Hoffmann bromamide reaction, Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid.

**Module V      Organometallic Compounds**

Organomagnesium compounds: the Grignard reagents-formation, structure and chemical reactions. Organolithium compounds: formation and chemical reactions.

**Module VI      Organosulphur Compounds**

Nomenclature, structural features, Methods of formation and chemical reactions of thiols, thioethers, sulphonamic acids, sulphonamides and sulphaguanidine

**Suggested Books:**

1. **Organic Chemistry**", I. L. Finar, Vol. I & II, Longman Ltd., New Delhi.
2. **Organic Chemistry**, Morrison and Boyd, Prentice Hall.
3. **Organic reaction and mechanism-structure and reactivity** by Jerry March
4. **Introduction to Organic Chemistry**, Streitwieser, Heathcock and Kosover, Macmillan.
5. **A Guide Book to Mechanism in Organic Chemistry**", P. Sykes, Orient Longman Ltd.
6. **Fundamentals of Organic Chemistry**, Solomons, John Wiley. **Organic Chemistry**, Jonathan Clayden, Nick Greeves, Stuart Warren, Peter Wothers, Oxford University Press, USA
7. **Organic Chemistry**, L.G. Wade Jr. Prentice Hall.
8. **Organic Chemistry**, Jonathan Clayden, Nick Greeves, Stuart Warren, Peter Wothers, Oxford University Press, USA
9. **Organic Chemistry**, L.G. Wade Jr. Prentice Hall.

**Semester-V**

**Inorganic Chemistry –I**

**Credit:3-1-0**

**Module I:** Atomic Structure : Idea of de Broglie matter waves. Heisenberg uncertainty principle. Schrödinger wave equation, significance of wave functions, Atomic orbitals. Quantum numbers. Aufbau and Pauli exclusion principles. Hund's multiplicity rule. Hydrogen atom: energy of orbitals, atomic spectra, P-fund, bracket series. Variation of orbital energies with atomic number and energy level diagram, electronic configuration of elements, effective nuclear charge and shielding; radial and angular wave functions and distribution curves, shape of s,p,d orbitals and their characteristics.

**Module II:** Multielectron systems: Quantum numbers and vectors, mutual inclination of electron orbits and resultant vectors, Russell-Saunders coupling, J-J coupling, ground states term symbols, microstates and derivation of Russell-Saunders terms:  $p^2$ ,  $d^2$  and  $pd$  configuration,

**Module III: Transition elements**

General group trends with special reference to electronic configuration, colour, variable valency, ability to form complexes, magnetic and catalytic properties, Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

**Module IV : Advance Electrochemistry**

Standard reduction potentials,  $E^\circ$ , relationship between  $E^\circ$ ,  $\Delta G^\circ$  and  $K$ , Formal Potential and its application: Effect of pH, complexation, solubility; Disproportionation and comproportionation reaction Redox stability in water: Frost-Ebsworth, Latimer and Pourbaix diagrams, applications of redox reactions to the extraction of elements from their ores: Ellingham diagrams.

**Module V: Chemistry of Non-aqueous Solvents**

Reactions in non-aqueous solvents with reference to liquid  $NH_3$ ,  $H_2SO_4$ , liquid HF,  $HSO_3F$ , liquid  $SO_2$ .  $N_2O_4$ ,  $PCl_5$ ,  $BrF_3$  superacids, ionic liquid: molten salts solvent systems, ionic liquid at ambient temperature; supercritical fluids: properties of supercritical fluids and their uses as solvents,

**Books Recommended:**

1. Basic Inorganic Chemistry by **F. A. Cotton & Wilkinson**, John Wiley
2. Inorganic Chemistry by **J. E. Huhey**, Harpes & Row
3. Comprehensive Co-ordination Chemistry by **G. Wilkinson, R. D. Gillars & J. A. Mccleverty**, Pergamon
4. Concise Inorganic Chemistry by **J D Lee**.

**Semester-V**

**Inorganic Chemistry –II**

**Credits :3-1-0**

**Module I:** Inorganic Rings, chains and cages

Catenation and Heterocatenation, Heterocyclic Ring System- Borazines, Phosphazines- Monomer and Polymer, S-N ring compounds, Homocyclic rings of S, Se and Te. Silicates minerals, Isopolyanions, Boranes: boron cage compounds-closo, nido, arachno, carboranes; cage compounds of S and P.

**Module II :** Coordination Chemistry

Bonding theories: Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of  $10 Dq$  ( $\Delta_o$ ), CFSE in weak and strong fields, pairing energies, factors effecting the magnitude of  $10 Dq$  ( $\Delta_o$ ,  $\Delta_t$ ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar coordination. Ligand field and MO Theories (Elementary idea only Chelate effect, polynuclear complexes.

**Module III:** Isomerism in coordination compounds

Stereoisomerism: geometrical and optical, Structural isomerism: coordination, ionization, hydrate, linkage.

**Module IV** Electronic spectra of coordination complexes

Types of electronic transitions, selection rule for d-d transitions, spectroscopic ground states. Explanation of electronic spectra on the basis of Orgel energy level diagrams. Spectrochemical series, nephelauxetic effect,

**Module V:** Reaction kinetics and mechanism

The trans effect, theories of trans effect, mechanism of trans effect, kinetics of substitution reactions in square planar complexes. Thermodynamic and kinetic stability including factors affecting them. Labile and inert complexes. Electron transfer reactions, Inner sphere, outer sphere, without breaking M-L bond.

**Books Recommended:**

1. Basic Inorganic Chemistry by **F. A. Cotton & Wilkinson**, John Wiley
2. Inorganic Chemistry by **J. E. Huhey**, Harpes & Row
3. Comprehensive Co-ordination Chemistry by **G. Wilkinson, R. D. Gillars & J. A. McCleverty**, Pergamon
4. Concise Inorganic Chemistry by **J D Lee**.

**Semester-V Inorganic Chemistry Lab: Credit:1.5 (0 -0-3)**

1. Volumetric analysis
  - (a) Determination of alkali content in antacid tablet using HCl.
  - (b) Estimation of ferrous and ferric by dichromate method.
  - (c) Complexometry (EDTA):  $\text{CaCO}_3$  and  $\text{MgCO}_3$  in mixture /  $\text{Mg}^{\text{II}}$  and  $\text{Zn}^{\text{II}}$  in mixture.
2. Gravimetric analysis:  
Analysis of Cu as  $\text{CuSCN}$
3. Synthesis and analysis
  - (a) Preparation of copper tetraammine complex,  $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$
  - (b) Preparation of cis and trans- bisoxalato diaquachromate(III) ion
  - (c) Preparation of sodium trioxalato ferrate (III),  $\text{Na}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$  and determination of its composition by permanganometry
4. Ion Exchange Method  
Separation and estimation of  $\text{Mg}(\text{II})$  and  $\text{Zn}(\text{II})$
5. Solvent extraction  
Separation and estimation of  $\text{Mg}(\text{II})$  and  $\text{Fe}(\text{II})$

**Books Recommended:**

1. Vogel's Textbook of Quantitative Chemistry.
2. Synthesis & characterization of Inorganic Compounds by W. L. Jolly, Prentice Hall.
3. Vogel's Text book of Macro & Semimicro Qualitative Analysis

**Semester-V                      Organic Chemistry Lab   Credits :1.5 (0-0-3)**

1. Steam Distillation
  - i. Naphthalene from its suspension in water
  - ii. Clove oil from cloves
  - iii. Separation of o- and p-nitrophenols
2. Column chromatography
  - i. Separation of fluorescein and methylene blue
  - ii. Separation of leaf pigments from spinach leaves
  - iii. Resolution of racemic mixture of mandelic acid
3. Qualitative Analysis
  - i. Analysis of an organic mixture containing two solid components using water,  $\text{NaHCO}_3$ ,  $\text{NaOH}$  for separation and preparation of suitable derivatives.
4. Synthesis of Organic Compounds
  - i. Acetylation of salicylic acid, aniline, glucose and hydroquinone. Benzoylation of aniline and phenol
  - ii. Aliphatic electrophilic substitution: Preparation of iodoform from ethanol and acetone
  - iii. Aromatic electrophilic substitution
    - a. Nitration: Preparation of m-dinitrobenzen, Preparation of p-nitroacetanilide
    - b. Halogenation: Preparation of p-bromoacetanilide, Preparation of 2,4,6-tribromophenol
  - iv. Diazotization/Coupling: Preparation of methyl orange and methyl red
  - v. Oxidation: Preparation of benzoic acid from toluene
  - vi. Reduction: Preparation of aniline from nitrobenzene, Preparation of m-nitroaniline from m-dinitrobenzene.
5. Multi-step organic synthesis:
  - i. Rf determination, crystallization, melting point determination.
  - ii. Characterization understanding through UV, IR and NMR spectroscopic analysis.

**Books Suggested:**

1. Vogels Textbook of Practical Organic Chemistry
2. Experiments in General chemistry, C. N. R. Rao and U. C. Agarwal
3. Experimental Organic Chemistry Vol 1 and 2, P R Singh, D S gupta, K S Bajpai, Tata McGraw Hill
4. Laboratory Manual in Organic Chemistry, R. K. Bansal, Wiley.



**Semester- VI**

**Physical Chemistry II**

**(Credit- 3-1-0)**

**I Elementary Quantum Mechanics**

Black – body radiation, Planck’s radiation law, photoelectric effect, heat capacity of solids, Bohr’s model of hydrogen atom (no derivation) and its defects, Compton effect. De Broglie hypothesis, the Heisenberg’s uncertainty principle, Sinusoidal wave equation, Hamiltonian operator, Schrodinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box. Schrodinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions. Molecular orbital theory, basic ideas- criteria for forming M.O, from A.O, construction of M.O’s by LCAO –  $H_2^+$  ion, calculation of energy levels from wave functions, physical picture of bonding and antibonding wave functions, concept of  $\sigma$ ,  $\sigma^*$ ,  $\pi$ ,  $\pi^*$  orbitals and their characteristics. Hybrid orbitals –  $sp$ ,  $sp^2$ ,  $sp^3$ , calculation of coefficients of A.O.’s used in these hybrid orbitals. Introduction to valence bond model of  $H_2$ , comparison of M.O. and V.B. models.

**II Spectroscopy**

Introduction: electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born- Oppenheimer approximation, degrees of freedom.

**Rotational Spectrum**

Diatomic molecules. Energy levels of a rigid rotor (semi- classical principles), selection rules, spectral intensity, distribution using population distribution (Maxell- Boltzmann distribution) determination of bond length, qualitative description of non- rigid rotor, isotope effect.

**Vibrational Spectrum**

Infrared spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.

Raman Spectrum: concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

**Books Recommended:**

1. The Elements of Physical Chemistry, P. W. Atkins, Oxford
2. Physical Chemistry, G. M.. Barrow, McGraw Hill
3. Physical Chemistry through problems: S. K. Dogra & S. Dogra, Wiley Eastern Ltd.

**Semester – VI**

**Physical Chemistry III**

**Credit 3-1-0**

**Module I : Electronic Spectrum**

Concept to potential energy curves for bonding and antibonding Molecular orbital, qualitative description of  $\sigma$  and  $n$  M.O., their energy levels and the respective transition.

**Module II : Photochemistry**

Interaction of radiation with matter, difference between thermal and photochemical process. Laws of photochemistry: Grothus – Drapper law, Stark – Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non – radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reaction – energy transfer processes (simple examples.)

**Module III: Physical Properties and Molecular Structure**

Optical activity, polarization – (Clausius – Mossotti equation), orientation of dipoles in an electric field, dipole moment, induced dipole moment, measurement of dipole moment temperature method and refractivity method, dipole moment and structure of molecules, magnetic properties – paramagnetism, diamagnetism and ferromagnetics.

**Module IV : Solutions, Dilute Solutions and Colligative Properties**

Ideal and non-ideal solutions, methods of expressing concentrations of solutions of solutions, activity and activity coefficient.

Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination. Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties.

Abnormal molar mass, degree of dissociation and association and association of solutes.

**Books Recommended:**

1. Physical Chemistry, R. A. Alberty, Wiley Eastern Ltd
2. The Elements of Physical Chemistry, P. W. Atkins, Oxford
3. Physical Chemistry, G. M.. Barrow, McGraw Hill

## Semester-VI

## Organic Chemistry-III (Credit – 3-1-0)

### Module I NMR Spectroscopy and Structure Determination

Nuclear magnetic resonance (NMR) spectroscopy:

Proton magnetic resonance ( $^1\text{H}$  NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of PMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone, Brief introduction to  $^{13}\text{C}$  NMR, Problems pertaining to the structure elucidation of simple organic compounds using UV, IR and NMR spectroscopic techniques. Gas Chromatography: Basic concepts

### Module II Photochemistry

Principles of photochemistry, photochemical reactions of carbonyl compounds and olefins, Paterno-Buchi Reaction, Norrish type-I and Norrish type-II reactions.

### Module III Heterocyclic Compounds

Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole. Introduction to condensed five and sixmembered heterocycles. Preparation and reactions of Indole, quinoline and isoquinoline with special reference to Fischer indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis. Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

### Module IV Organic synthesis via enolates

Acidity of  $\alpha$ -hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthesis using diethyl malonate and ethyl acetoacetate, Claisen condensation. Keto-enol tautomerism of ethyl acetoacetate, Alkylation of 1,3-dithianes. Alkylation and acylation of enamines

### Module V - Introductory Pericyclic Chemistry

Concerted reaction, Molecular orbital theory, LCAO methods, bonding and anti-bonding orbitals, orbital symmetry, correlation diagram for electrocyclic reactions, Diels-Alder reaction.

### Module VI Alkaloids & Terpens

Occurrence, importance, general structural features, Hofmann exhaustive methylation, structure and synthesis of nicotine and piperine. Terpenes: Occurrence, isolation, classification, Isoprene rule, structure and synthesis of citral, geraniol and  $\alpha$ -terpineol.

### Module VII Vitamins and Hormones

Chemical constitution and physiological functions of vitamins A, B2 (Riboflavin), C (Ascorbic acid); Thyroxin and estrone.

### Suggested Books:

1. **Organic Chemistry**, I. L. Finar, Vol. I & II, Longman Ltd., New Delhi.
2. **Organic Chemistry**, Morrison and Boyd, Prentice Hall.
3. **Organic reaction and mechanism-structure and reactivity** by Jerry March
4. **Introduction to Organic Chemistry**, Streitwieser, Heathcock and Kosover, Macmillan.
5. **A Guide Book to Mechanism in Organic Chemistry**, P. Sykes, Orient Longman Ltd.

**Semester-VI**

**Inorganic Chemistry -III**

**Credit: 4 (3-1-0)**

**Module I:** Lanthanides and actinides

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only). General features and chemistry of actinides, principles of separation of Np, Pu and Am from U. Trans-Uranium elements.

**Module II:** Magnetochemistry of coordination complexes

Definition of magnetic properties, types of magnetic bodies, two sources of paramagnetism: orbital and spin effects, Diamagnetism and Pascal's constant, methods of determining magnetic susceptibility, orbital contribution to magnetic moments, magnetic properties based on crystal field models: octahedral, tetrahedral, trigonal bipyramidal, square pyramidal, tetragonally distorted octahedral complexes, spin state equilibrium in octahedral stereochemistry: crossover region, Valence bond and crystal field interpretation of magnetic moments. Correlation of magnetic moment data and stereochemistry; anomalous magnetic moments.

**Module III:** Organometallic Chemistry

Definition and classification of organometallic compounds, EAN rule (18e and 16e), Preparation, properties, bonding and applications of alkyl and aryls of Li, Al, Hg, Sn, Ti. A brief account of metal-ethylenic complexes and homogeneous hydrogenation

**Module IV:** Metal carbonyls

Preparation, properties, structure and bonding of mononuclear carbonyls.  $\pi$ - acceptor behaviour of carbon monoxide, synergic effect (MO diagram of CO be refer for synergic effect refer to I R frequencies) Carbonylate anions, ferrocene and its reactions.

**Module V :** Bioinorganic Chemistry

Metal ions present in biological systems : classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump. Biochemistry of Mg and Ca Metalloenzyme oxaloacetate decarboxylase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb and As) reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Storage and transfers of iron.

**Books Recommended:**

1. Basic Inorganic Chemistry by **F. A. Cotton & Wilkinson**, John Wiley
2. Inorganic Chemistry by **J. E. Huhey**, Harpes & Row
3. Comprehensive Co-ordination Chemistry by **G. Wilkinson, R. D. Gillars & J. A. McCleverty**, Pergamon
4. Concise Inorganic Chemistry by **J D Lee**, Amazon.

## **IHU Foreign Language (German / French / etc) Language (2-0-1-3)**

### **A. AIMS AND OBJECTIVES**

1. Developing the following language skills:

LISTENING: To enable the learners to listen and understand the spoken German language which uses the elementary spoken structures.

SPEAKING: To enable the learners to speak and engage in simple dialogues in German.

READING SKILLS AND TEXTUAL COMPREHENSION: To enable the learners to read and understand the elementary texts in German.

WRITING: To enable the learners to write simple sentences and short paragraphs in German.

2. To enable the learners to manipulate the simple grammatical structures of the language and the most essential vocabulary.

3. To expose the learners to the culture of German speaking countries

### **D. Contents of the Syllabus**

1. Simple texts and interactions useful in daily life
2. Life and culture of Germany and German speaking countries
3. Describing the immediate environment and things of common interest.

### **E. Functional Grammar:**

1. Articles
2. Nouns and pronouns
3. Present tense
4. Position of verbs in different types of sentences
5. Direct and indirect objects
6. Interrogative sentences
7. Articles as pronouns
8. Internet sites for language skills
9. Geography of Germany and German speaking countries
10. Introduction to German culture (intercultural perspectives)

### **Books recommended :**

1. Tangram aktuell A 1 -1, Kursbuch, Arbeitsbuch, Glossar, Übungsheft und CD Lektion 1 - 4: Deutsch als Fremdsprache, Authors: Rosa-Maria Dallapiazza, Eduard von Jan, und Til Schönherr, Verlag: Hueber.
2. Tangram aktuell A1- 2, Kursbuch, Arbeitsbuch, Glossar, Übungsheft und CD, Lektion 5 - 8: Deutsch als Fremdsprache, Authors: Rosa-Maria Dallapiazza, Eduard von Jan, und Til Schönherr, Verlag: Hueber.
3. Cassel's Language Guides: German – **A Handbook of Grammar, Current usage and word power**

## VI Semester

### SAC 3003: Industrial Chemistry

Credits : 3(3-0-0)

**Introduction:** Unit dimension, basic chemical calculations, material balances involving chemical reactions, energy balances, Stoichiometric calculation involving various processes, basic idea about functioning of various industrial equipments like heat-exchangers, economizers, boilers, catalytic converters.

**Fuels and water:** Importance of Solid, liquid and gaseous fuels in industry, criteria for selection of a fuel, calorific value, determination of calorific values using various instrumentation techniques, combustion calculations, solid fuel: coal, carbonization of coal, manufacturing of metallurgical coke, liquid fuel: fractionation of petroleum, thermal and catalytic cracking, LPG, producer gas. Water: Hardness of water and its removal, alkalinity and pH, Boiler feed water quality and treatment procedures, dissolve oxygen and corrosion.

**Inorganic fine chemicals:** manufacturing of sulfuric acid, phosphoric acid, urea, caustic soda. High performance chemicals: hydrazine and boron hydride compounds.

**Pesticides and Pharmaceuticals:** BHC, 2, 4-D, Parathion, Penicillin

**Polymer:** Manufacturing and use of PVC, Rubber, Silicones, Polyamides, Polyesters.

**Metallurgical industry:** Iron, Aluminum and Copper

**Catalysts:** General properties of catalyst, Examples of some Inorganic and polymer catalysts, use in industry.

Pollution control aspect in industry, equipments / process used for control of SO<sub>x</sub>, fly ash, metal pollutants, organic pollutants; hazardous materials and safety aspects in industry.

### **References:**

1. Dryden's outlines of chemical technology for 21<sup>st</sup> century, 3<sup>rd</sup> edn. (2000) M. G. Rao, M. Sittig, East-west Press, New Delhi, ISBN-81-85938-79-2.
2. Stoichiometry, 3<sup>rd</sup> Edn. B. I. Bhatt, S. M. Vora, Tata McGraw Hill, New Delhi, (1999).
3. Elementary principles of chemical processes, 3<sup>rd</sup> Edn. R. M. Felder, R. W. Rousseau, John Wiley & Sons, Inc. (2000).

**Semester-VI**

**Physical Chemistry Lab**

**Credits:1.5(0-0-2)**

1. To study the saponification of ethyl acetate conductometrically.
2. To determine the Ionisation constant of a weak acid conductometrically.
3. To Titrate potentiometrically the given ferrous ammonium sulphate solution using  $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  as titrant and calculate redox potential of  $\text{Fe}^{+2}/\text{Fe}^{+3}$  system on the hydrogen scale.
4. To determine the specific rotation of a given optically active compound.
5. Determination of Molecular wt. Of a non-volatile solute by Rast Method/ Beckmann Method.
6. To verify Beer- Lambert Law for  $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  and determine the concentration of the given solution of the substance.
7. To determine the strength of the given acid conductometrically using Std. Alkali solution.
8. Investigate the adsorption of oxalic acid by activated charcoal and test the validity of Freundlich and Langmuir Isotherms.
9. Study the mutual solubility of Phenol and water at various temps and hence determine the CST.

**Books Recommended**

1. Findley's Practical Physical Chemistry, B. P. Levitt, Longman.

**SAC 3002: Industrial Chemistry Laboratory**

**Credits:1.5(0-0-2)**

**1. Water Quality monitoring**

i.Sampling & preservation

ii.Physical Examination- pH, electrical conductivity, turbidity, colour odour,TDS,TSS,TS,

iii.Chemical Characterization: Major cations & anions,minor cations & anions,Trace & toxic chemical constituents in water

iv.Biological Investigations:BOD/COD/TOC, E-coli count

**2. Air Quality Monitoring**

i.Suspended particulate matter in ambient air

ii.Flue gas analysis

iii.Primary & secondary gaseous pollutants sampling & analysis

**3. Soil Analysis:** Determination of soil pH conductivity and salinity soil, organic carbon, nitrogen and phosphorus, sodium & potassium, CEC available sulphur.

**4. Fuels :**

i.Proximate analysis of coal

ii.Ultimate (Elemental analysis of coal)

iii.Calorific value determination of solid fuel

iv. Calorific value determination of gaseous fuel

v.Petrographic studies

**5. Lubricants:**

i.Open & closed flash point determination

ii.Aniline /cloud/ pour point determination

iii.Viscosity & Viscosity index

iv.Carbon residue

**References:**

1. Practical Environmental Analysis by Miroslav Radojevic and Vladimir N.Bashkin, RSC.
2. Environmental Pollution Analysis by S. M. Khopker, New Age International Corporations
3. Vogel's Textbook of Quantitative Chemistry



**Semester-VII**

**Advanced Physical Chemistry SAC 1001: Credit: 4 (3-1-0)**

**1. Chemical Dynamics**

Methods of determining rate laws, temperature dependence of chemical reactions; elementary, consecutive and parallel reactions; steady state approximation; Collision theory, steric factor, treatment of unimolecular reactions. Transition state theory, comparison of results with Eyring and Arrhenius equations. Catalyst: Homogeneous catalysis and Michaelis-Menten kinetics; heterogeneous catalysis. General features of fast reaction, Study of kinetics by stopped flow technique, relaxation method, flash photolysis and magnetic resonance method.

**2. Surface Chemistry**

Adsorption: Langmuir and Freundlich adsorption isotherm, Gibbs Adsorption isotherm, BET equation, Micelles: Surface active agents, Classifications, micellization, hydrophobic interaction, CMC, Factors affecting the CMC surfaces, Counter ion binding, Thermodynamics of micellization-phase separation, solubilization, Micro-emulsion, Reverse micelles

**3. Electrochemistry**

Electrochemistry of solutions, Debye-Huckel theory for activity co-efficient of electrolytic solutions, Derivation of Debye-Huckel-Onsager equation, Thermodynamics of electrified interface equations, Polarography: Polarography theory, Ilkovic equations, Half wave potential and its significance, Introduction to corrosion, Homogeneous theory, Forms of corruptions, Corrosion monitoring and prevention method. Batteries, primary & secondary cell and Fuel cell.

**4. Photochemistry**

Laws of photochemistry, energy transfer in a photochemical process (Jablonski diagram), Quantum efficiency, combination of  $H_2$  and  $Br_2$ ,  $H_2$  and  $Cl_2$  (rate derivation included).

**5. Thermodynamics**

First law of thermodynamics, relation between  $C_p$  and  $C_v$ ; enthalpies of physical and chemical changes; temperature-dependence of enthalpies. Second law of thermodynamics, entropy, entropy of mixing, Maxwell's Relations and its applications and thermodynamic equations of state. Free energy, free energy mixing of gases and variation of free energy with temperature, pressure and volume (Gibbs-Helmholtz equations with its applications). Third law of thermodynamics and calculation of entropy, partial molar quantities, Gibbs-Duhem equation, equilibrium constant, temperature dependence of equilibrium constant, Fugacity.

**References:**

1. Physical Chemistry by **P. W. Atkins**, Elbs
2. Chemical Kinetics by **K. J. Laidler**, McGraw Hill.
3. Micelles Theoretical and Applied Aspects by **V. Moroi**, Plenum
4. Modern Electrochemistry – Vol – I & II, by **J. O. M. Bockris & A. K. N. Reddy**, Plenum.
5. Physical Chemistry Vol. 1-5, by K.L Kapoor
6. Physical Chemistry: A Molecular Approach by McQuarrie & Simon Viva Books

**SAC 1003:**

**Organic Reaction Mechanisms**

**Credit: 4 (3-1-0)**

### **1. Protecting Groups**

Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

### **2. Stereochemistry**

Conformation analysis of cycloalkanes, decalines, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding. Elements of symmetry, chirality, molecules with more than one chiral centre, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups & faces, stereospecific and stereoselective synthesis. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorous.

### **3. Reaction Mechanisms: Structure & Reactivity**

Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, Hammond's postulate, Curtin-Hammett principle, potential energy diagrams, transition states and intermediates. Hard & soft acids, Isotope effect, Mechanism of nucleophilic substitution ( $S_N1$  and  $S_N2$ ) and elimination ( $E1$  and  $E2$ ), pKa scale, Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes, Effect of structure on reactivity – resonance and field effects, steric effect. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft-equation.

### **4. Free radical reactions**

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead, Reactivity in the attacking radicals, the effect of solvents on reactivity. Oxidation of aldehydes to carboxylic acids, auto-oxidation, Sandmeyer reaction, freeradical rearrangement, Hunsdieker reaction.

### **5. Aromatic Electrophilic and Nucleophilic Substitution**

The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho / para ratio, ipso attack. Diazonium coupling, Vilsmeier reaction, Gattermann-Koch reaction, The  $S_NAr$ ,  $S_N1$ , benzyne and  $S_{RN}1$  mechanisms. Reactivity – effect of substrate structure, leaving group and attacking nucleophile. The Von Richter, Sommelet-Hauser, Smiles Rearrangement.

### **6. Pericyclic reactions**

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

#### **References:**

1. Stereochemistry of Organic Chemistry by **D. Nasipuri**, New Age International.
2. Advanced Organic Chemistry – Reactions, Mechanism and Structure by **Jerry March**, John Wiley
3. Pericyclic Reactions by **S. M. Mukherjee**, Macmillan, India.
4. Enzyme Chemistry: Impact and Applications, **Ed. Collin J Suckling**, Chapman & Hall.
5. Mechanisms and Theory in Organic Chemistry, T. H. Lowry and K. H. Richardson, Harper and Row.
6. Advanced Organic Chemistry, Part A: Structure and Mechanisms, F. A. Carey and R. J. Sundberg, Springer, New York 2006.

**Semester-VII**

**Metal Chemistry (SAC 1105) Credit: 4 (3-0-0)**

**Module I Chemical Bonding**

**5 Lectures**

Variation and LCAO methods, M.O. Theory of  $H_2$ ,  $H_2^+$ , homo and hetero-nuclear diatomic molecules of second period elements, Electron pair wave function, V.B. Theory and its application to  $H_2$ , hybrid orbitals, localized and delocalized M.O.,  $\sigma$ ,  $\pi$ ,  $\delta$  bonds, polyatomic molecules, electron deficient and hypervalent molecules.

**Module II Ligand Field Theory**

**8 Lectures**

The concept of a Ligand field, Qualitative demonstration of ligand field effect, The physical properties affected by ligand field theory (thermochemical properties & geometric distortion, spectral properties, magnetic properties), Crystal field & Ligand Fields.

Quantitative basis of Crystal Fields: Crystal Field Theory, The octahedral Crystal Field potential, The effect of  $V_{oct}$  on the d wavefunctions, the evaluation of  $\Delta$ , The tetrahedral and cubic potentials. Energy level of transition metal ions, Effect of ligands fields on the energy levels of transition metal ions.

**Module III Chemistry of Non-transition Elements:**

**6 Lectures**

General discussion on the properties of the nontransition elements; special features of individual elements; synthesis, properties and structure of their halides and oxides, polymorphism of carbon, phosphorus and sulphur. Synthesis, properties and structure of boranes, carboranes, borazines, silicates carbides, silicones, phosphazenes, sulphur –nitrogen compounds: peroxo compounds of boron, carbon and sulphur; oxy acids of nitrogen, phosphorus, sulphur and halogens, interhalogens pseudohalides and noble gas compounds.

**Module IV Reaction Mechanism of Transition Metal Complexes**

**8 Lectures**

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valency bond and crystal field theory, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, substitution reaction in square complexes, trans effect, redox reactions, electron transfer reactions, mechanism of one electron transfer reaction, outer sphere type reactions, inert sphere type reactions.

**Module V Electronic Spectra of transition metal complexes**

**8 Lectures**

Important features of transition metal electronic spectra- band intensities, band energies, band width and sets; characteristic spectra of complexes of first row transition metal ions, typical spectra of second & third row transition metal ions, Octahedral, tetrahedral and planar complexes of first row transition metal ions; spectrochemical & nephelauxetic series, charge transfer spectra. Spectroscopic ground state, Orgel and Tanabe – Sugano diagrams for transition metal complexes, calculations of  $D_q$ , B and beta parameters, Charge transfer spectra

**Reference Books**

1. Inorganic Chemistry – G. Wulfsberg
3. Physical Chemistry – D.A. Mcquarrie & J.D. Simon
4. Molecular Orbital Theory – C.J. Ballhausen & H.B. Gray
5. Ligand Field Theory – B.N. Figgis
6. Electronic Structure and Properties of transition metal compounds – I.B. Bersuker
7. Ligand Field Theory – C.J. Ballhausen
8. Electronic Absorption Spectroscopy – D.N. Satyanarayana
9. Inorganic Electronic Spectroscopy – A.B.P. Lever
10. Inorganic Reaction Mechanism – F. Basalo & R.G. Pearson
11. Inorganic Reaction Mechanism – R.B. Jordan

**Semester: VII**

**Environmental Chemistry SAC 1009**

**Credit: 3 (3-0-0)**

**1. Principles of Environmental Chemistry :**

Role, importance and scope of environmental chemistry, multidisciplinary nature Concept of an ecosystem, structure and function of an ecosystem, energy and nutrient flow, biogeochemical cycles, sources, pathways and fate of environmental pollutants-Environmental transformation & degradation processes

**2. Atmospheric Chemistry:**

Chemical composition of the earth's atmosphere, units for expressing atmospheric concentration

Various segments of atmosphere & their significance, sources and toxic effects of air pollutants, Stratospheric Chemistry- Ozone, formation & turnover of ozone, processes for catalytic decomposition of ozone, chlorofluorocarbons, arctic & Antarctic ozone hole formation.

Tropospheric Chemistry- Smog, Phototransformation, types of hydrocarbon in the troposphere, reaction of organic compounds in the atmosphere .Chemistry of photochemical smog, emissions from internal combustion engine and control measures , sulfurous smog & emissions from stationary sources and control measures

Tropospheric Chemistry – Precipitation .acid rains, sources & sinks.

Atmospheric Aerosols: Sources of aerosols, aerosol concentrations & life times, PM -2.5 & its significance, control of particulate emissions

The chemistry of global climate : energy balance & the earth's atmosphere, greenhouse gases & global warming

**3. Aquatic Chemistry**

The Hydrosphere: physical & chemical properties of water, concentration units used for aqueous solutions ,

Water resources, Chemistry of natural waters, physico-chemical properties of water, Water pollution: Deoxygenating substances, influence of chemical process on dissolved oxygen, sources of water pollution, various pollutants their detrimental effects.

Portability limits as per WHO & PHED specification, treatment of municipal supply water, slow sand filters, rapid sand filter, disinfections, their advantage & disadvantages, break point chlorination, Commonly used water purification techniques

**4. Soil Chemistry**

Soil formation: Physical weathering ,chemical weathering,Composition of soil, micro and macro nutrients,

Physical & chemical properties of soil. Sources and chemical nature of soil contaminants, Distribution of soil contaminants: Soil –water partition process, soil- organism processes, Ecological and health effects of soil contaminants.

**6.Chemistry of Solid wastes**

Sources, Classification and composition of MSW, Properties of MSW, MSW management, Waste minimization, Life cycle assessment, benefits, waste reduction techniques, Reuse and recycling, Biological MSW treatment, Thermal treatment, Landfill, Integrated waste management.

Radiation hazards: Types of radiation, sources, effects, control and disposal of nuclear waste.

**Books recommended:**

1. Environmental Chemistry : a global perspective,G.W.vanLoon, S.J. Duffy,Oxford publication
2. Practical Environmental Analysis by Miroslav Radojevic and Vladimir N. Bashkin, RSC.
3. An Introduction to Environmental Science & Engineering by Gilbert M. Masters.

**SAC 1002: Computational Chemistry Lab      Credit: 1.5 (1-0-2)**

**Object:** This syllabus is designed to provide a preliminary idea with experimentation about the Computational Chemistry/Molecular Modeling and their application.

1. Computer Fundamentals (Operating Systems e.g. MSDOS, Windows, LINUX).
2. Introduction and application about the computational chemistry & molecular modeling software.
3. Understanding of the chemical structure and physico-chemical properties using chemistry software "ChemOffice Ultra"
  - a) Draw a chemical structure and reactions with the example of organic and inorganic substances along with physical notations such as bonding, enthalpy, entropy, etc.
  - b) Concept, application and handling of 2D & 3D structure. Draw the structures of biological active molecules.
4. Understand the concept of stereochemistry and draw the stereochemical structure by using the example of nucleoside and amino acid.
5. Minimization of the chemical structure with the example of nucleoside.
6. Compute the structural and physico-chemical properties (e.g.; bond length, bond angle, dihedral angle, conformation, partial charge, steric energy, etc.) of the target molecule using ChemDraw Tools.

**Reference Books:**

1. Introduction to theory & application of molecular and quantum mechanics, Errol Lewars, (Springer)
2. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...  
by Charles Owens Wilson, John H. Block, Ole Gisvold, John Marlowe Beale

Semester: VII

SAC 1004:

Organic Chemistry Lab

Credit: 1.5 (0-0-3)

**A. Qualitative Analysis**

Identification of organic compounds (solid and liquid) using chemical analysis and preparation of their suitable derivatives

Separation, Purification and identification of compounds of binary / tertiary mixtures (one liquid and one solid) using TLC, Paper and Column chromatography, chemical tests, IR spectra.

**B. Organic Synthesis (any two)**

- i) Aldol Condensation
- ii) Sand Mayer Reaction
- iii) Acetoacetic ester condensation
- Cannizaro reaction

**C. Multistep Synthesis (any one)**

- i) Photochemical reaction – Benzophenone to Benzpinacol to Benzpinacolone
- ii) Beckmann Rearrangement – Benzanilidine from Benzene
- iii) Synthesis of heterocyclic compounds – Skraup Synthesis
- iv) Enzymatic synthesis – (a) Enzymatic reduction  
(b) Biosynthesis of ethanol from sucrose
- v) Synthesis of Binol from  $\beta$ -naphthol.

**D. Extraction of Organic compounds from natural sources (any two)**

- i) Isolation of caffeine from Tea leaves.
- ii) Isolation Casein from Milk
- iii) Isolation of Nicotine as dipicrate from tobacco.
- iv) Isolation of  $\beta$ -carotenes from carrots.

**E. Quantitative analysis (any two)**

- i) Determination of the percentage or number of hydroxyl groups in inorganic compounds by acetylation method.
- ii) Estimation of amines/phenols using bromate/bromite solution or Acylation method
- iii) Determination of iodine and saponification value of an oil sample.
- iv) Estimation of Glucose.
- v) Estimation of nitrogen by Kjeldahl analysis.
- vi) Estimation of carbonyl group using 2, 4 – DNP.

1. Vogel's Text book of Practical Organic Chemistry

2. Hand book of Organic Chemistry, Qualitative & Quantitative by H. Clark, Adward-Arnold

3. Systematic Qualitative Organic Analysis by H. Middleton, Adward-Arnold

**Semester-VIII SAC 2001:**

**Theoretical Chemistry Credit: 3-0-0**

**1. Quantum Chemistry**

Planck's quantum theory, wave – particle duality. Uncertainty Principle, operators and commutation relations; postulates of quantum mechanics and Schrodinger equation; free particle, particle in a box, degeneracy, harmonic oscillator, rigid rotator and the hydrogen atom, The variation method and perturbation theory: Application to the helium atom, antisymmetry and Exclusion Principle, Terms symbols and spectroscopic states. Born – Oppenheimer approximation, Hydrogen molecule ion. LCAO – MO and VB treatments of the hydrogen molecule; electron density, forces and their role in chemical binding. Hybridization and valence MOT of  $\text{H}_2\text{O}$ ,  $\text{NH}_3$  and  $\text{CH}_4$ . Huckel pi-electron theory and its applications to ethylene, butadiene and benzene. Idea of self-consistent field methods.

**2. Symmetry & Group theory**

Symmetry elements & symmetry operation, Definition of group, sub-group, relation between order of a finite group and its sub-group, classes, Point symmetry group, representation of groups by matrices, character of the representation, The great orthogonality theorem (without proof), its importance, character tables & their use.

**3. Statistical Thermodynamics**

Concept of distribution, Thermodynamic probability, Ensemble averaging, Canonical, grand canonical and micro canonical ensembles, Partition functions: Translational, rotational, Vibrational and electronic and calculation of thermodynamic properties, Applications Heat capacity behaviour of solids: Chemical Equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, Distribution law and applications to metals, Bose-Einstein statistics- distribution law and application to helium.

**4. Non-equilibrium thermodynamics**

Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for irreversible processes, non-equilibrium stationary states, electrokinetic phenomena, electric conduction, irreversible thermodynamics for biological systems, coupled reactions.

References:

1. Quantum Chemistry by **Ira. N. Levine**, Prentice Hall
2. Modern Quantum Chemistry by **N. S. Ostlund & A. Szabo**, McGraw Hill
3. Methods of Molecular Quantum Mechanics by **R. Mcweeny & B. T. Sutcliffe**, Academic Press
4. Density functional Theory of Atoms and Molecules by **R. G. Parr & W. Yang**, Oxford.
5. Theoretical Chemistry, S. Glasstone, ELBS
6. Symmetry and group theory, F. A. Cotton, Wiley.

**SAC 2003: Synthetic Organic Chemistry Credit: 4 (3-1-0)**

**Reagents of Synthetic Importance**

Principle, preparations, properties and applications of the following reagents in organic synthesis with Mechanistics details: Group – I & II metal organic compounds-Li, M, Hg, Cd, Zn & Ce compounds. Transition metals – Cu, Pd, Ni, Fe, Co, Rh, Cr & Ti compounds.

**Rearrangements** General Mechanistics considerations – nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwein, Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis

**Metalloenes, Nonbenzenoid Aromatics and Polycyclic Aromatic Compounds**

General considerations, synthesis and reactions of some representative compounds.

**Heterocyclic Chemistry**

Heterocyclic synthesis: Principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions. Benzo-Fused Five - Membered Heterocycles: Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes. Six Membered Heterocycles: Synthesis and reactions of pyrylium salts, pyrones, quinolizium and benzopyrylium salts, coumarins and chromones, diazines, triazines, tetrazenes and thiazines.

**Two group C-C disconnections**

Diels-Alder reaction, 1, 3-difunctionalised compounds,  $\alpha$ ,  $\beta$ -unsaturated carbonyl compounds, control in carbonyl condensation, 1, 5-difunctionalised compounds. Michael addition and Robinson annelation, Retrosynthetic analysis, Concept of umpolung Concept of synthetic efficiency: one pot, multi-step, multi-component and atom economical reactions.

**Ring synthesis**

Saturated heterocycles, synthesis of 3-, 4-, 5- and 6 membered rings, aromatic heterocycles in organic synthesis

**Synthesis of Some Complex Molecules**

Reserpine, Vitamin – D, Chlorophyll, Quinine, Morphine,  $\alpha$ -terpinol, Estrone, Biosynthesis of steroid

**References:**

1. Some modern methods of Organic Synthesis by **W. Carruthers**, Cambridge Univ. Press.
2. Advanced Organic Chemistry: Reactions, Mechanisms and Structure by **J. March**, Wiley.
3. Principles of Organic Synthesis by **R. Norman and J. M. Coxon**, Blackie Academia & Professional.
4. Modern Synthetic Reactions by **H. O. House and W. A. Benjamin**.
5. Organic Chemistry, Vol. 2, **I. L. Finar**, ELBS.
6. Natural Products: Chemistry and Biological Significance by **J. Mann, R. S. Davidson, J. B. Hobbs, D. V. Banthorpe and J. B. Harborne**, Longman, Essex.
7. Advanced Organic Chemistry, Part B: Reactions and Synthesis, F. A. Carey and R. J. Sundberg, Springer, New York 2006.



**SAC 2005: Advanced Analytical Techniques**

**Credit: 3 (3-0-0)**

**1. Scope of analytical sciences:**

Basic tools and operations, data handling and reliability of analytical tools, sampling and methodologies, introduction to Chemometrics, Review of the current and developing methods available for collection, assessment and storage of data generated from analytical equipment, GLP. Data Analysis: Types of errors, propagation of errors, accuracy and precision, least-squares analysis, average standard deviation.

**2. Atomic spectroscopy:**

Atomic absorption spectrophotometer: Theory, Instrumentation and applications in environmental sample analysis, back-ground correction, X-ray fluorescence spectroscopy.

**3. Thermoanalytical technique:**

Theory, instrumentation and applications of TGA, DTA, DSC.

**4. Electrochemical techniques:**

Electro-chemical instrumentation: coulometry, polarography, Cyclic voltametry: Theory, Instrumentation and applications in oxidation, reduction reactions, pulse technique and stripping voltametry

**5. An introduction to surface characterization techniques:**

SEM, XRD

**6. Principle and application of Chromatography:**

Classification of stationary and mobile phase, Principle of detection methods, Thin Layer Chromatography, HPTLC, Chromatography Paper Chromatography and Column Chromatography: Gravity, Flash and Vacuum, HPLC/UPLC, LC-MS/MS, Preparative Column Chromatography GC, GC-MS/MS, Gel Chromatography, GPC, Electrophoresis

**Reference Books**

1. Christian, G. D., Analytical Chemistry, 6<sup>th</sup> edition, John Wiley & Sons
2. Kealey, D. & Haines, P. J., Analytical Chemistry, Viva Books Pvt. Ltd.
3. Khopkar, S. M., Basic Concepts of Analytical Chemistry, 2<sup>nd</sup> edition, New Age Int. Pvt. Ltd.

**Semester-VIII                      Advanced Inorganic Chemistry (SAC 2011)    Credit: 4 (3-1-0)**

**Module I                      Magnetochemistry**

Definition of magnetic properties, Types of magnetic bodies, Experimental arrangements for the determination of magnetic susceptibility: Guoy method, Faraday method, Vibrating sample magnetometer, SQUID, NMR method; Diamagnetism in atoms and polynuclear systems, Pascals constant, Two sources of paramagnetism: Spin & Orbital effects, Spin orbit coupling, Lande interval rule, Energies of J levels, Curie equation, Curie & Curie – Weiss law, Temperature independent paramagnetism, Simplification & application of Van Vleck susceptibility equation, Magnetic behaviour of lanthanides & actinides, Low spin – high spin cross over, Anomalous magnetic moments, magnetic properties of binuclear and polynuclear complexes—ferromagnetism and anti-ferromagnetism

**Module II                      Nuclear Chemistry:**

Radioactive decay and equilibrium. Nuclear reactions; Q value, cross sections, types of reactions, Chemical effects of nuclear transformations; fission and fusion, fission products and fission yields. Radioactive techniques; tracer technique, neutron activation analysis, counting techniques such as G.M. ionization and proportional counter.

**Module III                      Crystal defects and Non-stoichiometry in solids:**

Perfect and Imperfect Crystals, intrinsic and extrinsic defects- Point defects, line and plane defects, Vacancies- Schottky and Frenkel defects. Thermodynamics of Schottky and Frenkel defects formation, Colour centres, Non-stoichiometry and defects.

**Module IV                      Electronic Properties & Band Theory in Solids:**

Evolution of band structure, Brillouin zone, Effective mass of electron, Occupation of bands by electrons, Intrinsic semiconductors, Concept of hole, Extrinsic semiconductors, Hall effect, Electrical conductivity of metals, alloys & semiconductors, Fermi levels in metals & semiconductors, Direct & indirect band gap semiconductors, Photo-conductivity, Properties of junctions: metal – metal, metal – semiconductor & semiconductor – semiconductor.

**Module V                      Solid State Reactions**

Thermal decomposition reactions - Type I, Type II, Polymorphism, Enantiotropy & Monotropy, Order-disorder transitions, Buerger's Classification, Polytypism, Sintering, Zone refining, Crystal growth, Growth from solutions, Flame fusion method, Vapour deposition technique, Chemical transport reaction, Growth by condensation.

**Reference Books**

1. Advanced Inorganic Chemistry: F. A. Cotton & Wilkinson
2. Inorganic Chemistry: J. E. Huhey
3. Comprehensive Co-ordination Chemistry : G. Wilkinson, R. D. Gillars & J. A. McCleverty
4. Concise Inorganic Chemistry: J D Lee, Amazon.
5. . Essentials of Nuclear Chemistry:H. J. Arnikar, 4th Edition Wiley Eastern (1987).
- 6.. Chemical Applications of Radioisotopes: H. J. M. Bowen. Buttler and Tanner (1969).
7. Introduction of Nuclear and Radiochemistry: G Friedlander, T. W. Kennedy, E. S. Macias and J. M. Miller, 3rd Edition, John Wiley (1981).
8. Elements of Magnetochemistry: R. L. Dutta, A. Syamal
9. Magnetochemistry: F.E. Mabbs and D.J. Machine
10. Introduction to Solids: LV Azaroff
11. Electronic Properties of Materials: R.E. Hummel

**SAC 2009: Environmental Monitoring & Control**

**Credit: 3 (3-0-0)**

**1. Ecology & Environment**

Basic concepts of ecology & ecosystem, Structure and function of an ecosystem, Energy & Nutrient flow, Segments of environment, Environmental factors, Environmental transformation and degradation processes.

**2. Air pollution monitoring and control**

Sampling and analysis of air pollutants, Units of pollutants, emission standards from industrial sources, control of air pollutants from mobile and stationary emission sources, Various control methods for particulate emission: gravitational settling chambers, cyclone separators, baghouse filters, electrostatic precipitators and wet scrubbers. Control of gaseous emissions, absorption by liquids, adsorption by solids, combustion. Control of Sox, NO<sub>x</sub>, CO, Hydrocarbons from mobile and stationary emission sources. Indoor air quality

**3. Water quality and control**

Municipal and industrial water quality, Drinking water standards-PHED and WHO, Sampling techniques and preservation of samples, Physical examination, chemical characterization and Biological investigation, Control measures: Primary, secondary and advanced treatments, Coagulation, flocculation, sedimentation, Industrial water treatment: softening, corrosion and scale prevention

**4. Soil pollution**

Soil Pollution: Analysis of micro and macro nutrients in soil, Trace element analysis, pesticide analysis

**5. Radiation, Noise and Odour: Measurement and control**

Radiation hazards: Types of radiation, sources, effects, control and disposal of nuclear waste. Noise: Sources of Noise, types of noise, noise measurement, mapping, Control measures-Anechoic chambers, Industrial noise abatement measures, Sources of odour, sampling, measurement

**6. Solid waste management**

Sources, Classification and composition of MSW, Properties of MSW, MSW management, Waste minimization, Life cycle assessment, benefits, waste reduction techniques, Reuse and recycling, Biological MSW treatment, Thermal treatment, Landfill, Integrated waste management, Case studies

**Books recommended:**

1. Environmental Pollution Control Engineering by C.S. Rao.
2. Practical Environmental Analysis by Miroslav Radojevic and Vladimir N. Bashkin, RSC.
3. Environmental Pollution Analysis by S. M. Khopker, New Age International Corporations.
4. An Introduction to Environmental Science & Engineering by Gilbert M. Masters.
5. Chemical analysis of ecological materials by S. E. Allen.

**SAC 2002: Inorganic Chemistry Lab Credit: 1.5 (0-0-3)**

**1. Qualitative Semi-microanalysis:**

Qualitative semi microanalysis of inorganic mixtures containing 6-8 radicals including interfering radicals and less common metal ions such as Mo, W, Ti, Zr, Th, V and U (Cationic/anionic form).

**2. Qualitative analysis of hematite** by  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$ .

**3. Quantitative analysis of alloys** (Brass or gun metal), steel using conventional chemical analysis and physical techniques.

**4. Qualitative analysis** of cement using conventional chemical analysis and physical techniques.

**5. Estimation of the following (ANY One)**

(a) Mg by EDTA method (b) Zn by potassium ferrocyanide (c) Ni by dimethyl glyoxime (DMG)  
(d) Manganese and steel by Sodium bismuthate method.

**6. Preparation of the following complexes and their studies (ANY ONE)** by IR, electronic spectra and Magnetic susceptibility measurement

(a) Hexamine cobaltic chloride (b) Sodium Nitroprusside (c) Potassium trioxalato chromate (d) Prussian Blue. (e) Nickel dimethyl glyoxime.

**7. Preparation of (ANY ONE) Co (III)/Cr (III) complexes**, their purification, molecular weight determination and elucidation of the structures.

- (a)  $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
- (b)  $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$
- (c)  $[\text{Cr}(\text{H}_2\text{O})_6]\text{NO}_3 \cdot \text{H}_2\text{O}$
- (d)  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot \text{H}_2\text{O}$

**8. Determination of Mn/Cr/V** in steel sample by spectrophotometric method.

**References:**

- 1. Vogel's Textbook of Quantitative Chemistry.
- 2. Synthesis & characterization of Inorganic Compounds by W. L. Jolly, Prentice Hall.
- 3. Vogel's Text book of Macro & Semi-micro Qualitative Analysis.

**SAC 2004: Physical Chemistry LAB**

**Credit: 1.5 (0-0-3)**

A. Error analysis and statistical data analysis

B. Adsorption: **(any two)**

- (i) to study surface tension-concentration relationship for solutions
- (ii) To study the adsorption of iodine from alcoholic solution of charcoal.
- (iii) To study the adsorption of acetic acid on charcoal

C. Chemical equilibrium : **(any one)**

- (i) Determination of congruent composition & temperature of a binary system – Phenol-water
- (ii) Determination of glass transition temperature of a given salt conductometrically
- (iii) To construct the phase diagram for a three component systems.
- (iv) to determine the equilibrium constant for the reaction  $KI + I_2 = KI_3$ .

D. Chemical Kinetics: **(any two)**

- (i) Determination of rate constant of saponification ethyl acetate by NaOH
- (ii) Determination of the effect of change of temperature, concentration of reactant and catalyst and ionic strength of the media on the velocity constant of hydrolysis of an ester
- (iii) Determination of the velocity constant of hydrolysis of an ester in micellar media.
- (iv) Determination of the rate constant for the oxidation of iodide ion by hydrogen peroxide, studying the kinetics as an iodine clock reaction
- (v) Oscillatory reaction: Chemical oscillation & pattern formation in B-Z system.

E. Electrochemistry:

Conductometry: **(any two)**

- I. Determination of velocity constant, order of reaction and energy of activation for saponification of ethyl acetate by NaOH conductometrically.
- II. Determination of solubility and solubility product of sparingly soluble salt conductometrically.
- III. Determination of the strength of strong and weak acids in a given mixture conductometrically.
- IV. Determination activity co-efficient of zinc ions in the solution of 0.002 M  $ZnSO_4$  using Debye-Huckel's limiting law.

Potentiometry-pH metry: **(any one)**

- I. Determination of strengths of halides in a mixture potentiometrically.
- II. Determination of valancy of mercurous **ions** potentiometrically. Determination of the strength of strong and **weak acids** in a given mixture using a potentiometer-pH meter.
- III. Determination of temperature dependence of e.m.f of a cell.

- (v) Acid-base titration in a non-aqueous media using a pH meter.
- (vi) Determination of transport number by Hittrof's method.

Cyclic voltametry: **(any one)**

- (i) To find the redox potential of the given sample using cyclic voltametry.

Polarography: **(one one)**

- (i) Determination of DO in aqueous solution of organic solvent

- (iii) Determination of half way potential of Cd & Zn

EMF:

- (iv) Determination of single electrode potential of  $\text{Cu}/\text{Cu}^{2+}$   
(v) Potentiometric titration of a redox system  
(vi) Determination of e.m.f of concentration cell.

F. Polarimetry: **(any one)**

- (i) Determination of rate constant for hydrolysis/inversion of sugar using a Polarimeter  
(ii) Enzyme kinetics-inversion of sucrose.

G. Spectroscopy: **(any one)**

- (i) Determination of  $\text{pK}_a$  of an indicator in aqueous and micellar medium  
(ii) Determination of Stoichiometry and stability constant of inorganic (ferric-salicylic acid) and organic (amine-iodine) complexes

H. Thermo chemistry: **(any one)**

- (i) to determine the enthalpy of neutralization of hydrochloric acid with NaOH  
(ii) Enthalpy of combustion of benzoic acid using DSC.

**References:**

1. Practical Physical chemistry, Ed. B. P. Lebitte, Longman
2. Practical Physical Chemistry by A. M. James & F. E. Prichard, Longman.

**Semester-IX Bio Inorganic & Organo -Metallic Chemistry SAC 3001 Credit: 4 (3-1-0)**

**Module I Basic Bio-inorganic Chemistry**

Elements of life, the natural selection of elements, metallo-biomolecules– enzymes and proteins, their differences, Metal ion storage and transport : Ferritin, metallothioneins, ceruloplasmin; Siderophores – enterobactin, transferrin; Natural Oxygen carriers : Hemoglobin, Hemocyanin, Hemerythrin– model compounds. Hydrolytic enzyme : Carboxypeptidase A, Redox enzyme : Blue Copper protein.

**Module II Model Systems in Bioinorganic Chemistry**

Oxygen

management : Super oxide dismutase, catalase, peroxidase, cytochrome P – 450. Chemistry of Vitamin B<sub>12</sub> , Iron – Sulphur proteins, Cytochrome, Nitrogenase- biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidences, other nitrogenase model systems, metal complexes in transmission of energy, chlorophylls, Photosystem I and II in cleavage of water- Model systems; Na<sup>+</sup> , K<sup>+</sup> pump, Ca<sup>2+</sup> transport, Hydrogenase.

**Module III Structure and bonding in Organometallic chemistry**

Introduction, Classical and non-classically bonded organometallic compounds, Metal-olefin complexes, Ziese's salt – modes of bonding, Non-conjugated and conjugated polenyl complexes and their bonding models specially allyl derivatives, Metal complexes of delocalized carbocycles, Metallocenes and metal arenes, Ferrocene, ruthenocene – structure and bonding , reactions. Multidecker compounds. Fluxional behavior of organometallic compounds. Transition metal carbene complexes, oxidative addition and migration ( Insertion reaction ) .

**Reference Books**

1. Bioinorganic Chemistry: Bertini, Gray, Lippard, Valentine
2. Bioinorganic Chemistry: A Second Short Course: Rosette M. Roat-malone
3. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide: Wolfgang Kaim, Brigitte Schwederski
4. The Structure & Properties of Materials – J. Wulff & Wiley, Vol – IV
5. Electronic Structure and Properties of transition metal compounds – I.B. Bersuk
6. The Organometallic Chemistry of the Transition Metals, 4<sup>th</sup> Edn.: Robert H Crabtree
7. Organometallic Chemistry: B- M. Bochmann (Oxford series)
8. Organometallic Chemistry: R. C. Mehrotra & A. Singh
9. Fluxanol Organometallic and Coordination compounds: Marcel Gielen, Rudolf Willem, Bernd Wrackmeyer

## VI Semester

### SAC 3003: Industrial Chemistry

Credits : 3(3-0-0)

**Introduction:** Unit dimension, basic chemical calculations, material balances involving chemical reactions, energy balances, Stoichiometric calculation involving various processes, basic idea about functioning of various industrial equipments like heat-exchangers, economizers, boilers, catalytic converters.

**Fuels and water:** Importance of Solid, liquid and gaseous fuels in industry, criteria for selection of a fuel, calorific value, determination of calorific values using various instrumentation techniques, combustion calculations, solid fuel: coal, carbonization of coal, manufacturing of metallurgical coke, liquid fuel: fractionation of petroleum, thermal and catalytic cracking, LPG, producer gas. Water: Hardness of water and its removal, alkalinity and pH, Boiler feed water quality and treatment procedures, dissolve oxygen and corrosion.

**Inorganic fine chemicals:** manufacturing of sulfuric acid, phosphoric acid, urea, caustic soda. High performance chemicals: hydrazine and boron hydride compounds.

**Pesticides and Pharmaceuticals:** BHC, 2, 4-D, Parathion, Penicillin

**Polymer:** Manufacturing and use of PVC, Rubber, Silicones, Polyamides, Polyesters.

**Metallurgical industry:** Iron, Aluminum and Copper

**Catalysts:** General properties of catalyst, Examples of some Inorganic and polymer catalysts, use in industry.

Pollution control aspect in industry, equipments / process used for control of SO<sub>x</sub>, fly ash, metal pollutants, organic pollutants; hazardous materials and safety aspects in industry.

### **References:**

1. Dryden's outlines of chemical technology for 21<sup>st</sup> century, 3<sup>rd</sup> edn. (2000) M. G. Rao, M. Sittig, East-west Press, New Delhi, ISBN-81-85938-79-2.
2. Stoichiometry, 3<sup>rd</sup> Edn. B. I. Bhatt, S. M. Vora, Tata McGraw Hill, New Delhi, (1999).
3. Elementary principles of chemical processes, 3<sup>rd</sup> Edn. R. M. Felder, R. W. Rousseau, John Wiley & Sons, Inc. (2000).



**SAC 3005-Advance Organic Chemistry**

**Credit : 4 (3-1-0)**

**1. Oxidation**

Alkyl Oxidation ( $\text{SeO}_2$ ,  $\text{CrO}_3$ ,  $\text{CrO}_2\text{Cl}_2$ , LTA, *t*-BuOOH, MCPBA), Alkene oxidation ( $\text{CrO}_2\text{Cl}_2$ , LTA,  $\text{PdCl}_2$ ,  $\text{HgSO}_4$ ,  $\text{KMnO}_4$ ,  $\text{OsO}_4$ , epoxidation), Carbonyl oxidation ( $\text{C}_6\text{H}_5\text{CO}_3\text{H}$ ,  $\text{RCO}_3\text{H}$ ,  $\text{CF}_3\text{CO}_3\text{H}$ ,  $\text{I}_2/\text{Py}$ ,  $\text{HIO}_4$ ), Alcohol oxidation ( $\text{CrO}_3$ , PCC, PDC, Des-Martin periodinane, IBX, NBS,  $\text{MnO}_2$ ,  $\text{AgNO}_3$ ,  $\text{Ag}_2\text{CO}_3$ ,  $\text{Ag}_2\text{O}$ ,  $\text{AgO}$ ), Nitro oxidation by  $\text{KMnO}_4$ , Amino oxidation ( $\text{KMnO}_4$ ,  $\text{H}_2\text{O}_2$ ,  $\text{MnO}_2$ , cyano ( $\text{H}_2\text{O}_2$ ), Oxidative bond cleavage ( $\text{KMnO}_4$ ,  $\text{NaIO}_4$  cat.  $\text{OsO}_4/\text{RuO}_4$ , Ozone, LTA), Dehydrogenation (DDQ, DDQ/ $\text{PbO}_2$ , LTA,  $\text{SeO}_2$ ).

**2. Reduction**

Catalytic hydrogenation and hydrogenolysis of various functional groups by  $\text{Pt}_2\text{O}$ , Pd/C, raney nickel, Homogeneous hydrogenation by transition metal complexes {Rh, Ru}, Metal hydrides {LiAlH<sub>4</sub>, alkoxyaluminate, DIBAL-H, NaBH<sub>4</sub>, NaBH<sub>3</sub>CN, LiBH<sub>4</sub>, Zn(BH<sub>4</sub>)<sub>2</sub>, NaBH<sub>4</sub>/CeCl<sub>3</sub>, alkoxy/alkyl borohydrides, super-hydride, selectrides, *n*-Bu<sub>3</sub>SnH}, dissolving metal {Li, Na in Liq. NH<sub>3</sub>, Zn/HCl or CH<sub>3</sub>COOH}, non-metallic reducing agent {hydrazine, Et<sub>3</sub>SiH, Ph<sub>2</sub>SiH<sub>2</sub>, formic acid}, Enzymatic and microbial reductions.

**3. Organic Photochemistry**

Singlet and triplet excited state, radiative and radiationless transition, potential energy surfaces, photoreduction, photoaddition, photorearrangement, photooxidation, aromatic substitution, photolysis (Norrish Type I), fragmentation (Norrish Type II), excimers and exciplexes, photochemistry of alkenes, carbonyl, aromatic compounds

**4. Asymmetric synthesis**

Preg's rule, Cram's rule, Karabatsos's rule, Felkin's rule and their application in organic synthesis, enzymatic and catalytic asymmetric synthesis, stereoselectivity in hydride reduction.

**5. Selected Name Reactions**

Sharpless asymmetric epoxidation and dihydroxylation, hydroxylations, Peterson's olefications, Robinson annelation, Barton reaction, Mukayama-aldol reaction, Evan's aldol reaction, Swern oxidation, Moffatt oxidation, Williamson ether synthesis, Prevost reaction, Oppenauer oxidation, Rosenmund reduction, Metathesis reactions, Wittig reaction, Click Reaction, McMurry olefination, Suzuki, Heck and Sonogashira coupling, Mitsunobu reaction, Nef reaction,

**Reference:**

1. Some modern methods of organic synthesis – W. Carruthers
2. Advanced organic chemistry – F. A. Carey and R. J. Sundberg
3. Principle of Organic Synthesis – R. O. C. Norman and J. M. Coxon
4. Named Organic reactions – T. Laue, A. Plagens
5. Organic reaction mechanism – V. K. Ahluwalia, R. K. Parashar
6. Organic synthesis- Michael B. Smith

**SAC 3004:      Advanced Characterization Lab      Credit : 1.5 (0-0-3)**

**I:      Examples of organic sample characterization by UV-VIS, IR, NMR, Mass, CHN, mp and single crystal diffraction techniques.**

**Experiment 1:** Synthesis and characterization of sugar intermediates using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.

**Experiment 2:** Synthesis of Nucleo-base analogs and characterization using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.

**Experiment 3:** Synthesis of Benzanilide and characterization using UV, IR, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), Mass, mp and CHN.

**II:      Examples of bimolecular and polymeric materials characterization using Intense Viscosity Measurement, Molecular Weight Determination and Distribution using GPC, Light Scattering Technique, FTIR, NMR, SEM, XRD**

**Experiment 1:** Determination of  $T_g$  and  $T_m$  of Polyvinyl chloride and methylmethacrylate polymer using TGA/DSC.

**Experiment 2:** Study of surface morphology of polymeric material /hybrid materials using XRD and SEM.

**Experiment 3:** Finding out molecular weight of PMMA using light-scattering/GPC.

**III:      Examples of inorganic sample characterization**

**Experiment 1:** Thermogravimetric analysis of  $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$

**Experiment 2:** Synthesis & characterization of Fluorescent Zn complexes by spectrofluoremeter.

**Experiment 3:** Study of surface morphology of inorganic materials using XRD and SEM.

### **List of Electives**

- 1. Modern Spectroscopy**
- 2. Polymeric Chemistry**
- 3. Medicinal Chemistry**
- 4. Computational Chemistry & drug design**
- 5. Environmental Toxicology**
- 6. Surface Chemistry**
- 7. Energy**
- 8. Fuel Chemistry**
- 9. Biomaterials**

## Elective

### SAC 1007: Modern Spectroscopy

Credit: 3 (3-0-0)

#### 1. Unifying Principles

Electromagnetic radiation, Interaction of electromagnetic radiation with matter-absorption, emission, transmission, reflection, refraction, dispersion, polarization and scattering, Uncertainty relation and natural line width & broadening, Transition probability, Time dependent perturbation theory, transition moments, selection rules, intensity of spectral lines, Born-Oppenheimer approximation, rotational, Vibrational and electronic energy level.

#### Microwave Spectroscopy

Classification of molecules, Rigid-rotor model, effect of isotopic substitution on transition frequency, intensities, non-rigid rotor, Stark effect, nuclear & electron spin interaction and effect of external field, Applications.

#### Vibrational Spectroscopy

Infrared Spectroscopy: Vibrational energies of diatomic molecule, zero point energy, force constant & bond strength, Morse potential energy diagram, Vibration, rotation spectroscopy, vibrations of polyatomic molecules, selection rules, normal modes of vibrations, Group frequencies, overtones, hot bands, factors affecting band positions and intensities, far IR region, Metal ligand vibration. Raman spectroscopy: Classical & quantum theories of Raman Effect, Pure rotational, Vibrational and Vibrational-rotational Raman spectra, selection rules, mutual exclusion principles.

#### Electronic Spectroscopy

Molecular spectroscopy: Energy levels, Molecular orbitals, electronic spectra of polyatomic molecules,

#### Magnetic Resonance Spectroscopy

Nuclear Magnetic Resonance Spectroscopy: Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurement, factors influencing chemical shifts, deshielding, spin-spin interaction, factors influencing coupling constant J, spin decoupling.

#### References:

1. Modern Spectroscopy by J. M. Hollas, John Wiley
2. Introduction to Molecular Spectroscopy by G. M. Barrow, McGraw Hill.
3. Basic Principles of Spectroscopy by R. Chang, McGraw Hill.
4. Applied Electron Spectroscopy for Chemical Analysis by H. Windawi & F. L. Ho, Wiley Interscience.
5. Organic Spectroscopy, W. Kemp, ELBS
6. Spectroscopic methods in Organic Chemistry, D. H. Williams and I. Fleming, McGraw Hill.
7. Molecular spectroscopy, C. N. Banwell, TMH publications.

## **Elective**

### **SAC 3007: Polymer Chemistry**

#### **1. Macromolecules**

Polymer, Types of polymers-electrically conducting, fire resistant, liquid crystal polymers, Molecular mass, number & mass average molecular mass, Molecular mass determination (Osmometry, Viscometry, Diffusion & Light scattering method), Sedimentation, Chain configuration of macromolecules, Calculation of average dimensions of various chain structures.

#### **2. Polymers:**

Importance of polymers, Basic concepts: monomers, repeat units, degree of polymerization, linear, branched and network polymers, classification of polymers, polymerization: condensation, addition and free radical chain-ionic and coordination and co-polymerization, polymerization conditions and polymer reactions; Kinetics & mechanism of polymerization in homogenous and heterogeneous systems.

#### **3. Polymer characterization:**

Polydispersion and molecular weight concept, number average, weight average and viscosity average molecular weights, polydispersity and molecular weight distribution, The practical significance of molecular weight, measurement of molecular weights, end group, viscosity, light scattering, osmotic and ultracentrifugation methods, analysis and testing of polymers, chemical analysis of polymers, spectroscopic methods, X-ray diffraction study, microscopy, Thermal analysis and physical testing-tensile strength, Fatigue, impact, tear resistance, hardness and adhesion resistances.

#### **4. Structure and properties:**

Morphology and order in crystalline polymer configurations of polymer chains, crystal structure of polymers, morphology of crystalline polymers, strain induced morphology, crystallization and melting, crystalline melting temperature  $T_m$ , effect of chain flexibility and steric factors, entropy and heat of fusion. The glass transition temperature  $T_g$ , relationship between  $T_m$  and  $T_g$ , effects of molecular weight, diluents, chemical structures, chain topology, branching and cross linking, property requirements and polymer utilization.

#### **5. Properties of commercial polymers:**

PE, PVC, Polyamides, Polyesters, Phenolic resins, epoxy resins, silicone polymers, Functional polymers, Fire-retarding polymers and electrically conducting polymers, biomedical polymers: contact lens, dental polymers, artificial hearts and skin materials

#### **References:**

1. Text book of polymer sciences, F. W. Billmeyer, Jr., Wiley
2. Polymer Sciences, V.R. Gowariker, N. V. Biswanathan, J. Sreedhar, Wiley-Eastern
3. Contemporary polymer chemistry, H. R. Alcock, F. W. Lambe, Prentice Hall
4. Physics and chemistry of polymers, J. M. G. Cowie, Blackie academic and professional.

## Elective

### SAC 3009 Medicinal Chemistry

#### 1. Bio-physicochemical properties

Acidity/Basicity, Solubility, Ionization, Hydrophobic properties, Hydrophilic properties, Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as  $K_i$ ,  $K_d$ ,  $LD_{50}$ ,  $EC_{50}$ ,  $IC_{50}$ ,  $CC_{50}$ , ADMET properties

#### 2. Structural properties

Isosterism, Bioisosterism, Nonclassical isosteres, Understanding of the 3D-structure along with bond length, bond angle and dihedral angle, Concept of Configuration and Conformation with examples, Concept of stereochemistry in terms of biological response with examples, Stereoselective receptors or enzymes such as muscarinic receptor, Stereochemically pure drug and racemates, Examples such as catecholamines, etc.

#### 3. Drug target understanding

Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist, Examples.

#### 4. Medicinal Chemistry of Therapeutic Agent

Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents such as Anti-infective agent, Antimalarials, Antibacterial, Antiviral, Anticancer, CNS acting drug, Adrenergic Agents, Cholinergic Drug, Diuretics, Cardiovascular, local anesthetic agent, Analgesic Agents, Histamine and Antihistamine agents

#### **Steroids, Prostaglandins, Enzyme, Hormone and Vitamins**

Biophysico-chemical properties, Steroid Hormone Receptors, Chemical Contraceptive agents, COX-2 inhibitors, Prostaglandins for Ophthalmic use, pharmaceutically important enzyme products such as Pancreatin, Trypsin, Insulin. Classification of vitamins with examples.

#### 5. Concept of rational drug design

Structure activity relationship, Drug-receptor understanding, Molecular modeling, Structure based drug design. QSAR. Brief discussion about the rational discovery of anti-influenza compound and anti-HIV compound.

### Reference Books:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...  
by Charles Owens Wilson, John H. Block, Ole Gisvold, John Marlowe Beale
2. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, W. O. Foye
3. Remington: The Science and Practice of Pharmacy Vol 1, Ed. 19 by Joseph Price Remington,  
Alfonso R. Gennaro.
4. **Burger's Medicinal Chemistry** by Manfred E. Wolff, Alfred **Burger**
5. **Burger's Medicinal Chemistry and Drug Discovery** by Alfred **Burger**, Donald J. Abraham.
6. The Organic Chemistry of Drug Design and Drug Action by Richard B. Silverman
7. Exploring QSAR: Fundamental and applications in Chemistry and Biology by Carowari Hansch  
and Albert Leo, ACS, Washington DC-1995.

## Elective

### SAC 3011 Supramolecular Chemistry

#### 1. Supramolecular Chemistry and X-ray Crystallography

Introductory concept of Supramolecular Chemistry, Methods for the understanding of supramolecular systems such as NMR and X-ray Crystallography, X-ray Crystallography, Single Crystal, Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structure analysis of crystals, Index reflection, Identification of unit cells, Space Group, Structure of simple lattices and X-ray intensities, Structure factor and its relation to intensity and electron density.

##### 1. Supramolecular Chemistry to understand Non-covalent interaction

Supramolecular assembly by Noncovalent interactions, Definition and examples of supramolecular system to understand noncovalent interaction such as weaker noncovalent interactions, hydrogen bonding, metal coordination, hydrophobic interactions, hydrophilic interaction, electrostatic interactions, van der Waals interactions, arene interactions,  $\pi \dots \pi$  interactions, C-H...  $\pi$  interaction, halogen interactions, cation...  $\pi$  interaction, and charge transfer interactions.

##### 2. Supramolecular Chemistry in Crystal engineering

Concept of the crystal packing, Building block of supramolecular chemistry, Self assembly of organic and inorganic system, Molecular network, Construction of the crystalline materials or new solids, Molecular folding, Interlocked molecular-architecture, Host-guest chemistry, Cavitands, Calixarenes, Cyclodextrin complex with fullerene, Metal-organic materials (benzo-15-crown-5 complex with calcium picrate and water), Gelators fibres and adhesives, Dendrimers, Catenanes, Rotaxanes, Nanomaterials, Novel liquid crystals.

##### 3. Supramolecular Chemistry in pharmaceutical development

Concept of polymorphism, Application of polymorphism to alter biophysico-chemical properties such as melting point, density, compressibility, solubility, stability, hardness, dissolution rates, dipole moment and bioavailability. Analytical techniques such as powder XRD, differential scanning calorimetry (DSC), thermal gravimetric analysis (TGA), hot stage microscopy (HSM), Thermogravimetric/*Infrared* analysis (*TG/IR*), TGMS, NIR, Far-IR, Raman Spectroscopy etc. to characterize the polymorphism. Concept of the co-crystal structure, Pharmaceutical cocrystals: co-crystal of an active pharmaceutical ingredient (API) with non-toxic chemicals.

##### 7. Supramolecular Chemistry in Drug Design

Molecular Recognition, Lock and key theory, Drug Receptor Interaction, Receptor ligand co-crystal study, Nanoparticles in the Drug Delivery System.

#### Books Required:

1. J. -M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, VCH, Weinheim, 1995.
2. *The Weak Hydrogen Bond in Structural Chemistry and Biology* by G. R. Desiraju and T. Steiner, Oxford University Press, Oxford, 1999: 528 pages.
3. *Crystal Design. Structure and Function* edited by G. R. Desiraju, Perspectives in Supramolecular Chemistry, 7, Wiley, Chichester, 2003: multi-author work with 9 chapters, 408 pages.
4. J. W. Steed and J. L. Atwood, Supramolecular Chemistry, John Wiley and Sons, New York,
5. Desiraju, G. R., Ed. *Perspectives in Supramolecular Chemistry*, Vol. 2: *Crystal Engineering and Molecular Recognition* Wiley: Chichester (1995).

**SAC 3013 Computational Chemistry and Drug Design**

**Credits:3(3-0-0)**

- Module 1: Introduction about the computational chemistry and molecular modeling, Coordinate systems, Concept of 2D and 3D structure, molecules, Surfaces, Molecular energetic profile, Brief idea about the computational software's for drawing, visualization and simulation of small and large molecules. Basic concept of Chemoinformatics, 3D-Structure file system and Databases.
- Module 2: Brief introduction about Quantum Mechanics & Molecular Mechanics, Molecular Orbital Theory, The Hartree-Fock method, ab-initio calculation, Semi-empirical methods, Huckel theory, Valence bond theories, Force Field, Geometrical Parameters, Non-covalent Parameters: understanding of electrostatic interactions, van der Waals interaction, Hydrogen bonding, hydrophobic interactions,; application of quantum mechanics and molecular mechanics in drug design.
- Module 3: Computer simulation methods: Minimization, Molecular dynamics, Monte Carlo Simulations, Simulated Annealing, Conformational Search and Conformational Analysis, Understanding of iterations, convergence, protocols and algorithm such as steepest descents, conjugate gradient etc.,
- Module 4 Quantitative Structure Activity Relationship (QSAR): Mathematical parameters or descriptors: Lipophilicity, Electronic and Steric factor, Mathematical Models based on physicochemical relations: Hammett equations, Taft Equation and Linear Free Energy Relationship (LFER), Hansch Equations and Hansch analysis, mixed approach, Other QSAR Approaches
- Module 5: Structure-Based Drug Design: Protein Structure preparation, Ligand structure preparation, Homology modeling, Molecular docking, Induced Fit Docking, Scoring
- Module 6 Drug like properties and its *in-silico* prediction: Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as  $K_i$ ,  $K_d$ ,  $LD_{50}$ ,  $EC_{50}$ ,  $IC_{50}$ ,  $CC_{50}$ , ADMET. Brief introduction about the computational software for the prediction of drug like properties.

**Books:**

1. Computational Chemistry, Introduction to Theory and Application of Molecular and Quantum Mechanics. By Errol Lewars, Springer
2. Molecular Modelling : Principle and Application, 2<sup>nd</sup> Ed. By Andrew R. Leach, Addison-Wesley Longman Ltd, (February 2001) ISBN: 0582382106.
3. Guidebook on Molecular Modeling in Drug Design, J. G. Vinter, Mark Gardner (Editor), CRC Press (May 1994) ISBN: 084937772.



## **Environmental Pollutant Analysis**

### **1. Basic concepts of Pollutant analysis**

Environmental Analysis, errors Sampling & preservation, Modern methods of pollution analysis- Spectroscopic, light scattering technique, molecular luminescence, Electroanalytical, radio analytical, separation techniques like adsorption, partition, ion exchange, HPLC, HPTLC, Solvent extraction

### **2. Air pollution monitoring and control**

Sampling and analysis of air pollutants, Units of pollutants, emission standards from industrial sources, control of air pollutants from mobile and stationary emission sources, Various control methods for particulate emission: gravitational settling chambers, cyclone separators, baghouse filters, electrostatic precipitators and wet scrubbers. Control of gaseous emissions, absorption by liquids, adsorption by solids, combustion. Control of Sox, NO<sub>x</sub>, CO, Hydrocarbons from mobile and stationary emission sources. Indoor air quality

### **3. Water quality and control**

Municipal and industrial water quality, Drinking water standards-PHED and WHO, Sampling techniques and preservation of samples, Physical examination, chemical characterization and Biological investigation,

Control measures: Primary, secondary and advanced treatments, Coagulation, flocculation, sedimentation,

Industrial water treatment: softening, corrosion and scale prevention

### **4. Soil pollution**

Soil Pollution: Analysis of micro and macro nutrients in soil, Trace element analysis, pesticide analysis

### **5. Radiation, Noise and Odour: Measurement and control**

Radiation hazards: Types of radiation, sources, effects, control and disposal of nuclear waste.

Noise: Sources of Noise, types of noise, noise measurement, mapping, Control measures-Anechoic chambers, Industrial noise abatement measures, Sources of odour, sampling, measurement

### **6. Solid waste management**

Sources, Classification and composition of MSW, Properties of MSW, MSW management, Waste minimization, Life cycle assessment, benefits, waste reduction techniques, Reuse and recycling, Biological MSW treatment, Thermal treatment, Landfill, Integrated waste management, Case studies

### **7. Environmental modeling**

Type of models: Conceptual, Physical, Mathematical and Computational Validation, verification, sensitivity analysis.

#### **Books recommended:**

1. Environmental Pollution Control Engineering by C.S. Rao.
2. Practical Environmental Analysis by Miroslav Radojevic and Vladimir N. Bashkin, RSC.
3. Environmental Pollution Analysis by S. M. Khopker, New Age International Corporations.
4. An Introduction to Environmental Science & Engineering by Gilbert M. Masters.
5. Chemical analysis of ecological materials by S. E. Allen.

## Elective

### **SAC -Chemistry of Environmental Pollutants (SAC 3015)**

#### **Module-I Principles of Environmental Chemistry**

Importance and Scope of environmental chemistry, Basic Properties of chemicals in the environment, States of matter in the environment, Nature of bonds and their influence on physical and chemical properties in the environment.

#### **Module-II Environmental Transformation and Degradation Processes**

Abiotic transformation and degradation: oxidation through combustion, Phototransformation, Hydrolysis, Biotransformation and Biodegradation: Microbial transformation, Types of microbial degradation, Kinetics of transformation and degradation.

#### **Module-III Environmental Toxicology**

Routes and Mechanisms of toxicant entry, Distribution of toxicants, Phases of Biotransformation, Excretion of toxicants, Classes of poisons based on effects, Measure of toxicity, Factors influencing toxicity, Bioassays, Alternative methods for toxicity assessment Ecotoxicological concepts, risk assessment process, exposure assessment, dose-response relationship

#### **Module IV Petroleum Hydrocarbons and Polyaromatic hydrocarbons**

Petroleum Hydrocarbons: Chemical nature of petroleum, various transformation Processes in the environment, Petroleum in aquatic organisms, Polychlorinated biphenyls and dioxines: sources of environmental contaminants, Physicochemical properties, environmental distribution and behaviour, toxicity, Polycyclic aromatic hydrocarbons: Sources, chemical nature, , mechanism of formation, Carcinogenicity and Toxicity, Effect on Human health

#### **Module V Organometallic Compounds, Soaps & Detergents**

Soaps and detergents: Surfactants, synthesis, Sorption and Bioaccumulation, Organometallic compounds: Sources, behaviour and nature of organomercury compounds, organotin compounds, organolead compounds and Organoarsenic compounds,

#### **Module VI Synthetic polymers and Pesticides**

Synthetic Polymers: Plastics, Elastomers and synthetic fibers, Combustion, Biodegradation, Photodegradation and recycling of synthetic polymers, Pesticides: Chlorinated hydrocarbon pesticides, organophosphate insecticides, carbamates, Pyrethrins and pyrethroids, Phenoxyacetic acid herbicides.

#### **Books Recommended**

1. Basic concepts of Environmental Chemistry : . W. Connell
2. Chemistry and Ecotoxicology of Pollution: D. W Connell and G. J Miller
3. Risk Assessment Methods: Approaches for assessing health and Environmental risks: VT Corvello and MW Morkhofer
4. Environmental Chemistry: Stanley E Mannahan

### **Atmospheric Chemistry and Climate Change (SAC 3019)**

#### **Module- I    Atmospheric chemistry overview**

Chemical composition of the Earth's Atmosphere, Atmospheric Aerosols and Clouds, Physical properties and structure of the troposphere and the stratosphere, Temperature profile, Different types of inversion, Concentration profiles, Atmospheric radiation and photochemistry

#### **Module-II Chemistry of the Troposphere**

Sources, Sinks and Transport, Oxidation and Transformation, Air Pollution, Primary and Secondary Pollutants, Tropospheric chemical cycles, Hydroxyl and chlorine radical, chemical cleansing, hydrocarbons in the troposphere

#### **Module-III Chemistry of the Stratosphere**

Atmospheric Chemistry of the Stratosphere – ozone cycle, depletion, Influence of trace constituents, Effect of ozone depletion on surface UV radiation, Polar ozone holes, Man's impact on stratosphere

#### **Module-IV Atmospheric Pollution**

Chemistry of oxides of Carbon, Nitrogen, Sulphur, Hydrocarbons and Particulate Matter, Photochemical Smog, Acid rain, Volatile organic compounds, Stationary and Mobile emission sources, Pollution Standard Index, Criterion Pollutants, Ambient Air Quality Standards

#### **Module-V Global Atmospheric Change**

Atmospheric stability, Adiabatic lapse rate, Radiation inversion, subsidence inversion, Global temperature, Energy balance, Radiative forcing, Carbon cycle and emissions from fossil fuels, Green House effect and Global warming Potential

#### **Module-VI Global initiatives**

Montreal, Kyoto Protocol and Copenhagen summit, Air pollution regulations: Domestic and International, Environmental disasters, Nuclear accidents, Frontier Areas in Atmospheric Chemistry

#### **Books Recommended:**

1. **Chemistry of Atmospheres: Richard P. Wayne**
2. **Introduction to Environmental Engineering: G.M. Masters**
3. **Environmental Chemistry: S.E Mannahan**
4. **Environmental Pollution Monitoring and Control: S.M. Khopkar**
5. **Atmospheric chemistry Fundamentals and Experimental Techniques: Finlayson- B.J Pitts and J.N. Pitts**

### Aquatic Chemistry (SAC 3017)

#### **Module- I Introduction to Hydrosphere**

Global water Resources, Hydrological cycle, Physical chemistry of sea water, Physical & chemical properties of water, Unusual properties of water, concentration & units used for aqueous solutions, Biochemical Processes

#### **Module-II Distribution of species in water**

Structure and interactions of water molecule, Dissociation of Water, Speciation, Distribution of species in aquatic systems, behaviour of solutes, Dissolution of salts, Oxidation-Reduction, pE/pH diagrams, Measurement of pE Gases in water: Gases that react with water, Gas-Liquid Equilibrium, Effect of ionization of dissolved gases, CO<sub>2</sub> dissolution, Alkalinity and Acidity

#### **Module-III Chemistry of Metals in Aqueous Systems**

Speciation of dissolved metals, metal ion buffers, metal oxides and hydroxides, Precipitation and Complexation, Redox reactions, Redox titration and geochemical redox sequence, Adsorption reactions

#### **Module-IV Water Pollution**

Water Pollutants, Metals, Pesticides and Pathogens, Nutrients, Eutrophication, Trace elements in water, Chemical speciation, Biochemical Oxygen demand, Effect of oxygen demanding waste in rivers, Aquifers, Hydraulic gradient, Darcy's law, Contaminant transport, Contaminants in ground water.

Municipal and waste water quality, Drinking water standards-PHED and WHO, Sampling techniques and preservation of samples, Physical examination, chemical characterization and Biological investigation, Control measures: Primary, secondary and advanced treatments, Coagulation, flocculation, sedimentation

#### **Module-V Industrial Water Pollution**

Industrial water: Specifications for industrial water , troubles in boiler water: scales & Sludge formation ,Priming & foaming ,caustic embrittlement, carry over, boiler corrosion, water treatment: softening, external treatment ,internal treatment ,Desalination of brackish water, reverse osmosis, ion exchange.

#### **Module-VI Water Resource Management:**

Water Conservation, Rain Water Harvesting, Water Shed Management, Water Pollution and Control Acts, Water Pollution and Public Health

#### **Books Recommended:**

1. **Water Chemistry: Mark M Benjamin**
2. **Environmental Chemistry: Stanley E Mannahan**
3. **Chemistry for Environmental Engineering: C N Sawyer, PL Mc Carthy, GF Parkin**
4. **Water in crisis: A guide to the world's fresh water Resources: Gleick P H**

### **Environmental Impact Assessment (SAC 3021)**

#### **Module-I**

Pollution Sources, Classification and their effect on environment air pollution

Air Pollution, Sampling and measurement

#### **Module-II**

Waste water sampling and analysis, instrumentation, Detailed procedure,

#### **Module-III**

Energy and environmental correlation, case studies on power plants, cement industry, iron and steel, chemical and refinery.

#### **Module-IV**

National environmental policy, methodology of environmental impact studies, methods of impact identification, Production and assessment of impacts on the air environment,

#### **Module-V**

Prediction and assessment of impacts on surface water, soil and ground water environment,

#### **Module-VI**

Socio economic environment, Evaluation alternatives, Public participation in environmental decision making

#### **Books Recommended:**

1. Risk Assessment Methods: Approaches for assessing health and Environmental risks: VT Corvello and MW Morkhofer
2. A Handbook of Environmental Chemistry: O. Hutzinger
3. Environmental Pollution Monitoring and Control: S.M. Khopkar

Elective

### **Electrodeics**

Electrified interface and electrodeics, thermodynamics and kinetics of electrochemical reaction, Butler-Volmer equation, Tafel plot.

Electrochemical techniques: Cyclic Voltammetry, chronocoulometry, chronoamperometry, pulse and squarewave voltammetry, hydrodynamic voltammetry and bulk electrolysis.

Types of electrode reactions-reversible, irreversible and quasi reversible, Electrode reaction with coupled homogeneous chemical reactions.

Spectroelectrochemistry of selected transition metal complexes.

### **Books:**

1. John O'M. Bockris, A.K.N. Reddy and M.G-Aldeco, Modern Electrochemistry, Fundamentals of electrodeics. Kluwer academic, 2000.
2. Allen J. Bard and L.R. Faulkner, Electrochemical methods, Wiley, 2001.