



# **Sir P. T. Sarvajani College of Science**

**Autonomous**

**Affiliated to Veer Narmad South Gujarat University, Surat**

**Re-Accredited 'A+' with CGPA 3.35**

**SYLLABUS**

**FOR**

**SEM I & II**

**Program: M. Sc.**

**Course: Organic Chemistry**

**For**

**Academic year**

**2024-25**

**(NEP-2020)**

**(To be effective from June, 2024)**



## Board of Studies in Chemistry

Undergraduate and Post graduate

	Name	Designation	Institute/Industry
<b>Head of the Department</b>			
1	Dr. Mahendrasinh B. Mahida	Chairman	Sir P. T. Sarvajanik College of Science
<b>Subject Expert nominated by Vice-Chancellor</b>			
1	Dr. Kishor. H. Chikhaliya	Professor	Department of Chemistry, VNSGU Surat
<b>Representative from Industry/corporate sector/allied area</b>			
1	Dr. Yogen Talia	Technical Director	Veer Pharmachem, Bharuch
<b>Meritorious Alumnus</b>			
1	Mr. Ketan Desai	Proprietor	Primer Dye Chem
<b>Two experts from other than the parent University</b>			
1	Dr. Shushilkumar Dhanmane	Associate Professor	Fergusson College (Autonomous), Pune
2	Dr. Harichandra Parbat	Associate Professor & Head	Wilson College (Autonomous), Mumbai
<b>Faculty of the specialisation</b>			
1	Dr. Mahendrasinh B. Mahida	Associate Professor	Sir P. T. Sarvajanik College of Science
2	Dr. Sandeep A. Joshi	Associate Professor	Sir P. T. Sarvajanik College of Science
3	Dr. Hemlata D. Desai	Associate Professor	Sir P. T. Sarvajanik College of Science
4	Dr. Ketan C. Desai	Associate Professor	Sir P. T. Sarvajanik College of Science
5	Dr. Hetalkumar B. Gajjar	Associate Professor	Sir P. T. Sarvajanik College of Science
6	Dr. Sambhav P. Vora	Associate Professor	Sir P. T. Sarvajanik College of Science
7	Dr. Mukesh H. Chaudhari	Associate Professor	Sir P. T. Sarvajanik College of Science
8	Dr. Bhavesh M. Patel	Assistant Professor	Sir P. T. Sarvajanik College of Science
9	Dr. Ketan C. Parmar	Assistant Professor	Sir P. T. Sarvajanik College of Science
10	Dr. Nimesh R. Kamdar	Assistant Professor	Sir P. T. Sarvajanik College of Science



11	Dr. Sutapa Mondal Roy	Adhyapak Sahayak	Sir P. T. Sarvajanik College of Science
12	Dr. Ishanki Bhardwaj	Adhyapak Sahayak	Sir P. T. Sarvajanik College of Science
13	Dr. Amitkumar C. Purohit	Adhyapak Sahayak	Sir P. T. Sarvajanik College of Science
14	Dr. Chiragkumar B. Mistry	Adhyapak Sahayak	Sir P. T. Sarvajanik College of Science
15	Dr. Mimanshaben P. Mali	Adhyapak Sahayak	Sir P. T. Sarvajanik College of Science



## Acknowledgement

At the outset, I would like to thank our, Principal Dr. Pruthul R. Desai for his guidance and support during the curriculum restructuring process. I am also grateful to all the esteemed members of the Board of Studies, for their constructive suggestions and contributions.

Above all, I am deeply indebted to all the young and vibrant colleagues in the Department of chemistry for the long and arduous work they have put in during the compiling of the restructured syllabus.

**Dr. Mahendrasinh B. Mahida**  
**Chairperson**  
**Board of Studies in Chemistry**



## Graduate Attributes (GA)

After the successful completion of modules in different courses of M. Sc., the learner will be able to:

- Demonstrate comprehensive knowledge and understanding of major concepts, theoretical principles and experimental findings in related fields of study, including broader interdisciplinary subfields.
- Enhance the knowledge to become master in specific branch of science and also to be able to communicate effectively within and across disciplinary lines.
- Employ critical thinking and efficient problem-solving skills in the basic areas of chemistry.
- Understand and adopt the best safety practices in chemical laboratory works and in research.
- Ask relevant/Appropriate questions relating to issues and problems in the specific field of science, and plan, execute and report the results of an experiment or investigation.
- Work effectively in diverse teams in both classroom, laboratory and in industry and field-based situations.
- Identify appropriate resources required for a project, and manage a project through to completion, while observing responsible and ethical scientific conduct; and safety and chemical hygiene regulations and practices.
- Participate in scientific discussions showing proper knowledge and lead interdisciplinary works with experts from other fields.
- Develop ability for employment in public sector, private sector and national laboratories.
- Built up entrepreneurship ability by taking advantage of industrial hub in periphery of our college for the betterment of our society.



### **Programme Specific Outcomes (PSO)**

After the successful completion of modules in different courses of M. Sc. ORGANIC CHEMISTRY, the learner will be able to:

<b>PSO1</b>	Define and explain the fundamental concepts in Inorganic, Organic, Physical, and Analytical Chemistry as well as advanced concepts of Organic Chemistry.
<b>PSO2</b>	Correlate and apply the theoretical chemistry knowledge in explaining practical schemes (examples), research-based problems.
<b>PSO3</b>	Solve numerical problems, mechanisms, analytical interpretation using chemistry concepts and knowledge.
<b>PSO4</b>	Synthesize, separate and characterize inorganic and organic compounds and complexes using laboratory and instrumental techniques.
<b>PSO5</b>	Analyze chemical species (both organic and inorganic) qualitatively and quantitatively using appropriate analytical techniques.
<b>PSO6</b>	Apply knowledge in classical laboratory techniques and be able to use modern instrumentation, to perform new experiments, obtain experimental data and its interpretation through theoretical principals.
<b>PSO7</b>	Develop analytical thinking and apply the same for the understanding of underlining principles, proposing mechanism, problem solving, and arriving to logical conclusion
<b>PSO8</b>	Access, search and review the chemical literature to integrate knowledge learned in Chemistry to various Industry and Pharmaceutical needs.
<b>PSO9</b>	Design and analyze research problem related to novel research areas of interest and accordingly plan the methodology for execution
<b>PSO10</b>	Develop time management, confidence, and leadership skills to achieve the goals in competitive examinations for higher learning courses in chemistry.
<b>PSO11</b>	Apply the knowledge in chemistry for the social responsibility in educating general public about protection of environment against pollution.



## Course Content

Sr. No	Semester	Course number	Course Code	Course title
<b>COURSES THEORY &amp; PRACTICAL</b>				
1	<b>I</b>	Core Course 1	CC101	Inorganic Chemistry
2		Core Course 2	CC102	Organic Chemistry
3		Core Course 3	CC103	Physical Chemistry
4		Elective Course 1	EC101 OR EC102	Analytical Chemistry-I OR Analytical Chemistry-II
5		Skill Enhancement Course 1	SEC101	Solution and Safety
6		Practical CC1	PCC101	Practical Inorganic Chemistry
7		Practical CC2	PCC102	Practical Organic Chemistry
8		Practical CC3	PCC103	Practical Physical Chemistry
1	<b>II</b>	Core Course 1	CC201	Inorganic Chemistry
2		Core Course 2	CC202	Organic Chemistry
3		Core Course 3	CC203	Physical Chemistry
4		Elective Course 2	EC201 OR EC202	Analytical Chemistry-III OR Analytical Chemistry-IV
5		Skill Enhancement Course 1	SEC201	Perfumes and Cosmetics
6		Practical CC1	PCC201	Practical Inorganic Chemistry
7		Practical CC2	PCC202	Practical Organic Chemistry
8		Practical CC3	PCC203	Practical Physical Chemistry

### Credit Framework of M.Sc. (Organic Chemistry) Sem- 1 & 2 Syllabus

Semester	Core Courses	Elective Course	SEC	Total Credit
1	18	4	2	24
2	18	4	2	24
Total				48



## Distribution of Credit M. Sc. Organic Chemistry Syllabus

M. Sc. 1<sup>st</sup> Year Syllabus with effect from the Academic year June, 2024-25

Course No.	Course Title	Course Code	Credits	Hour	Module	Lectures per module (1 Hr)	Examination		
							Internal Marks	External Marks	Total Marks
<b>SEMESTER I</b>									
<b>Major Courses THEORY and PRACTICAL</b>									
CC 1	Inorganic Chemistry	CC101	4	60	4	15	30	70	100
CC 2	Organic Chemistry	CC102	4	60	4	15	30	70	100
CC 3	Physical Chemistry	CC103	4	60	4	15	30	70	100
EC 1	Analytical Chemistry I OR Analytical Chemistry II	EC101 OR EC102	4	60	4	15	30	70	100
SEC 1	Solution and Safety	SEC101	2	30	2	15	20	30	50
PCC1	Practical Inorganic Chemistry	PCC101	2	4	-	-	20	50	200
PCC2	Practical Organic Chemistry	PCC102	2	4	-	-	20	50	
PCC3	Practical Physical Chemistry	PCC103	2	4	-	-	20	40	
<b>SEMESTER II</b>									
<b>Major courses THEORY and PRACTICAL</b>									
CC 1	Inorganic Chemistry	CC201	4	60	4	15	30	70	100
CC 2	Organic Chemistry	CC202	4	60	4	15	30	70	100
CC 3	Physical Chemistry	CC203	4	60	4	15	30	70	100
EC 1	Analytical Chemistry III OR Analytical Chemistry IV	EC201 OR EC202	4	60	4	15	30	70	100
SEC 1	Perfumes and Cosmetics	SEC201	2	30	2	15	20	30	50
PCC1	Practical Inorganic Chemistry	PCC201	2	4	-	-	20	50	200
PCC2	Practical Organic Chemistry	PCC202	2	4	-	-	20	50	
PCC3	Practical Physical Chemistry	PCC203	2	4	-	-	20	40	

Medium of Instruction: English



## M. Sc. (CHEMISTRY) SEMESTER I

### Core Course-I

### COURSE TITLE: INORGANIC CHEMISTRY

### COURSE CODE: CC101 [CREDITS - 04]

#### Course Learning Outcome

After the successful completion of the course, the learner will be able to:

1. Explain the of matrices and vectors matrix notations, reducible representation, evaluate their relation, solve problems involving applications of group theory.
2. Describe quantum mechanics, angular momentum, understanding the solution of Schrodinger equation, solve problems involving different types of operators and evaluate their uses.
3. Discuss different types of inorganic reaction mechanism, differentiate between acid hydrolysis & base hydrolysis. conjugate base mechanism, solve problems involving their synthetic application.
4. Write the introduction and classification of metal clusters, evaluate electron counting scheme for HNCCs and Wade's rule and their synthetic application , solve problems involving Wade's rule.

#### Module 1

#### MOLECULAR SYMMETRY AND GROUP THEORY

[15L]

#### Learning Objectives:

This module is intended to

- Acquaint the students with the knowledge of Symmetry operations and Group theory.

#### Learning Outcome:

After the successful completion of the module, the learner will be able to

- Define and characterize the matrices and vectors matrix notations, reducible representation, evaluate their relation, explain matrix operations
- Solve problems involving applications of group theory.

#### 1.1

#### Molecular Symmetry and Group Theory:

Recapitulation of point groups, Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules, Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups,

- a) Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups  $C_{2v}$ ,  $C_{3v}$  and  $C_{2h}$ . Structure of character tables.
  - b) Determination of symmetry species for translations and rotations.
  - c) Mulliken's notations for irreducible representations.
  - d) Reduction of reducible representations using reduction formula.
- Applications of Group Theory Symmetry adapted linear combinations



	(SALC), symmetry aspects of MO theory, sigma bonding in AB <sub>n</sub> (NH <sub>3</sub> , CH <sub>4</sub> ) molecule.	
<b>Module 2</b>	<b>QUANTUM MECHANICS</b>	<b>[15L]</b>
<b>Learning Objectives:</b> This module is intended to		
<ul style="list-style-type: none"><li>• Make students familiarize with the advanced quantum mechanics in chemical systems</li></ul>		
<b>Learning Outcome:</b> After the successful completion of the module, the learner will be able to		
<ul style="list-style-type: none"><li>• Describe quantum mechanics, angular momentum, explain the solution of Schrödinger equation.</li><li>• Solve problems involving different types of operators and evaluate their uses</li></ul>		
<b>1.2</b>	<b>Quantum Chemistry:</b> Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics. Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions. Operators and their algebra, linear and Hermitian operators, operators for the dynamic variables of a system such as, position, linear momentum, angular momentum, total energy, eigen functions, eigen values and eigen value equation, Schrödinger wave equation as the eigen value equation of the Hamiltonian operator, average value and the expectation value of a dynamic variable of the system, Postulates of Quantum Mechanics, Schrödinger's Time independent wave equation from Schrödinger's time dependent wave equation. Application of quantum mechanics to the following systems: a) Free particle, wave function and energy of a free particle. b) Particle in 1D, 2D and 3D box, separation of variables, Expression for the wave function and energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels. c) Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula.	
<b>Module 3</b>	<b>INORGANIC REACTION MECHANISM</b>	<b>[15L]</b>
<b>Learning Objectives:</b> This module is intended to		
<ul style="list-style-type: none"><li>• Make students aware about the elementary Inorganic Reaction Mechanism to learners</li></ul>		



**Learning Outcome:**

After the successful completion of the module, the learner will be able to

- Describe different types of inorganic reaction mechanism, differentiate between acid hydrolysis & base hydrolysis, characterize conjugate base mechanism
- Solve problems involving their synthetic application

**1.3**

Labile and inert complexes, factors responsible for lability and inertness of complexes. Reactivity of metal complexes, ligand replacement reaction: classification of mechanism and energy profile of reaction. Inert and labile complexes, interpretation of lability and inertness of transition metal complex on the basis of reaction rate, Valence Bond Theory (VBT) and Crystal Field Theory (CFT). Transition state or activated complex, substrate, attacking reagents electrophilic and nucleophilic, nature central atom. Kinetic application of CFT. Determination stability complex by Job's method. Substitution reactions in square planar complexes e.g. Kinetic substitution reactions in Pt(II) complexes. Kinetics of octahedral substitution, acid hydrolysis, factor affecting acid hydrolysis, base hydrolysis conjugate base mechanism, direct and indirect evidences in favor of conjugate mechanism.

**Module 4 METAL CLUSTERS**

**[15L]**

**Learning Objectives:**

This module is intended to

- Make the students understands the basic principles and electron counting of metal clusters

**Learning Outcome:**

After the successful completion of the module, the learner will be able to

- Understand the introduction and classification of metal clusters
- Evaluate electron counting scheme for HNCCS and Wade's rule and their synthetic application
- Solve problems involving Wade's rule

**1.4**

Introduction, classification, carbonyl cluster, Low Nuclearity Carbonyl Clusters (LNCCs), High Nuclearity Carbonyl Clusters (HNCCs), electron counting scheme for HNCCs, Wade's rules.  
Halides types clusters: dinuclear clusters, trinuclear clusters, tetranuclear clusters, hexanuclear cluster.  
Chevrel phases and Zintl ions, Carboranes, metalloboranes, metallo carboranes, higher boranes (Hexaborane-10, Decaborane-14), number and types of bonds present in higher boranes.



### References:

1. Chemical applications of group theory by F.A Cotton (Second edition), Wiley Eastern Limited, 1976 New Delhi
2. Group theory and its application by P.K. Bhattacharya, Himalaya publishing hours, Mumbai, 1986
3. Group theory and symmetry by L. R. Hall, McGraw hill, New York, 1989.
4. Quantum Chemistry by Ira N. Levine, Prentice-Hall of India Pvt. Lid, New Delhi, 1994.
5. Introductory Quantum Chemistry (Third edition) by N. W. Hanna, Benjamin, Menlo Park, Calif, 1988.
6. Quantum Chemistry and Spectroscopy by M. S. Pathania, Vishal Publications India, 1981.
7. Kinetic and Mechanism by A. A. Frost and R. G. Pearson, Wiley, New York, 1961.
8. Mechanism of Inorganic Reactions by F. Basolo and R.G. Pearson, Second Edition, Wiley Eastern Limited, New Delhi, 1977.
9. Advanced Inorganic Chemistry by F.A. Cotton and R.G. Wilkinson, John Wiley & Sons, N. Y.
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11. Advanced Inorganic Chemistry by S. K. Agarwala and Keemtilal, Pragati Prakashan, Meerut.
12. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.
13. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.
14. R.K. Prasad, Quantum Chemistry, 2ndEdn., New Age International Publishers, 2000.
15. Inorganic Chemistry by Gary L Miessler and Donald A. Tarr, Pearson Education International.

### Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√				√				√
2.	√	√	√						√		
3.		√		√	√	√	√				
4.	√		√		√	√		√			



## M. Sc. (CHEMISTRY) SEMESTER I

### Core Course-II

### COURSE TITLE: ORGANIC CHEMISTRY COURSE

CODE: CC102 [CREDITS - 04]

#### Course Learning Outcome

After the successful completion of the Course, the learner will be able to:

1. Discuss the generation of reactive intermediates, their mechanism, rearrangement based on each intermediate and apply the concept in organic synthesis and industrial application.
2. Define basic principles and classify different types of pericyclic reaction and construct Woodward-Hoffman correlation diagram and derive the selection rule for electrocyclic, cycloaddition and sigmatropic reaction.
3. Apply the acquired knowledge to solve complex problems related to pericyclic reactions in the context of organic chemistry,
4. Describe the mechanisms of aliphatic nucleophilic substitution reactions (SN1, SN2, SNi).
5. Identify and interpret reactions involving allylic halides neighbouring group participation, and reaction rate enhancement.
6. Evaluate the factors affecting reactivity in aromatic nucleophilic substitution reactions.
7. Apply, predict regioselectivity in elimination reactions and design synthesis on the basis of Hoffmann and Zaitsev's rules.
8. Define and explain fundamental principles including stereoisomerism, Stereo selective and Stereo specific reactions, Resolution techniques, basics of conformational analysis, interconversions and newer method of asymmetric synthesis.

**Module 1**

**REACTION MECHANISM & REACTIVE INTERMEDIATES**

**[15L]**

#### Learning Objectives:

This module is intended to

- Make students familiarize with fundamental concepts of reactive intermediates, their mechanism, rearrangement and their application in organic synthesis and industries.

#### Learning Outcome:

After the successful completion of the module, the learner will be able to

- Discuss the generation of reactive intermediates, their mechanism, rearrangement based on each intermediate.
- Apply the concept of reactive intermediate in organic synthesis and industrial application.



2.1	<p>Detailed study of organic reaction intermediates. Generation, structure, stability, reactions and factor affecting of reactivity;</p> <p><b>Carbocations (Classical and non-classical):</b> Phenonium ion, norbornyl system, common carbocation rearrangements, Demjanov, Dienone-Phenol, Rupe.</p> <p><b>Carbanions:</b> Mechanism of condensation involving enolates - Aldol, Mannich, Dieckmann, Michael and Shapiro reactions.</p> <p><b>Carbenes:</b> Mechanism of Arndt-Eistert reaction, Wolf rearrangement and Bamford Steven's rearrangement reaction.</p> <p><b>Free Radicals:</b> Coupling of alkenes and arylation of aromatic compounds by diazonium salts, Sandmeyer Reactions, Free radical rearrangements-Hunsdiecker Reaction.</p>	
<b>Module 2 PERICYCLIC REACTION</b>		<b>[15L]</b>
<b>Learning Objectives:</b> This module is intended to		
<ul style="list-style-type: none"><li>Familiarize students understand, remember and apply the fundamental principles and theories of pericyclic reactions.</li></ul>		
<b>Learning Outcome:</b>		
After the successful completion of the module, the learner will be able to		
<ul style="list-style-type: none"><li>Define basic principles and classify different types of pericyclic reaction</li><li>Construct Woodward-Hoffman correlation diagram and derive the selection rule for electrocyclic, cycloaddition and sigmatropic reaction</li><li>Apply the acquired knowledge to solve complex problems related to pericyclic reactions in the context of organic chemistry</li></ul>		
2.2	<p><b>Introduction</b> - Definition, Characteristics and Classification of Pericyclic reaction, Molecular orbitals and symmetry properties of ethylene, 1,3-butadiene, 1,3,5- hexatriene and allyl systems.</p> <p><b>Electrocyclization Reactions and reversion of cyclization reaction:</b> Woodward-Hoffman Correlation diagram and derivation of selection rules, Conrotatory and disrotatory motions, FMO, PMO &amp; orbital symmetry approach for <math>4n</math> and <math>(4n+2)</math> electron system and allyl systems.</p> <p><b>Cycloaddition Reactions:</b> Antarafacial and suprafacial additions. FMO, PMO &amp; orbital symmetry approach for <math>4n</math> and <math>(4n+2)</math> electron Systems, Diels- Alder reaction, 1, 3- dipolar cycloadditions, 2+2 addition of ketene.</p> <p><b>Sigmatropic rearrangements &amp; Pericyclic reaction of conjugated carbocation &amp; Carbanion:</b> Suprafacial and antarafacial shifts. The Cope, Oxy-cope reaction, Claisen rearrangements, Ene reaction Examples of electrocyclic, cycloaddition and sigmatropic rearrangements e.g. Oxy-Cope rearrangement etc.</p>	



Module 3	SUBSTITUTION AND ELIMINATION REACTIONS	[15L]
<b>Learning Objectives:</b> This module is intended to <ul style="list-style-type: none"><li>This module is intended to gain comprehensive understanding of advanced organic chemistry concepts including aliphatic and aromatic nucleophilic substitution mechanisms, factors influencing reactivity, and elimination reactions.</li></ul>		
<b>Learning Outcome:</b> After the successful completion of the module, the learner will be able to <ul style="list-style-type: none"><li>Describe the mechanisms of aliphatic nucleophilic substitution reactions (<math>S_N1</math>, <math>S_N2</math>, <math>S_{Ni}</math>).</li><li>Identify reactions involving allylic halides neighbouring group participation, and reaction rate enhancement.</li><li>Interpret the reactivity patterns of allylic halides and neighbouring group participation.</li><li>Evaluate the factors affecting reactivity in aromatic nucleophilic substitution reactions.</li><li>Apply and design synthesis Hoffmann and Zaitsev's rules to predict regioselectivity in elimination reactions.</li></ul>		
2.3	<b>A:</b> Aliphatic Nucleophilic Substitution: The $S_N1$ , $S_N2$ , $S_{Ni}$ mechanisms (Retention and inversion of configuration). Reactions of Allylic halides, neighboring group participation by -OH, -NH <sub>2</sub> , -COO-, -RS, C=C, Cyclopropone ring, - halogen, aromatic ring. <b>B:</b> Aromatic Nucleophilic Substitution: The $S_N2$ , $S_N1$ (addition elimination and elimination addition) and benzyne mechanisms, Reactivity - effect of substrate structure, leaving group and attaching nucleophile, The Von Richter rearrangement. <b>C:</b> Elimination reaction: Hoffmann and Zaitsev's rule of elimination, E1, E2 and E1CB Reaction and their regioselectivity.	
Module 4	STEREOCHEMISTRY AND CONFORMATIONAL ANALYSIS	[15L]
<b>Learning Objectives:</b> This module is intended to <ul style="list-style-type: none"><li>Master fundamental principles in organic chemistry, including stereoisomerism, chirality, stereo-selective, and stereo-specific reactions, as well as optical activities in absence chiral center.</li><li>Comprehend the basics of conformational analysis, interconversions, various projections, and newer methods of asymmetric synthesis.</li></ul>		



### Learning Outcome:

After the successful completion of the module, the learner will be able to

- Define and explain fundamental principles, stereoisomers, chirality, Stereo selective and Stereo specific reactions, optical activities, separation of racemic mixture, symmetry elements to check chirality in molecules.
- Explain basics of conformational analysis, interconversions, different projections, newer method of asymmetric synthesis, effects of conformation on reactivity and stability.

2.4

#### A. STEREOCHEMISTRY:

Stereo chemical principles; Enantiomeric relationships; Distereomeric relationship; R-S and E-Z nomenclature; Dynamic stereochemistry; Chiral- Prochiral relationships, due to faces and ligands, Stereo selective and Stereo specific reactions; Enantio and Diastereo selective excess, Racemates and racemic modification, Resolution of racemic modification, Optical activity in the absence of chiral carbons biphenyl, Allenes, Spiranes.

#### B. CONFIRMATIONAL ANALYSIS:

Interconversion of Fischer, Newman and Sawhorse projections. Newer method of asymmetric synthesis (including enzymatic and catalytic nexus), Bayer's strain theory, Chemistry of cyclohexane, (chair & boat cyclohexanes), Conformation of mono and disubstituted cyclohexanes (1,1 1,2 and 1,4), Conformation of Decalin, Anthracene, Perhydrophenanthrene.



### References:

1. Carbenes, Benzynes and Nitrenes by Gilchrist, T. L. and Rees.
2. Mechanism and Theory In Organic Chemistry-2007 by Thomas H. Lowry, Kathleen S. Richardson, Forbes. Harper& Row, Publishers. New York, Hagerstown, San Francisco, London
3. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
4. Reaction Mechanism in Organic Chemistry by S. M. Mukherji and S. P. Singh (McMillan India Ltd., 1976).
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6. Organic Chemistry (5/e) by Morrison & Boyd (Prentice Hall).
7. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
8. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Plenum.
9. Organic chemistry 2nd ed. Jonathan Clayden, Nick Greeves, Stuart Warren.
10. Reaction Mechanism and Reagents in Organic Chemistry by C. R. Chatwal (Himalaya Publishing House, Bombay, 1987).
11. Pericyclic Reactions, S. M. Mukherji, Macmillan, India.
12. Photochemistry and Pericyclic Reactions 3rd ed. by Jagdamba Singh 2010. New Age International Publishers Ltd. New Delhi.
13. Pericyclic Reactions A mechanistic and problem solving approach Sunil Kumar, Vinod Kumar, S. P. Singh Academic Press 2015
14. Organic Chemistry - Reaction mechanism, by P.S. Kalsi, New Age International publishers

### Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1.	√	√					√				
2.	√	√	√				√				
3.	√	√	√				√				
4.	√	√	√								
5.			√				√				
6.		√	√				√				
7.		√	√				√		√		
8.	√	√	√				√				



## M. Sc. (CHEMISTRY) SEMESTER I

### Core Course-III

### COURSE TITLE: PHYSICAL CHEMISTRY

### COURSE CODE: CC103 [CREDITS - 04]

#### Course Learning Outcome

After the successful completion of the Course, the learner will be able to:

1. Describe, recognize and calculate rate of change associated with chemical change, reversible reaction and consecutive reaction.
2. Determine rate law for enzyme catalysis, chain reaction, based on experimental data.
3. Evaluate and solve numerical problems involving different chemical changes.
4. Explain behavior of mixtures and discuss difference between state and path function, partial molar quantities
5. Justify excess functions for non-ideal solutions by deriving expressions for excess thermodynamic functions and solve problems related to PMV, TMV etc.
6. Explain the connection between quantum mechanics and thermodynamics.
7. Describe and derive different parameters of statistical thermodynamics.
8. Identify classification, stereochemistry, kinetic behavior and thermodynamics of polymerization and distinguish different phase techniques and their utility.
9. Explain the difference, formula and techniques to calculate  $M_n$  and  $M_w$  and their relation to PDI and solve numerical problems.
10. Explain Thermal transitions in polymers and its significance

#### Module 1

#### CHEMICAL KINETICS

[15L]

#### Learning Objectives:

This module is intended to make students

- Understand rate of reversible reaction, Consecutive reactions
- Understand enzyme catalysis, chain reaction
- Understand methods to solve numerical problems involving decomposition reactions.

#### Learning Outcome:

After the successful completion of the module, the learner will be able to

- Describe the concept of rate of change associated with chemical change,
- Recognize the rate-change and calculate rate of reversible reaction and consecutive reaction.
- Determine rate law for enzyme catalysis, chain reaction, based on experimental data.
- Evaluate some decomposition reactions
- Solve numerical problems involving these chemical changes.



3.1	Theories of Uni-molecular gas reactions: Lindemann theory, Kinetics of some complex reactions (i) Reversible reactions (only first order opposed by first order) (ii) Consecutive reactions ( $A \rightarrow B \rightarrow C$ ); Equation of Relaxation time for (i) first order opposed by first order and (ii) second order opposed by second order, Steady state treatment or approximation, The Rice–Ramsperger–Kassel (RRK) theory and Rice–Ramsperger–Kassel–Marcus (RRKM) theory of chemical reactivity; Enzyme catalyzed reactions, Kinetics of general Chain reaction, Kinetics of photochemical reactions ( $H_2-Cl_2$ and $H_2-Br_2$ ), Kinetics, Mechanism, determination of activation energy and chain length of some organic decomposition (i) decomposition of ethane (ii) decomposition of acetaldehyde, Effect of Ionic strength on rates of ionic reactions (Primary and secondary salt effect), Numerical.	
<b>Module 2</b> <b>THERMODYNAMICS</b> <b>[15L]</b>		
<b>Learning Objectives:</b> This module is intended to <ul style="list-style-type: none"><li>• Impart knowledge about behavior of mixtures</li><li>• Understand State and Path functions and difference between them.</li><li>• Understand Partial molar quantities</li><li>• Explain the behavior of mixtures specially in explaining Thermodynamic parameters</li><li>• Justify excess functions for non-ideal solutions by deriving expressions for excess thermodynamic functions.</li><li>• Solve Numericals</li></ul>		
<b>Learning Outcome:</b> After the successful completion of the module, the learner will be able to <ul style="list-style-type: none"><li>• Explain behavior of mixtures</li><li>• Discuss difference between state and path function, partial molar quantities</li><li>• Justify excess functions for non-ideal solutions by deriving expressions for excess thermodynamic functions.</li><li>• Solve problems related to PMV, TMV etc.</li></ul>		
3.2	Introduction to Laws of thermodynamics, state and path functions and their applications, thermodynamic description of various types of processes, Maxwell's relations, Partial molar quantities, Calculation of partial molar quantities, determination of partial molar volume and partial molar enthalpy, Ideal and non-ideal liquid mixtures, Thermodynamics functions of mixing of non-ideal solutions (i) free energy of mixing (ii) entropy of mixing (iii) volume of mixing and (iv) enthalpy of mixing, Excess functions ( $\mu^E$ , $G^E$ , $S^E$ , $H^E$ and $V^E$ ) for non-ideal solutions and expression for excess thermodynamic functions. Introduction to non-equilibrium thermodynamics. Numericals.	



<b>Module 3</b>	<b>STATISTICAL THERMODYNAMICS</b>	<b>[15L]</b>
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**Learning Objectives:**

This module is intended to

- Understand types of assembly, types of ensembles and different thermodynamic terms.
- Understand, concept of three different statistics and partition functions.
- Derive the relation between thermodynamic parameters such as pressure, temperature, entropy and heat capacity from the distribution functions.

**Learning Outcome:**

After the successful completion of the module, the learner will be able to

- Explain the connection between quantum mechanics and thermodynamics.
- Describe and derive thermodynamic statistic and differentiate them.
- Derive the vibrational and translational partition functions.
- Derive and compute thermodynamic functions from partition functions.
- Describe the different ensembles.

<b>3.3</b>	Basics of Statistical thermodynamics (Assembly, Canonical ensemble, occupation number statistical weight factor, probability), Thermodynamic probability, Probability and entropy, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Lagrange's methods of multipliers, Partition function, Thermodynamic properties in term of partition functions (i) Internal energy (ii) Heat Capacity (iii) Helmholtz free energy (iv) Enthalpy (v) Gibb's free energy (vi) Chemical potential (viii) Equilibrium constant Molecular partition functions for an ideal gas, Derivation for Translational, Rotational and Vibrational partition functions Numerical.	
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<b>Module 4</b>	<b>POLYMER CHEMISTRY</b>	<b>[15L]</b>
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**Learning Objectives:**

This module is intended to understand

- Various ways of Classification of polymers and their stereochemistry
- Kinetics of addition and condensation polymerization, Thermodynamics, Phase techniques and  $M_n$ ,  $M_w$ ,  $M_z$ ,  $M_v$  and PDI of polymerization
- Techniques to determine Molecular weight of polymers like Viscometry & Osmometry
- Thermal transitions in polymers & its significance and Solving Numericals

**Learning Outcome:**

After the successful completion of the module, the learner will be able to

- Identify classification, stereochemistry, kinetic behavior and thermodynamics of polymerization.
- Distinguish different phase techniques and their utility.
- Explain the difference and formula to calculate  $M_n$  and  $M_w$  and their relation to PDI and solve numerical problems.
- Explain various techniques to determine average molecular weights and solve numerical problems related to them.
- Explain Thermal transitions in polymers and its significance

**3.4**

Types of polymers, Stereochemistry of polymers, Kinetics of Addition polymerization (free radical, cationic and anionic) and Condensation polymerization, Thermodynamics of polymerization, Phase techniques of polymerization (Bulk, solution, suspension and emulsion), Number & Mass average Molecular mass ( $M_n$ ,  $M_w$ ,  $M_z$ ,  $M_v$  determination), Polydispersity Index (P.D.I) Molecular mass determination by Viscometry and Osmometry, Mark–Houwink equation for determining intrinsic viscosity, Thermal transitions in polymer: glass transition temperature and its significance, Numericals.

**References:****Module I:**

1. Essential of chemical kinetics by Dr. Harishchandra A. Parbat and Dr. Damodar V., Prabhu, Sara Publication, 1<sup>st</sup> edition, (2022)
2. Chemical Kinetics, Laidler K.J. TATA McGRAW-HILL PUBLISHING CO. LTD.
3. Principles of Chemical Kinetics, James E. House, Elsevier Publication
4. Kinetics and Mechanism of Chemical Transformations, Rajaraman, J. and Kuriacose, J., McMillan (2008)
5. Kinetics of chemical reactions, S.K. Jain, Vishal Publications
6. Engel, T. & Reid, P. Physical Chemistry, Pearson
7. Maron, S. & Prutton Physical Chemistry

**Module II:**

1. Thermodynamics for chemist Samuel Glasstone, East-West Press Pvt. Ltd. (2008)
2. Physical Chemistry, Volume1: Thermodynamics and Kinetics (10<sup>th</sup> Ed) by Professor Peter Atkins, Julio De Paula
3. Principles of Physical Chemistry Puri B.R., Sharma L.R. and Pathania, M.S., Vishal Publishing Co.
4. A textbook of Physical Chemistry by K.L. Kapoor, Vol-5, McMillan India Ltd. 2007.
5. An introduction to chemical thermodynamics, R.P. Rastogi and R.R. Mishra, Vikas Publishing house Pvt. Ltd. 6<sup>th</sup> edition.
6. Advanced Physical Chemistry, D.N. Bajpai, S.Chand & Company Ltd. 2<sup>nd</sup> edition.



### Module III:

1. Statistical thermodynamics, M.C. Gupta, New Age International, 2007.
2. An introduction to statistical thermodynamics, Terrell L. Hill, Addition Wesley Publishing Co.
3. Principles of Physical Chemistry, B. R. Puri, L.R. Sharma, M.S. Parthania, Vishal Publishing Co.
4. A text book of Physical Chemistry, K. L. Kapoor, Vol-5, Macillan India Ltd. 2007

### Module IV:

1. Polymer science by V.R.Gowarikar. WILEY EASTERN LTD.
2. Principal of polymer chemistry by A. Ravve, Springer
3. A Textbook of Polymer Chemistry, M S Bhatnagar, S Chand Publications.
4. Principles of Physical Chemistry Puri B.R., Sharma L.R. and Pathania, M.S., Vishal Publishing Co

### Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1.	√	√	√								
2.		√	√				√				
3.		√	√				√				
4.	√	√									
5.	√	√	√				√				
6.	√										
7.	√										
8.		√	√				√				
9.	√	√	√								
10.	√										



**M. Sc. (CHEMISTRY) SEMESTER I**

**Elective Course-I**

**COURSE TITLE: ANALYTICAL CHEMISTRY I**

**COURSE CODE: EC101 [CREDITS - 04]**

**Course Learning Outcome**

After the successful completion of the Course, the learner will be able to:

1. Define the various analytical and statistical terms used in Analytical Chemistry.
2. Identify the different types of errors in analysis.
3. Sketch out the role and importance of total quality management, safety, accreditations and GLP in industries.
4. Perform basic calculations required in chemical analysis and understand stoichiometry of reactions.
5. Define the basic concept of electronic transitions and effects on wavelength absorption.
6. Calculate the  $\lambda_{\max}$  of different organic compounds.
7. Apply fundamental concepts of UV-Visible and IR spectroscopic methods.
8. Explain the instrumentation of different thermal techniques.
9. Describe the various automated instruments and their application in industry to increase output.
10. Explain qualitative and quantitative representation of compounds by different analytical techniques.
11. Solve numerical problems related to different analytical methods

**Module 1**

**LANGUAGE OF ANALYTICAL CHEMISTRY**

**[15L]**

**Learning Objectives:**

This module is intended to

- Enable learners to have comprehensive knowledge, understanding of the types of instruments with operations and automated methods of analysis.

**Learning Outcome:**

After the successful completion of the module, the learner will be able to

- Define the various analytical and statistical terms used in Analytical Chemistry.
- Identify the different types of errors in analysis.
- Sketch out the role and importance of total quality management, safety, accreditations and GLP in industries.





	<p>solution</p> <p>Calculations of pH of acids, bases, acidic and basic buffers</p> <p>Concept of formation constants, stability and instability constants, stepwise formation constants</p> <p>Oxidation number, rules for assigning oxidation number, redox reaction in term of oxidation number, oxidizing and reducing agents, equivalent weight of oxidizing and reducing agents, stoichiometry of redox titration (Normality of a solution of an oxidizing / reducing agent and its relationship with molarity).</p>	
<b>Module 3</b>	<b>ORGANIC SPECTROSCOPY: UV AND IR SPECTROSCOPY</b>	<b>[15L]</b>
<b>Learning Objectives:</b> This module is intended to		
<ul style="list-style-type: none"><li>Understand UV and IR spectroscopic methods.</li></ul>		
<b>Learning Outcome:</b> After the successful completion of the module, the learner will be able to		
<ul style="list-style-type: none"><li>Define the basic concept of electronic transitions and effects on wavelength absorption.</li><li>Calculate the <math>\lambda_{\max}</math> of different organic molecules.</li><li>Apply fundamental concepts of UV-Visible and IR spectroscopic methods.</li></ul>		
<b>4.3</b>	<p>(A) [Recapitulation: Introduction of Electromagnetic Radiation]</p> <p>Types of electronic transition, Chromophore, Auxochrome, Hypsochromic effect, Bathochromic effect, Hyperchromic effect, Hypochromic effect, Factor affecting <math>\lambda_{\max}</math> like resonance, hyper conjugation, hydrogen bonding, steric effect, Woodward's rules for calculation of <math>\lambda_{\max}</math> for Diene-enones systems, aromatic substituents, Effect of solvent on absorption bands, Instrumentation.</p> <p>(B) IR spectroscopy: Introduction: Theory, Useful terms: IR region, types of vibrations: fundamental and overtones, linear and non-linear molecule, equation for vibrational frequency, selection rule, Factors Influencing Vibrational Frequencies: coupling, Fermi resonance, Hydrogen bonding, Electronic effects, IR Spectra: Group frequency regions, Fingerprint region, Spectra interpretations and structural elucidation of organic compounds. Instrumentation-FTIR</p>	
<b>Module 4</b>	<b>INSTRUMENTAL METHODS-I</b>	<b>[15L]</b>
<b>Learning Objectives:</b> This module is intended to		
<ul style="list-style-type: none"><li>Get familiar with comprehensive knowledge and applications of thermal and automated methods in chemical analysis.</li></ul>		



### Learning Outcome:

After the successful completion of the module, the learner will be able to

- Explain the instrumentation of different thermal techniques.
- Describe the various automated instruments and their application in industry to increase output.

#### 4.4

#### Thermal Methods:

Introduction: Types of thermal methods, comparison between TGA and DTA, Differential Scanning Calorimetry-Principle, comparison of DTA and DSC. Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting DSC Curves. Applications - Heat of reaction, Safety screening, Polymers, liquid crystals, Drug analysis.

#### Automation in chemical analysis:

Need for automation, Objectives of automation, An overview of automated instruments. Process control analysis, flow injection analysis, discrete automated systems, automatic analysis based on multi-layered films, gas monitoring equipments, Automatic titrators.

### References:

#### Unit I

1. Modern Analytical Chemistry; David Harvey, McGraw-Hill, Higher Education, (2000)
2. Principles of Instrumental Analysis; Skoog, Holler and Nieman, 5th Edition, Ch: 1.
3. Fundamentals of Analytical Chemistry, Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004, Ch: 5.
4. Undergraduate Instrumental Analysis; J W Robinson, Marcel Dekker, 6th edition Ch:1.
5. ISO 9000 Quality Systems Handbook; David Hoyle. 4th edition (Chapter: 3 & 4) (Free download).
6. Quality in the Analytical Laboratory ; Elizabeth Pichard, Wiley India, Ch: 5, Ch: 6 & Ch: 7.
7. Quality Management; Donna C S Summers, Prentice-Hall of India, Ch:3.
8. Quality in Totality: A Manager's Guide To TQM and ISO 9000, Parag Diwan, Deep & Deep Publications, 1st Edition, 2000.
9. Quality Control and Total Quality Management - ; P.L. Jain-Tata McGraw-Hill (2006) Total Quality Management - Bester field - Pearson Education, Ch:5.
10. Industrial Hygiene and Chemical Safety, ; M H Fulekar, Ch:9, Ch:11 & Ch:15.
11. Safety and Hazards Management in Chemical Industries ; M N Vyas, Atlantic Publisher, Ch:4, Ch:5 & Ch:19.
12. World Health Organization (2009) Handbook: Good Laboratory Practice (GLP)
13. OECD Principles of Good Laboratory Practice (as revised in 1997)". OECD Environmental Health and Safety Publications. OECD. 1. 1998.



14. "A systematic approach for evaluating the quality of experimental toxicological and ecotoxicological data".;Klimisch, HJ; Andreae, M; Tillmann, U (1997).  
doi:10.1006/rtph.1996.1076. PMID 9056496.

### **Unit II**

1. 3000 solved problems in chemistry, Schaums Solved problem series, ; David E. Goldbers, Mc Graw Hill international Editions, Chapter 11,15,16,21,22

### **Unit III**

1. Principles of Instrumental Analysis, ; D. A. Skoog, F. J. Holler, T. A. Nieman, 5th Edition, Harcourt Asia Publisher. Chapter 6, 7,8, 13, 14, 16,17
2. Instrumental Methods of Analysis,; H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, 6 th Edition, CBS Publisher. Chapter 2.
3. Introduction to Instrumental Analysis, ; R. D. Braun , McGraw Hill Publisher. Chapter 5, 8, 12
4. Instrumental Methods of Chemical Analysis, ; G. W. Ewing, 5 th Edition, McGraw Hill Publisher, Chapter 3.
5. The effect of temperature on ultraviolet absorption spectra and its relation to hydrogen bonding,; M. Ito, J. Mol. Spectrosc. 4 (1960) 106-124.
6. The effect of temperature on the visible absorption band of iodine in several solvents; A. J. Somnessa, Spectrochim. Acta. Part A: Molecular Spectroscopy, 33 (1977) 525-528.
7. Infrared Spectroscopy- Materials Science, Engineering and Technology. Z. M. Khoshhesab (2012). Prof. TheophanidesTheophile (Ed.). ISBN: 978-953- 51-0537- 4, InTech,(open access)

### **Unit IV**

1. Introduction to instrumental methods of analysis; Robert D. Braun, Mc. Graw Hill (1987): Chapter 27,28.
2. Thermal Analysis-theory and applications; R. T. Sane, Ghadge, Quest Publications.
3. Instrumental methods of analysis; Willard, Merrit, Dean:7 th Edition, Chapter 25, 26
4. Instrumental Analysis, ; Skoog, Holler and Nieman, 5 th Edition, Chapter 31,33
5. Vogel's Quantitative Chemical Analysis,; 6 th Edition, Chapter 12
6. Analytical Chemistry - Open Learning: Thermal Methods; James W. Dodd, W. James and Kenneth H. Tonge.



### Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1.	√										
2.	√	√									
3.	√	√									
4.		√	√				√				
5.	√										
6.		√	√				√				
7.		√	√				√				
8.	√										
9.	√	√					√				
10.	√										





- Describe the key steps in performing Thin layer chromatography (TLC) and Gas chromatography (GC).
- Explain the terms and factors involved in GC and TLC.
- Describe the steps involved in a chromatographic investigation.

**Learning Outcome:**

After the successful completion of the module, the learner will be able to

- Describe the expression for the partition coefficient, principle of TLC and GC.
- Explain the difference between mobile phase and stationary phases.
- Explain different detectors and columns used in GC.
- Discuss qualitative and quantitative representation of TLC and GC.

<b>4.2</b>	Thin-Layer Chromatography: Selection of stationary and mobile phase, Detection techniques – Elementary idea of HPTLC Gas Chromatography: Principle of GC, Construction, function and working of GC, Selection of mobile phase – Selection of stationary phase in GLC and GSC, Methods of Injection, Detectors: FID (with modifications), TCD and ECD, Their comparison, Packed column, Capillary Column (WCOT, SCOT) (advantages and disadvantages) –Temperature programming – Derivatization in GC. Qualitative (Basic terms: retention Time, Retention Volume, Relative Retention) and Quantitative (Measurement of Area, Area Normalization Method, Internal Standard Method) Analysis, Chromatogram.	
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<b>Module 3</b>	<b>CHEMICAL MATHEMATICS</b>	<b>[15L]</b>
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**Learning Objectives:**

This module is intended to

- Differentiate the type of errors related to chemical analysis.
- Analyze and compute the different statistical terms for the given data.
- Determine the different tests like Q-test, students' t-test and least square methods.

**Learning Outcome:**

After the successful completion of the module, the learner will be able to

- Explain difference between different types of errors observed during analysis.
- Analyze the use of statistical treatment of data, learn to accept and reject the data.

<b>4.3</b>	Errors in Chemical analysis, classification of errors, nature and origin of errors, Propagation of error, Accuracy and precision, Average deviation and standard deviation and its physical significance, Normal Distribution curve and its properties. Confidence limit and probability, Statistical treatment for error analysis, rejection criteria like students' 't' test, Q-test, 2.5d and 4d rule, least square method.	
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<b>Module 4</b>	<b>TITRIMETRIC METHODS AND ELEMENTAL ANALYSIS</b>	<b>[15L]</b>
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**Learning Objectives:**

This module is intended to

- Understand different concentration terms of solution and non-aqueous titrimetric methods.
- Get familiar with determination of elements in organic compounds by Elemental Analysis.



### Learning Outcome:

After the successful completion of the module, the learner will be able to

- Explain preparation of solutions of different concentrations and learn the non-aqueous titration methods when aqueous titration fails.
- Determine various elements in organic compounds by Elemental Analysis.

4.4

#### Solution and Their Concentration:

Molarity, Molality, Normality, ppm, ppb, ppt, % w/v, % w/w, % v/v, Formality, Primary and Secondary standard, Acid Value, Density and Specific Gravity, Numerical.

#### Non-Aqueous Titration:

Protic and Aprotic Solvent, Solvent system, Dielectric constant, Titrant, Titration Curve, Determination of Equivalence point, Karl Fisher Titration.

#### Elemental Analysis:

Step on Analysis, C and H Analysis, N Analysis, Halogen Analysis and Sulphur Analysis, Elementary Idea of Modern Elemental analyzer.

### References:

1. Fundamental of molecular spectroscopy, C. N. Banwell, Tata Mc-Graw Hill Pub. Camp.
2. Spectrometric Identification of Organic Compounds (4<sup>th</sup> edition/5<sup>th</sup> edition), Silverstein, Bassler & Morrill, John Wiley & Sons.
3. Introduction to Molecular Spectroscopy, G. M. Barrow, McGraw – Hill.
4. Modern Spectroscopy, J. M. Hollas, John Wiley.
5. Basic Principles of Spectroscopy, R. Chang, McGraw-Hill.
6. Modern Methods of Chemical Analysis (2<sup>nd</sup> ed.), Pecsok, Shields, Cairns & McWilliam, John Wiley & Sons.
7. Instrumental Analysis by R. D. Braun, McGraw-Hill.
8. Introduction to Instrumental Analysis by R. D. Brawn, McGraw-Hill Book.
9. Fundamentals of Analytical Chemistry: Skoog D. R. and West D. M. (Holt, Rinehart & Winston, New York).
10. Instrumental Methods of Analysis by G. W. Ewing.
11. Modern Method of Chemical Analysis by Pecsok, Shield, Cairns, McWilliam, John Wiley and Sons.
12. Quantitative Analysis, 6<sup>th</sup> Ed., R. A. Day and A. L. Underwood, Prentice – Hall of India, 1993.
13. Instrumental Analysis: G. D. Caristian and J. E. O'Reilly (Allyn & Bacon Inc., New York, 2<sup>nd</sup> edition.
14. Instrumental Methods of Chemical Analysis: G. W. Ewing (McGraw-Hill, New York), 5<sup>th</sup> edition.
15. Instrumental Methods of Analysis: H. R. Willard, L. L. Merrit, J. A. Dean, F. A. Settle (VanNostrand Reinhold Co., New York), 6<sup>th</sup> edition.



16. Modern Methods of Chemical Analysis: Pecsok, Shield & Cairns (John Wiley), 2<sup>nd</sup> edition.
17. Introduction to Instrumental Analysis (1987), R. D. Braun (McGraw-Hill Book Company), NewDelhi.
18. Analytical Chemistry: Principles and Techniques: Larry G. Hargis (Prentice-Hall International edition).
19. Introduction to Modern Liquid Chromatography: L. R. Snyder & J. J. Kirkland (John Wiley & Sons, New York).
20. Handbook of Analytical Chemistry: L. Meites (McGraw-Hill, New York)

#### Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1.	√	√									
2.	√										
3.	√	√									
4.		√	√								
5.	√										



## M. Sc. (CHEMISTRY) SEMESTER I

### Skill Enhancement Course-I

**COURSE TITLE: CHEMICALS: SOLUTION AND SAFETY**

**COURSE CODE: SEC101 [CREDITS - 02]**

<b>Course Learning Outcome</b>		
After the successful completion of the Course, the learner will be able to:		
<ol style="list-style-type: none"><li>1. Describe different standardization methods and calculate concentration terms</li><li>2. Explain and prepare standard solutions of different substances and their standardization</li><li>3. Operate instruments like weighing balance and fire extinguisher</li><li>4. Depict understanding of rules and safety measures to be followed in a chemical laboratory</li><li>5. Apply the knowledge of safe storage and disposal of chemicals in laboratory</li></ol>		
<b>Module 1</b>	<b>SOLUTION PREPARATION AND HANDLING</b>	<b>[15L]</b>
<b>Learning Objectives:</b>		
This module is intended to familiarize students about preparation and handling of standard solutions in laboratory.		
<b>Learning Outcome:</b>		
After the successful completion of the module, the learner will be able to		
<ul style="list-style-type: none"><li>• Operate a weighing balance</li><li>• Prepare standard solutions of various substances of different normalities</li><li>• Standardize the solutions</li></ul>		
<b>5.1</b>	Prepare solution and operate weighing balance for sampling to prepare different types of solution as per the Equivalent weight, Molecular weight, atomic weight, Specific gravity, Normality, Acidity, Basicity, Concentration, Normal Solution and Molar Solutions, Prepare the acid solutions, basic solutions and oxidizing - reducing agent, solutions. Prepare solutions of different concentration and determine the concentration and percentage purity, Prepare the Complexometric solutions, indicators, sampling in solids, liquids and gases. Standardize the solutions, primary standardize, secondary standards, Prepare the Ethylene diamine tetra acetic acid (EDTA) solution & indicator.	



Module 2	CHEMICAL SAFETY AND ETHICAL HANDLING OF CHEMICALS	[15L]
<b>Learning Objectives:</b> <p>This module is intended to make students aware of various parameters of safety measures to be followed in a chemical laboratory and its associated ethical principles.</p>		
<b>Learning Outcome:</b> <p>After the successful completion of the module, the learner will be able to</p> <ul style="list-style-type: none"><li>• Apply safety rules and measures while working in a chemical laboratory</li><li>• Define and illustrate the hazardous nature of various chemical substances</li><li>• Apply the knowledge of safe storage and disposal of chemicals in laboratory</li><li>• Illustrate fire prevention techniques and operate firefighting extinguisher</li></ul>		
5.1	Safe chemical working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation, safe storage and use of a hazardous chemicals, procedure for working with substance that pose hazards, flammable or explosive hazards, procedures for working with gases at pressure above and below atmospheric level, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identifications, verification and segregation of a laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals, knowledge about the personnel safety and use of personnel protective equipment (PPE), explain the Behavior Based Safety (BBS), Operate firefighting extinguisher and knowledge of the Fire prevention.	



### References:

1. Quantitative Analysis, 6<sup>th</sup> Ed., R. A. Day and A. L. Underwood, Prentice – Hall of India, 1993.
2. Elements of Analytical Chemistry by R. Gopalan; P.S. Subramanian and K. Rengarajan, Sultan Chand & Sons. 2003.
3. Vogel's Qualitative Inorganic analysis, 7<sup>th</sup> Edition, 2012.
4. Chemical Hazards in the workplace, measurement and control, Gangadhar Choudhary, American Chemical Society.
5. Safety at work by John Ridley.
6. The safe handling of Chemicals in Industry, Vol. I and II, PA Carsion, CJ Mumford, Longmann & J W & Sons, New York.
7. Industrial Hygiene and Chemical Safety, M. H. Fulekar, I. K. International
8. Fundamentals of Industrial Safety and Health, Dr. K. U. Mistry, Siddharth Prakashan Ahmedabad

### Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1.	√	√	√			√	√	√			
2.	√	√	√			√	√				
3.	√	√	√					√			√
4.	√	√	√			√	√	√			√
5.	√	√	√			√	√	√			√



## M. Sc. (CHEMISTRY) SEMESTER I

### Practical Core Course-I

#### COURSE TITLE: PRACTICAL INORGANIC CHEMISTRY I

#### COURSE CODE: PCC101 [CREDITS - 04]

#### Course Learning Outcome

After the successful completion of the Course, the learner will be able to:

1. Illustrate basics analysis and separation of Inorganic mixtures.
2. Identify anions by dry test of the mixture.
3. Identify each cation and confirm it by confirmative test.
4. Demonstrate different methods of Preparations of inorganic salts.
5. Appreciate good laboratory practices.

#### Learning Objectives

This module is intended to

- Impart basic knowledge of qualitative analysis of Inorganic mixture
- Identify three anions and three cations including one rare earth element by group separation.
- Impart knowledge of different radicals by confirmative test.
- Learn preparation of inorganic metal salts and it's crystallization

#### 1. Inorganic Qualitative Analysis:

(Six elements including ONE rare element Any seven rare earths elements)  
(Minimum Eight Mixture)

#### 2. Inorganic Preparation.

- a. Hexa-ammine nickel (II) chloride
- b. Mohr's salt (Ferrous Ammonium sulphate)
- c. Sodium trioxalato ferrate trihydrate
- d. Sodium cobaltinitrite
- e. Tetra amine cupric sulphate
- f. Reineck's salt (Ammonium Tetrathiocyanate Diammine Chromate)

3. Graph plotting of mathematical functions-linear, exponential and trigonometry and identify whether they are acceptable or non-acceptable as wave-functions?



### References:

1. Textbook of practical inorganic chemistry – A.I. Vogel
2. Practical Chemistry by Dr O. P. Pandey, D. N. Bajpai, Dr. S. Giri
3. Advance inorganic analysis by Agarwal, Keemti lal
4. Qualitative Inorganic analysis – Vogel
5. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.
6. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rdEdn., Longman Group Ltd., 1974.
7. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

### Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1.		√		√	√	√					
2.		√		√	√	√					
3.		√		√	√	√					
4.		√		√	√	√					
5.		√		√	√	√					



## M. Sc. (CHEMISTRY) SEMESTER I

### Practical Core Course-II

#### COURSE TITLE: PRACTICAL ORGANIC CHEMISTRY I

#### COURSE CODE: PCC102 [CREDITS - 04]

Course Learning Outcome	
After the successful completion of the Course, the learner will be able to:	
<ol style="list-style-type: none"><li>1. Demonstrate basics of separation of organic tertiary mixtures. Establish mechanism and monitor a reaction at specified condition.</li><li>2. Identify chemical nature of mixture.</li><li>3. Identify each component through their functional group test, elemental analysis and M.P/BP.</li><li>4. Purify the compounds using different techniques including distillation, crystallization</li><li>5. Record physical constants for individual compounds and perform good laboratory practices</li></ol>	
Learning Objectives	
This module is intended to	
<ul style="list-style-type: none"><li>• Impart basic knowledge for the separation of organic ternary mixture</li><li>• Identify nature of mixture i.e., solid-solid, solid-liquid, liquid- liquid etc.</li><li>• Impart knowledge of different purification techniques including distillation.</li><li>• Learn separation and identification of component with their functional group test and M.P. /B.P.</li><li>• Confirm the structure and prepare the relevant derivative.</li></ul>	
Contents	
<ol style="list-style-type: none"><li>1. <b>Mixture analysis: (Minimum eight mixtures)</b> Tertiary mixture to be given. (S+S), (L+L), (S+L), (S+L+L). Type determination, Separation by physical and chemical methods. (both permitted in case of liquids)</li><li>2. <b>Paper Chromatography:</b> Chromatographic separation of amino acid mixture (Three amino acids) by ascending paper chromatography</li></ol>	



### References:

1. A text book of practical organic chemistry – A. I. Vogel
2. Practical organic Chemistry – Mann and Saunders
3. A handbook of quantitative and qualitative analysis – H. T. Clarke
4. Comprehensive Practical Organic Chemistry : Qualitative Analysis V K Ahluwalia & S. Dhingra.
5. Comprehensive Practical Organic Chemistry : Preparations and Quantitative Analysis V K Ahluwalia& R. Aggarwal Universities Press.
6. An Advance Course in practical Chemistry, A K. Nad, B. Mahapatra and A. Ghoshal.

### Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1.		√		√	√	√					
2.		√		√	√	√					
3.		√		√	√	√					
4.		√		√	√	√					
5.		√		√	√	√					



**M. Sc. (CHEMISTRY) SEMESTER I  
Practical Core Course-III**

**COURSE TITLE: PRACTICAL PHYSICAL CHEMISTRY I**

**COURSE CODE: PCC103 [CREDITS - 04]**

**Course Learning Outcome**

After the successful completion of the Course, the learner will be able to:

1. Inspect the rate of reactions in chemical kinetics
2. Utilize knowledge of preparation of solutions
3. Demonstrate use of pH-meter, potentiometer, and colorimeter
4. Determine the molecular weight of polymer
5. Analyse and interpret the tertiary phase diagram

**Learning Objectives**

- To study the rate constant of chemical reaction
- To understand pH metric and potentiometric titrations.
- To study the properties of surfactant and polymer in aqueous solution
- To determine the concentration of solution by colorimetry
- To understand the conductivity behavior of electrolytic solution.
- To understand phase behaviour of three component system

**Contents**

1. Determine the dissociation constants of a given dibasic acid pH-metrically.
2. Determine the amount of ferrous sulphate / ferrous ammonium sulphate and redox potential potentiometrically using ceric salt solution.
3. Verification of Onsager's equation and determination of equivalent conductance at infinite dilution of strong electrolytes
4. Calculate the molar absorptivity of each of the given two solutions (A) and (B) and also find out concentration of supplied unknown solution colorimetrically.
5. Investigation the reaction between  $K_2S_2O_8$  and KI at two different temperatures and calculate the energy of activation for the reaction.
6. To study the phase diagram of a three component system Water – acetic acid – chloroform.
7. Determine the molecular weight of a given polymer from viscosity measurement.
8. Determine CST of Phenol -Water system
9. Determine CST of Phenol –NaCl system

Note: Students require minimum seven experiments to be performed

**References:**

1. Advanced Practical Physical Chemistry by Yadav J. B., Krishna Prakashan Media
2. Practical Physical Chemistry, Dr. M. Satish Kumar Sankalp Publication
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson

**Mapping of CLOs and PSOs**

Course Learning Outcomes	Programme Specific Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1.		√		√	√	√					
2.		√		√	√	√					
3.		√		√	√	√					
4.		√		√	√	√					
5.		√		√	√	√					