MANAV RACHNA UNIVERSITY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF CHEMISTRY

PROGRAM STRUCTURE

&

DETAILED SYLLABUS

M.Sc. Chemistry

BATCH: 2020-2022

MANAV RACHNA UNIVERSITY
DEPARTMENT OF CHEMISTRY
M.SC (CHP01)
SCHEME-B (Effective from July 2019)

SEMESTER-1

SUBJECT CODES	SUBJECT NAME	OFFERING DEPARTMENT	COURSE NATURE (Hard/Soft/ NTCC)	COURSE TYPE (Core/ Elective etc)	L	T	P	O	CONTACT HOURS PER WEEK	NO. OF CREDITS
CHH501B	Physical Chemistry-I	CH	Hard	Core	4	0	0	0	4	4
CHH502B	Inorganic Chemistry-I	CH	Hard	Core	4	0	0	0	4	4
CHH503B	Organic Chemistry-I	CH	Hard	Core	4	0	0	0	4	4
CHH504B	Analytical Chemistry	CH	Hard	Core	4	0	0	0	4	4
CHH505B	Laboratory-I	CH	Practical	Core	0	0	12	0	12	6
	Total (L-T-P-O/Contact Hours/Credits)				16	0	12	0	28	22

SEMESTER - 2

SUBJECT CODES	SUBJECT NAME	OFFERING DEPARTMENT	*COURSE NATURE (Hard/Soft/ NTCC)	COURSE TYPE (Core/ Elective etc)	L	T	P	O	CONTACT HOURS PER WEEK	NO. OF CREDITS
CHH506B	Physical Chemistry-II	CH	Hard	Core	4	0	0	0	4	4
CHH507B	Inorganic Chemistry-II	CH	Hard	Core	4	0	0	0	4	4
CHH508B	Organic Chemistry-II	CH	Hard	Core	4	0	0	0	4	4

CHH509B	**Molecular Spectroscopy**	**CH**	**Hard**	**Core**	**4**	**0**	**0**	**0**	**4**	**4**
CHH510B	**Laboratory-II**	**CH**	**Practical**	**Core**	**0**	**0**	**8**	**0**	**8**	**4**
RDO503	**Scientific Research-I**	**CH**	**NTCC**	**Core**	**0**	**0**	**0**	**4**	**2**	**4**
	Total (L-T-P-O/Contact Hours/Credits)				**16**	**0**	**8**	**4**	**26**	**24**

SEMESTER - 3

SUBJECT CODES	SUBJECT NAME	OFFERING DEPARTMENT	*COURSE NATURE (Hard/Soft/ NTCC)	COURSE TYPE (Core/ Elective etc)	L	T	P	O	CONTACT HOURS PER WEEK	NO. OF CREDITS
CHH 601B	**Symmetry & Group Theory**	**CH**	**Hard**	**Core**	**4**	**0**	**0**	**0**	**4**	**4**
CHH 602B	**Physical Special-I (Magneto-chemistry, Chemical Kinetics, Catalysis & ion transport)**	**CH**	**Hard**	**Special Core**	**4**	**0**	**0**	**0**	**4**	**4**
CHH 608B	**Inorganic Special-I (Organometalic Chemistry of Transition Metals & Bio Inorganic Chemistry)**									
CHH613B	**Organic Special-I (Statistical Stereochemistry & Asymmetric Synthesis)**									
CHH 603B	**Physical Special-II (Irreversible thermodynamics, Transport Phenomenon, Photochemistry & Fast Reaction)**	**CH**	**Hard**	**Special Core**	**4**	**0**	**0**	**0**	**4**	**4**
CHH 609B	**Inorganic Special-II (Supramolecular Chemistry & Metal Clusters)**									

CHH614B	Organic Special-II (Photochemistry & Pericyclic Reaction)									
CHH 604B / CHH 605B	Physical Elective:(Advanced Spectroscopy/ Advanced Chemical Kinetics)	CH	Hard	Special Core	4	0	0	0	4	4
CHH 610B/ CHH 611B	Inorganic Elective: (Solid state Materials / Inorganic & Biological Catalysis)									
CHH615B CHH616B CHH617B	Organic Elective (Modern Organic Synthetic Technique / Bioorganic Chemistry/ Chemistry of Natural Products)									
CHH 606B	Physical Laboratory	CH	Practical	Core	0	0	8	0	8	4
CHH-612B	Inorganic Laboratory									
CHH-618B	ORGANIC LABORATORY WORK									
RDO603	Scientific Research-II	CH	NTCC	Core	0	0	0	4	2	4
	Total (L-T-P-O/Contact Hours/Credits)				16	0	8	4	26	24

SEMESTER - 4

SUBJECT CODES	SUBJECT NAME	OFFERING DEPARTMENT	COURSE NATURE (Hard/Soft/ NTCC)	COURSE TYPE (Core/ Elective etc)	L	T	P	O	CONTACT HOURS PER WEEK	NO. OF CREDITS

CHN619B	MAJOR PROJECT (Industrial or research lab training)	CH	NTCC	CORE	0	0	0	12	0	12
	TOTAL (L-T-P-O/CONTACT HOURS/CREDITS)				**0**	**0**	**0**	**12**	**0**	**12**

Semester	**Classroom Contact hours**	**Non teaching Outcome hrs**	**credits**
FIRST SEMESTER	**28**	**0**	**22**
SECOND SEMESTER	**26**	**4**	**24**
THIRD SEMESTER	**26**	**4**	**24**
FOURTH SEMESTER	**0**	**12**	**12**
TOTAL	**80**	**20**	**82**

PROGRAMME BOOKLET

M.Sc. Chemistry (CHP01)
(Academic Session: 2020-2021)
(Syllabus: Scheme B)

Department of Chemistry
School of Applied Sciences
Manav Rachna University

MANAV RACHNA UNIVERSITY

Vision

To educate students in frontier areas of knowledge enabling them to take up challenges as ethical and responsible global citizens

Mission

- **To impart outcome based holistic education**
- **To disseminate education in frontier areas**
- **To produce globally competitive, ethical and socially responsible human resources**
- **To produce human resources sensitive to issues of Environment and Sustainable Development**
- **To develop Environment and Sustainable development as a thrust area of research and development.**

Quality Policy

To continuously learn from the best practices, study role models and develop transparent procedures for empowerment of stakeholders.

Strategic Objectives

- **To facilitate, enhance & promote innovation in curriculum design and delivery and have Outcome-oriented Learning Culture.**
- **To promote Research Environment and Management Practices.**
- **To enhance the quality of the student learning experience.**
- **To provide Resources and Infrastructure for Academic Excellence.**

DEPARTMENT OF CHEMISTRY

Vision

To educate students in frontier areas of sustainable chemistry aspects through research and innovation for the society.

Mission

- To impart outcome based holistic education in thrust areas of the chemistry.
- To produce globally competent and socially responsible citizens.
- To develop human resource with better ethical and moral values.
- To innovate environmentally benign products using alternative approaches of the chemistry.

M.Sc. Chemistry

Programme Educational Objectives (PEOs)

- **Preparation:** A broad general education assuring an adequate foundation in mathematics, science relevant to computer engineering.
- **Core Competence:** A solid understanding of concepts fundamental to the discipline of computer science engineering.
- **Breadth:** Good analytic, design and implementation skills required to formulate and solve computing problems.
- **Professionalism:** The ability to function and communicate effectively as ethically socially responsible computer science engineering professionals.
- **Learning Environment:** To provide student awareness of the life-long learning and provide a familiarity with professional issues in computer science engineering: ethics, emerging technologies, and fostering of important job related skills.

Programme Outcomes (POs) & Programme Specific Outcomes (PSOs)

- Graduates will demonstrate knowledge of Chemistry and chemical technologies.
- Graduates will be able to design, carry out, record and analyze the results of chemical experiments.
- Graduates will be able to use modern instrumentation and classical techniques, to design experiments, and to properly record the results of their experiment.
- Graduates will be skilled in problems solving, critical thinking and analytical reasoning.
- Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries.
- Graduates will demonstrate skills to use modern chemical equipments to solve an issue related to Chemistry.
- Graduates will demonstrate knowledge to use modern library searching and retrieval methods to obtain information about a topic.
- Graduates will be able to communicate effectively in both verbal and written form.
- Graduates will show the understanding to identify and solve chemical problems and explore new areas of research.
- Graduates will develop confidence for self-education and ability for life-long learning.
- Graduates can participate and succeed in competitive examinations.

Programme Structure

Semester I							
Course Code	Course Name	Offering Department	Course Type Deptt./Allied Core/Elective/ Audit	Structure L	 T	 P	Credits
CHH501B-T	Physical Chemistry-I	CH	CORE	4	0	0	4
CHH502B-T	Inorganic Chemistry-I	CH	CORE	4	0	0	4
CHH503B-T	Organic Chemistry-I	CH	CORE	4	0	0	4
CHH504B-T	Analytical Chemistry	CH	CORE	4	0	0	4
CHH505B	Laboratory-I	CH	CORE	0	0	12	6
Semester II							
Course Code	Course Name	Offering Department	Course Type Deptt./Allied Core/Elective/ Audit	Structure L	 T	 P	Credits
CHH506B	Physical Chemistry-II	CH	CORE	4	0	0	4
CHH507B	Inorganic Chemistry-II	CH	CORE	4	0	0	4
CHH508B	Organic Chemistry-	CH	CORE	4	0	0	4

	II						
CHH509B	**Molecular Spectroscopy**	**CH**	**CORE**	**4**	**0**	**0**	**4**
CHH510B	**Laboratory-II**	**CH**	**CORE**	**0**	**0**	**8**	**4**
RDO503	**Scientific Research-I**	**CH**	**CORE**	**0**	**0**	**0**	**4**
Semester III							
Course Code	**Course Name**	**Offering Department**	**Course Type**	**Structure**			**Credits**
			Deptt./Allied Core/Elective/ Audit	**L**	**T**	**P**	
CHH601B	**Symmetry & Group Theory**	**CH**	**Core**	**4**	**0**	**0**	**4**
CHH602B/ CHH608B/ CHH613B	**Specialization-I: Magneto-chemistry, Chemical Kinetics, Catalysis & ion transport/ Organometallic Chemistry of Transition Metals & Bio Inorganic Chemistry/ Statistical Stereochemistry & Asymmetric Synthesis**	**CH**	**Special Core**	**4**	**0**	**0**	**4**
CHH603B/ CHH609B/ CHH614B	**Specialization-II Irreversible thermodynamics, Transport Phenomenon, Photochemistry & Fast Reaction/ Supramolecular Chemistry & Metal Clusters/ Photochemistry & Pericyclic Reaction**	**CH**	**Special Core**	**4**	**0**	**0**	**4**
CHH604B/ CHH605B/	**Elective: Advanced Spectroscopy/**	**CH**	**Special Core**	**4**	**0**	**0**	**4**

CHH610B/ CHH611B/ CHH615B/ CHH616B/ CHH617B	**Advanced Chemical Kinetics/ Solid state Materials / Inorganic & Biological Catalysis/ Modern Organic Synthetic Technique / Bioorganic Chemistry/ Chemistry of Natural Products**						
CHH606B/ CHH612B/ CHH618B	**Physical Laboratory/ Inorganic Laboratory/ Organic Laboratory**	**CH**	**Core**	**0**	**0**	**8**	**4**
RDO603	**Scientific Research-II**	**CH**	**Core**	**0**	**0**	**4**	**4**

Semester IV							
Course Code	**Course Name**	**Offering Department**	**Course Type**	**Structure**			**Credits**
			Deptt./Allied Core/Elective/ Audit	**L**	**T**	**P**	
CHN619B	**Major Project (Industrial or Research Lab Training)**	**CH**	**CORE**	**0**	**0**	**12**	**12**

Total Credits Scheme

S. No.	Semester	Classroom Contact Hours	Non Teaching Outcome Hrs	Credits
1	I	28	0	22
2	II	26	4	24
3	III	26	4	24
4	IV	0	12	12
Total		80	30	82

Semester-I

Course Code	Course Name	Offering Department	Course Type	Structure			Credits
			Deptt./Allied Core/Elective/ Audit	L	T	P	
CHH501B-T	Physical Chemistry-I	CH	CORE	4	0	0	4
CHH502B-T	Inorganic Chemistry-I	CH	CORE	4	0	0	4
CHH503B-T	Organic Chemistry-I	CH	CORE	4	0	0	4
CHH504B-T	Analytical Chemistry	CH	CORE	4	0	0	4
CHH505B	Laboratory-I	CH	CORE	0	0	6	6
TOTAL (L-T-P) /CREDITS)				16	0	6	22

Course Title/Code	Physical Chemistry-I (CHH501B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To familiarize students with Electrochemistry and Quantum Chemistry	
Course Outcomes (COs)		Mapping
CO1	Learn the experimental methods to determine mean activity coefficient	Skill Development
CO2	Comprehend the need for modification in the Debye-Hückel Theory	Skill Development
CO3	Understand the basics of Quantum mechanics	Skill Development
CO4	Identifies correctly the mathematical space that contains all possible states+ of a physical system, using Dirac's notation	Skill Development
Prerequisites	B.Sc. with Chemistry as one of the Subject, Thermodynamics, Quantum chemistry etc,	

SECTION-A

Electrochemistry: Solutions: Activity coefficients and ion-ion interactions. Physical significance of activity coefficients, mean activity coefficient of an electrolyte and its determination, Derivation of the Debye-Hückel theory of activity coefficients (both point ion size and finite ion size models), Excess functions, Metal/Electrolyte interface: Introduction and characteristics (OHP and IHP, potential profile across double layer region)

SECTION-B

Surface phenomena: Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micelle concentration (CMC), Krafft temperature, Factors affecting the CMC of surfactants, counterion binding to micelles, thermodynamics of micellization, solubilization, microemulsions, reverse micelles, surface films (eletrokinetic phenomena), catalytic activity at surfaces. Electrode/ electrolyte interface; Nernst equation.

SECTION-C

Quantum Chemistry: Postulates of Quantum mechanics, Linear and Hermitian operators, Turn-over rule, Commutation of operators and Uncertainty principle. Some exactly soluble problems: Particle in a box (1-D, 2-D & 3-D) and ring. Concept of degeneracy and its application to Jahn-Teller distortion, Simple harmonic oscillator problem and its solution using series solution or factorization method, Calculation of various average values, Brief Description: Angular momentum operators, Eigen values and eigen-functions, Radial distributions.

SECTION-D

Approximate methods: First order time-independent perturbation theory for non-degenerate states, Variation theorem and variational methods, Use of these methods illustrated with some examples (particle in a box with a finite barrier, anharmonic oscillator, and approximate functions for particle in a box and hydrogen atom).
HMO method and its applications: π-Electron approximation, Huckel Molecular Orbital Theory of conjugated systems Ladder operators and recursion relations of Hermite polynomials, Generating functions, Rodrigues Representation. Derivation of rigid rotator and H-atom (energy quantization)

Books Recommended

1. J. M. Bockris and A. K. N. Reddy, Modern Electrochemistry 1 (Ionics), Springer (2006).
2. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
3. Lowe, J. P. & Peterson, K. Quantum Chemistry Academic Press (2005).
2. McQuarrie, D. A. Quantum Chemistry Viva Books Pvt Ltd.: New Delhi (2003).
3. Mortimer, R. G. Mathematics for Physical Chemistry 2nd Ed. Elsevier (2005).
4. Pilar F. L. Elementary Quantum Chemistry 2nd Ed., Dover Publication Inc.: N.Y. (2001).
5. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
6. Levine, I. L. Quantum Chemistry 5th Ed., Prentice-Hall Inc.: New Jersey (2000).

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH501B	**Physical Chemistry-I**	**CO1**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
		CO2	**1**	**-**	**3**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1**
		CO3	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**1**
		CO4	**1**	**-**	**2**	**-**	**1**	**1**	**-**	**-**	**1**	**-**	**1**

Course Title/Code	Inorganic Chemistry-I (CHH502B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To familiarize students with Metal-Ligand Bonding in Transition Metal Complexes, to interpret electronic spectra of Transition Metal Complexes and understand the mechanism of catalytic activity by organometallic compounds.	
Course Outcomes (COs)		Mapping
CO1	Understand the theories of bonding in coordination compounds and Identify the type of metal-ligand bonding/ distortions in transition metal complexes.	Skill Development
CO2	Understand the electronic spectra of transition metal complexes and interpret structural information from the electronic spectral data	Skill Development
CO3	Understand the basics of Organometallic compounds and identify their role in catalysis	Employability
CO4	Understand the basic of metal carbonyls and interpret the bonding and structure from its vibrational spectra.	Skill Development
Prerequisites	B.Sc. with Chemistry as one of the Subject, Werner theory, valence bond theory & crystal field theory, introduction, classification and role of organometallic compounds in catalysis.	

SECTION-A

Metal-Ligand Bonding In Transition Metal Complexes: Crystal field theory, CFT splitting of d orbitals in octahedral, tetrahedral and square planar complexes, factors affecting CFT, CFSE, applications of CFT, Spectrochemical series and effects of covalency. Nephelauxetic series, magnetic properties of transition metal complexes, Jahn-Teller distortions, Jahn Teller stabilization energy; molecular orbital theory of octahedral complexes

SECTION-B

Electronic Spectra Of Transition Metal Complexes: Types of transition, selection rules for electronic transitions and relaxation of selection rules, width of absorption bands, electronic spectra of transition metal complexes, Term-symbols, Russel-Saunders states, Spectroscopic ground states; Coupling schemes, Orgel diagrams,determination of *Dq*and Racah parameters, Charge transfer spectra (MLCT, LMCT).

SECTION-C

Organometallic Chemistry-I: Classification of organometallic compounds, nomenclature, EAN, 18 e rule, reactions: oxidative addition, reductive elimination, insertion; σ bonded organometallic compounds and Π bonded organometallic compounds, role of organometallic compounds in catalysis (hydrogenation, hydroformylation)

SECTION-D

Metal Carbonyls: Classification of metal carbonyls (mono, bi, poly, bridging), general method of preparation, structure of metal carbonyl, vibrational spectra of metal carbonyls for bonding and structural elucidation (homoleptic and heteroleptic), introduction to tertiary phosphine as ligands.

Books Recommended

1. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed. Pearson Education, 2006.
2. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, 2006.
3. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999.
4. R. C. Mehrotra and A. Singh, Organometallic Chemistry: A Unified Approach, New Age International, 2006.
5. A. J. Elias, B. D. Gupta; Basic Organometallic Chemistry: Concepts, Synthesis and Applications of Transition metals, CRC Press and Universities Press, 2010.
6. J. D. Lee; Concise Inorganic Chemistry, 4th ed. Chapman and Hall, 1991

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH502B	Inorganic Chemistry-I	CO1	1	-	1	-	-	-	-	-	-	-	1
		CO2	1	-	3	-	-	1	-	-	-	-	1
		CO3	1	-	-	-	1	-	-	-	1	-	1
		CO4	1	-	2	-	1	1	-	-	1	-	1

Course Title/Code	Organic Chemistry-I (CHH503B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To give knowledge of the intermediates and their reacting behavior towards various reagents	
Course Outcomes (COs)		Mapping
CO1	To understand and enhance the knowledge of the students towards reaction intermediates and its use in synthesis	Skill Development
CO2	Develop the ability to demonstrate the reaction mechanism of organic reaction towards nucleophilic substitution reaction	Skill Development
CO3	To develop the ability to synthesize different aromatic organic compounds and identify the mechanism and reasons of the formation of the desired product towards nucleophilic and electrophilic reactions	Skill Development
CO4	To develop the ability to identify the neighbouring group behavior of the molecules in nucleophilic reaction	Skill Development
Prerequisites	Basic knowledge of organic Chemistry	

SECTION A

Reactive Intermediates in Organic Chemistry

Carbocations: Classical and non-classical, neighbouring group participation, ion-pairs, molecular rearrangements in acyclic, monocyclic and bicyclic systems, stability and reactivity of bridge-head carbocations.

Carbanions: Generation, structure and stability, ambident ions and their general reactions; HSAB principle and its applications.

Free Radicals: Generation, structure, stability and reactions, cage effects; radical-cations & radical anions,

Carbenes: Formation and structure, reactions involving carbenes and carbenoids.

Nitrenes: Generation, structure and reactions of nitrenes.

Arynes: Generation and reactivity of arynes, nucleophilic aromatic substitution reactions, SNAr mechanism; Ipso effect.

SECTION B

Nucleophilic Substitution at Saturated Carbon: Mechanism and Stereochemistry of $S_N1$and S_N2, S_Ni reactions. The reactivity effects of substrate structure, solvent effects, competition between $S_N1$and S_N2 mechanisms

SECTION-C

ELECTROPHILIC AROMATIC SUBSTITUTION: The Arenium ion mechanism, orientation and reactivity in monosubstituted benzene rings, ortho/ para ratio. Ipso substitution

NUCLEOPHILIC AROMATIC SUBSTITUTION: The Aromatic S_N1, S_N2 and benzyne mechanisms. Reactivtiy – effect of substrate structure, leaving group, and attacking nucleophilic

SECTION-D

Neighbouring Group Participation: Evidences of N.G.P.; the phenonium ion, participation by π and σ bonds, Anchimeric assistance, Classical versus non-classical carbonium ions

Books recommended

1. M.B. Smith and J. March; March's Advanced Organic Chemistry, 5th Edition, John Wiley & Sons, New York, 2001
2. P. Sykes; A Guide book to Mechanism in Organic Chemistry, 6th Edition, Orient Longman Ltd., New Delhi, 1997
3. S. M. Mukherjee and S.P. Singh; Reaction Mechanism in Organic Chemistry, 1st ed. Macmillan India Ltd., New Delhi, 1990
4. I. L. Finar;Organic Chemistry, Vol. II, 5th Edition, ELBS and Longman Ltd, New Delhi, 1996
5. R.T. Morrison and R.N. Boyd; Prentice: Organic Chemistry, 6thEdition, 1992.

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH503B	Organic Chemistry-I	CO1	3	-	-	3	3	-	-	-	2	2	3
		CO2	3	-	-	3	3	-	-	-	2	2	3
		CO3	3	2	-	3	3	-	-	-	2	2	3
		CO4	3	2	-	3	3	-	-	-	2	2	3

Course Title/Code	Analytical Chemistry (CHH504B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To impart knowledge on various analytical techniques To familiarize with the principle of analytical chemometrics	
Course Outcomes (COs)		Mapping
CO1	Understand the basics of analytical tools, data collection and design of analytical instruments	Skill Development
CO2	Analyze the working, instrumentation, principle, recording of the result obtained through latest analytical techniques	Skill Development
CO3	Able to evaluate data obtained from various techniques and apply them in chemical industries	Skill Development
CO4	Apply the concept of hyphenated instrumentation for molecular structural determination for various chemical industries	Employability
Prerequisites	B.Sc. with Chemistry as one of the Subject	

SECTION A

Analytical chemistry and chemical analysis, Classification of analytical methods, Method selection, Sample processing, Steps in a quantitative analysis, Data organization, analytical validations, Limit of detection and limit of quantization.
Atomic Spectroscopy: Atomic absorption (AAS), emission (AES) and inductively coupled plasma (ICP) spectroscopy.

SECTION B

Photoelectron Spectroscopy: Principle and Instrumentation, Types of Photoelectron Spectroscopy – UPS & XPS Binding Energies, Koopman's Theorem, Chemical Shifts. Photoelectron Spectra of Simple Molecules: N_2, O_2, F_2, CO, HF, NH_3 and H_2O - ESCA in qualitative analysis, Principles of Auger electron spectroscopy.

SECTION C

Optical Methods: Electronic spin resonance spectra, Mossbauer spectroscopy.
Theory, Instrumentation and applications of X-rays (emission, absorption, diffraction Methods)
Capillary electrophoresis, Potentiometry, Coulometry, Voltametry

SECTION D

Chromatographic Techniques: HPLC, HPTLC and GC its instrumentation, working, applications and limitations, Supercritical Chromatography.
Imaging Techniques – Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM)
Hyphenated Techniques: HPLC-MS, GC-MS, GC-IR, ICP-MS and TLC-MS

Books Recommended

1. D. A. Skoog; Principles of Instrumental Analysis, 5th ed. Saunders College Publishing,Philadelphia, London, 1998
2. G.W. Ewing; Instrumental Methods of Chemical Analysis, 5th ed. McGraw Hill Books Co.,New York, 1978
3. J.H. Kennedy, Analytical Chemistry: Principles, 2nd ed. Saunders Holt, London, 1990
4. G. D. Christian; Analytical Chemistry, 5th ed. John Wiley & Sons, New York, 1994
5. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William; Modern Methods of Chemical Analysis, 2nded. John Wiley, New York, 1976
6. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch; Analytical Chemistry - An Introduction, 7th ed. Saunders College Publishing, Philadelphia, London, 2000

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH504 B	Analytical Chemistry	CO1	2	2	-	-	3	3	2	2	2	2	2
		CO2	3	3	-	-	3	3	2	2	2	2	2
		CO3	3	2	-	-	2	3	2	2	2	2	2
		CO4	2	3	-	-	3	3	2	2	2	2	2

Course Title/Code	Laboratory-I (CHH505B)	
Course Type	Core	
L-T-P Structure	0-0-12	
Credits	6	
Course Objective	To introduce different experiments to develop the skills and strategic approaches for qualitative analysis of organic compounds, quantitative analysis of inorganic compounds, synthesis of chemical compounds	
Course Outcomes (COs)		Mapping
CO1	To be able to perform common laboratory techniques including reflux, distillation, recrystallization, vacuum filtration,and thin-layer chromatography	Skill Development
CO2	To be able to interpret detailed organic structure analysis	Skill Development
CO3	To be able to estimate the metals by gravimetrically or titrimetric ally	Skill Development
Prerequisites	Laboratory skills from Graduation	

LIST OF EXPERIMENTS

1. To prepare crystals of tetra-amine copper (II) sulphate $[Cu(NH_3)_4]\ SO_4$.
2. To prepare Nickel Dimethylglyoxime Complex $[Ni\ (DMG)_2]$ using Dimethylglyoxime
3. To prepare crystals of Sodium Ferrioxalate $Na_3[Fe(C_2O_4)_3].9H_2O$
4. To estimate magnesium in standard $MgSO_4$ solution using M/100 EDTA in complexometric titration usingEriochrome Black T indicator titrimetrically
5. To estimate amount of calcium in standard CaCO3 solution using M/10 EDTA in complexometric titration usingEriochrome Black T indicator titrimetrically
6. To prepare crystals of Chrome Alum $[K_2SO_4Cr_2(SO_4)_3.24H_2O]$
7. To estimate Aluminium or aluminium oxide in potash alum or ammonium aluminiumsulphate.
8. To estimate Ni2+ gravimetrically as Nickeldimethyl glyoxime (Ni-DMG) complex using DMG
9. To estimate Ba2+ gravimetrically as barium chloride

Books Recommended

1. A. Gaddamwar and P. R. Rajput, Organic and Inorganic Practical Chemistry, PragatiPrakashan, 2010
2. R. W. Helmkamp; A Text-book of Practical Organic Chemistry Including Qualitative Organic Analysis, Longman Green and Co. New York, 1956
3. J. Singh and L. D. S. Yadav; Advanced Practical Chemistry, PragatiPrakashan, 2012
4. A. Gaddamwar and P. R. Rajput, Organic and Inorganic Practical Chemistry, PragatiPrakashan, 2010
5. J. Singh and L. D. S. Yadav; Advanced Practical Chemistry, Pragati Prakashan, 2012

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH505 B	Laboratory -I	CO1	-	1	-	1	-	-	2	1	1	1	2
		CO2	-	1	-	1	-	-	1	2	1	2	1
		CO3	-	1	-	1	-	-	2	2	1	2	1

Semester-II

Course Code	Course Name	Offering Department	Course Type	Structure			Credits
			Deptt./Allied Core/Elective/ Audit	L	T	P	
CHH506B	Physical Chemistry-II	CH	CORE	4	0	0	4
CHH507B	Inorganic Chemistry-II	CH	CORE	4	0	0	4
CHH508B	Organic Chemistry-II	CH	CORE	4	0	0	4
CHH509B	Molecular Spectroscopy	CH	CORE	4	0	0	4
CHH510B	Laboratory-II	CH	CORE	0	0	8	4
RDO503	Scientific Research-I	CH	CORE	0	0	0	4
TOTAL (L-T-P) /CREDITS)				16	0	8	24

Course Title/Code	Physical Chemistry-II (CHH506B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	The student would be able to conceptualize and apply the concepts of Statistical Mechanics and Chemical kinetics	
Course Outcomes (COs)		Mapping
CO1	explain the connection between classical statistical mechanics and quantum statistical mechanics	Skill Development
CO2	define and discuss the Boltzmann distribution and the role of the partition function	Skill Development
CO3	Identify and describe different diffraction methods	Employability
CO4	To understand the different theories of chemical kinetics	Skill Development
Prerequisites	B.Sc. with Chemistry as one of the Subject, Thermodynamics, Quantum chemistry etc,	

SECTION-A

Statistical Mechanics: Fundamentals: Idea of microstates and macrostates, Concept of distributions- Binomial & multi-nomial distributions for non-degenerate and degenerate systems, Thermodynamic probability and most probable distribution, Canonical and other ensembles, Statistical mechanics for systems of independent particles and its importance in chemistry, Types of statistics: Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Thermodynamic probability (W) for the three types of statistics, Derivation of distribution laws (most probable distribution) for the three types of statistics, Lagrange's undetermined multipliers, Stirling's approximation, Molecular partition function and its importance, Assembly partition function

SECTION-B

Thermodynamics Applications to ideal gases*:* The molecular partition function and its factorization, Evaluation of translational, rotational and vibrational partition functions for monatomic, diatomic and polyatomic gases, The electronic and nuclear partition functions, Calculation of thermodynamic properties of ideal gases in terms of partition function, Statistical definition of entropy, Ortho- and para-hydrogen, statistical weights of ortho and para states, symmetry number, Calculation of equilibrium constants of gaseous solutions in terms of partition function, perfect gas mixtures.

SECTION-C

Diffraction Methods: Atomic scattering factors, Scattering by a small crystal, Direct and reciprocal lattice, Miller indices, Bragg's law and Laue's equations, Structure factor, Systematic absences for different types of unit cells (primitive, face-centred, body-centred, side-centred) and application to some common metal and metal salt structures (rock salt, zinc blende). Space groups, Glide planes and screw axes, Structure determination for organic crystals like naphthalene, Fourier series **Patterson's functions** Heavy atom method, Comparison of X-ray method with electron and neutron diffraction methods,

SECTION-D

Kinetics: *Theories of reaction rates:* Collision theory, Potential energy surfaces (basic idea), Transition state theory (both thermodynamic and statistical mechanics formulations), Theory of unimolecular reactions, Lindemann mechanism, Hinshelwood treatment, RRKM model (qualitative treatment)

Solution kinetics: Factors affecting reaction rates in solution, Effect of solvent and ionic Strength (primary salt effect) on the rate constant, Secondary salt effects

Books Recommended

1. McQuarrie, D. A. *Statistical Mechanics* Viva Books Pvt. Ltd.: New Delhi (2003).
2. Bagchi B. Statistical Mechanics for Chemistry and Material Science, CRC Press (2018).
3. L. D. Landau and E. M. Lifshitz, Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd ed. (2005).
4. Kakkar, R., *Atomic & Molecular Spectroscopy* Cambridge University Press (2015).
5. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
6. McQuarrie, D. A. & Simon, J. D. *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books (2001).

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH506B	**Physical Chemistry-II**	**CO1**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
		CO2	**1**	**-**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1**
		CO3	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**1**
		CO4	**1**	**-**	**2**	**-**	**1**	**1**	**-**	**-**	**1**	**-**	**1**

Course Title/Code	Inorganic Chemistry II (CHH507B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	A. The course objective is to utilize the concept of coordination chemistry and study their reaction mechanism and kinetics. B. To teach the basic aspects of reactions of complexes having different geometries, characterization of their intermediates and transition state. C. To study the mechanism of electron transfer in coordination spheres	
Course Outcomes (COs)		Mapping
CO1	Identify the products formed while studying the reaction mechanism of coordination complexes	Employability
CO2	Understand the use of different precursors in industrial manufacturing of certain product with same molecular formula but different configuration	Skill Development
CO3	Understand the use of electron transfer reactions and shall demonstrate an ability to display reactant compounds, conditions like temp, pressure and concentrations carried out in chemical laboratory	Skill Development
CO4	Understand the impact of chemical end product development in formulation of drug synthesis and in various chemical industries	Employability
CO5	Develop the understanding of thermal and optical electron transfer reactions	Employability
Prerequisites	Inorganic Chemistry I	

SECTION-A

Kinetics And Mechanism Of Substitution Reactions-I: Mechanisms of substitution reactions of tetrahedral, square planar, trigonal bipyramidal, square pyramidal and octahedral complexes; Potential energy diagrams, transition states and intermediates, Substitution reactions in octahedral complexes their mechanisms and kinetics, concept of lability and inertness on the basis of VBT and CFT, rate laws (Eigen-Wilkins mechanism, Fuoss Eigen equation), Acid hydrolysis, Base hydrolysis.

SECTION-B

Kinetics And Mechanism Of Substitution Reactions-II: Substitution in Square Planar Complexes, kinetics, Berry pseudorotation, Trans Effect and its applications to synthesis of complexes, theories of trans effect, mechanism, factors affecting rate of substitution, applications of complexes.

Metal complex sensitizers: Electron relay, semiconductor supported metal oxide systems, water photolysis, nitrogen fixation and CO_2 reduction.

SECTION-C

Electron Transfer Reactions-I : Mechanism and rate laws; various types of electron transfer reactions (outer and inner sphere), HOMO and LUMO of oxidant and reductant, chemical activation. Precursor complex formation and rearrangement, Marcus-Husch theory, Nature of bridge ligands, fission of successor complexes, Two-electron transfers,Synthesis of coordination compounds using electron transfer reactions, mixed valence complexes andinternal electron transfer.

SECTION-D

Electron Transfer Reactions-II: Redox reactions of metal complexes in excited states, correlation between thermal and optical electron transfer reactions; excited electron transfer reactions using $[Ru(bpy)_3]^{2+}$ complex and $[Fe(bpy)_3]^{3+}$ complex as examples. Role of spin-orbit coupling, life-times of excited states in these complexes

Books Recommended

1. F. Basalo and R. G. Pearson;Mechanism of Inorganic Reactions, 2nd ed. Wiley Eastern Ltd., New Delhi, 1967
2. D. F. Shriver and P. W. Atkins;Inorganic Chemistry, 3rded. ELBS, London, 1999
3. F. A. Cotton and G. Wilkinson;Advanced Inorganic Chemistry, 6thed.John Wiley & Sons, New York, 1999
4. D.N. Sathyanarayana;Electronic Absorption Spectroscopy and Related Technique,Universities Press (India) Ltd., Hyderabad, 2001
5. K.F. Purcell, J.C. Kotz; Inorganic chemistry, Saunders, 1977

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH507B	Inorganic Chemistry-II	CO1	-	-	-	1	-	2	-	3	-	-	1
		CO2	-	1	-	-	2	-	3	-	-	-	1-
		CO3	-	1	-	-	-	-	2	-	3	-	-
		CO4	1	2	-	-	-	3	-	-	-	-	1
		CO5	-	-	1	-	-	2	-	3	-	-	-

Course Title/Code	Organic Chemistry-II (CHH508-B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To familiarize students with carbon carbon multiple bond, aromaticity linear free energy relationship and advance heterocyclic reactions To impart knowledge on Elimination reactions.	
Course Outcomes (COs)		Mapping
CO1	Distinguish between the mechanism of nucleophilic addition reactions, elimination reactions.	Skill Development
CO2	Apply the Huckle's rule to determine the concept of aromaticity	Skill Development
CO3	Understand the concept of linear free energy relationship, Hammet Equation	Skill Development
CO4	Synthesis the advanced Heterocyclic compounds and understand its importance	Skill Development
CO5	Develop confidence for self-education and ability for life-long learning	Employability
Prerequisites	None	

SECTION A

Addition To Carbon–Carbon Multiple Bonds: Electrophilic, free-radical and nucleophilic addition: Mechanistic and Stereo chemical aspects involving electrophiles, nucleophiles and free radicals, regio– and chemoselectivity, Orientation and reactivity. Hydrogenation of doubleand triple bonds, hydrogenation of aromatic rings.Hydroboration and Michael reaction, SharplessEpoxidation.

SECTION B

Elimination Reactions: The E1, E2 and E1Cb (Elimination Unimolecular conjugate Base) mechanisms, Orientation of the double bond. Hofmann versus Saytzeff elimination, Pyrolyticsyn-elimination, Competition between substitution and elimination reactions

SECTION C

Nature of Bonding in Organic molecules: Delocalized chemical bonding –conjugation, cross conjugation, resonance, hyperconjugation, tautomerism. Aromaticity in benzenoid and nonbenzenoid compounds, alternante and non-alternante hydrocarbons, Huckel's rule

Effects Of Structure On Reactivity: Linear free energy relationships (LFER), the Hammett equation – substituent and reaction constants; the Taft treatment of polar and steric effects in aliphatic compounds

SECTION D

Heterocyclics With Two Hetero Atoms: Synthesis, reactivity, aromatic character and importance of the following heterocycles:Indole,Pyrazole, Imidazole, Oxazole, Thiazole, Isoxazole, Isothiazole, Pyridazine, Pyrimidine.Pyrazine, Oxazine, thiazine, benzimidazole, benzoxazole and benzthiazole.

Books recommended

1. M.B. Smith and Jerry March; March's Advanced Organic Chemistry, 5th ed. John Wiley & Sons, New York, 2001
1. P. Sykes;A Guide Book to Mechanism in Organic Chemistry, 6th ed. Orient Longman Ltd., New Delhi, 1997
2. S. M. Mukherjee and S.P. Singh; Reaction Mechanism in Organic Chemistry, 1st ed. Macmillan India Ltd., New Delhi, 1990
3. T.H. Lowry and K. S. Richardson; Mechanism and Theory in Organic Chemistry, 3rd ed. Addison – Wesley Longman Inc., 1998
4. P. S. Kalsi; Organic Reactions and Their Mechanisms, 1st ed. New Age International Pub., New Delhi, 1996

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH508-B	Organic Chemistry II	CO1	-	2	-	3	3	-	-	2	-	2	2
		CO2	1	-	-	-	-	-	-	2	-	2	2
		CO3	-	-	-	-	-	-	1	-	-	-	2
		CO4	-	2	2	3	-	-	-	3	-	3	3
		CO5	-	-	-	-	-	-	-	3	-	3	-

Course Title/Code	Molecular Spectroscopy (CHH509B)

Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To use spectroscopic methods for qualitative and quantitative analysis with imparting knowledge of the basic aspects of nuclear magnetic resonance (NMR) spectroscopy, UV-Visible, IR Spectroscopy and mass fragmentation.	
Course Outcomes (COs)		Mapping
CO1	To understand the UV-Visible, Molecular Luminescence & Vibrational Spectroscopy.	Skill Development
CO2	To demonstrate the principles of 1H-NMR & 13 C-NMR Spectroscopy.	Skill Development
CO3	To learn the interpretation of NMR spectra for identification of compounds.	Skill Development
CO4	To analyze the fragmentation pattern of the compound by mass spectroscopy.	Skill Development
Prerequisites	Analytical Chemistry from Sem I	

SECTION A

Spectroscopy-I: Principle, Instrumentation and application of UV-visible, Molecular luminescence (fluorescence, chemiluminescence, phosphorescence)

Vibrational Spectroscopy: IR spectroscopy (Far IR and near IR), Raman Spectroscopy, Difference between Raman and IR spectra, Emission spectra

SECTION B

Spectroscopy-II: PMR: Natural abundance of ^{13}C,^{19}F and ^{31}P nuclei,the spinning nucleus, effect of external magnetic field, precessional motion and frequency Energy transitions Chemical shift and its measurements, factors influencing chemical shift, anisotropic effect, integral of protons spin spin coupling splitting theory magnitude of coupling constant simple, virtual and complex spin coupling , Chemical and magnetic equivalence proton exchange, factors affecting the coupling- First and non first order spectra, simplification of complex spectra (solvent effect, double resonance and field effect).

SECTION C

Spectroscopy-III: CMR: Resolution and multiplicity of ^{13}C NMR, ^{1}H-decoupling noise decoupling, broad band decoupling, Deuterium, fluorine and phosphorus coupling, NOE signal enhancement off-resonance, proton decoupling, structural application of CMR DEPT and INEPT experiments, Introduction to 2D NMR .

SECTION D

Spectroscopy-IV: Mass: Theory, instrumentation and modification Unit mass and molecular ions Important terms single, double/multiple charged ion metastable peak base peak isotopic mass peak, relative intensity etc.

Books Recommended-

1. R.M. Silverstein, D. J. Kiemle and F.X. Webster; Spectroscopic identification of organic compounds, 7th ed. John Wiley & sons, 2005
2. William Kemp; Organic spectroscopy 3rd ed. Palgrave publishing house, 2008
3. M. Rose and R.A. W. Johnstone; Mass Spectrometry for Chemists and biochemists, 2nd ed. Cambridge University Press, 2012
4. D.H. Williams and I. Fleming; Spectroscopic methods in organic chemistry, 6th ed. McGraw Hill Publishing Co. 1989

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH509B	Molecular Spectroscopy	CO1	-	3	-	-	-	3	1	1	-	1	2
		CO2	-	3	-	-	-	3	1	2	-	2	3
		CO3	-	3	-	-	-	3	1	2	-	1	1
		CO4	-	3	-	-	-	3	1	2	-	1	2

Course Title/Code	Laboratory-II (CHH510B)

Course Type	Core	
L-T-P Structure	0-0-8	
Credits	4	
Course Objective	To introduce different experiments to develop the skills and strategic approaches for qualitative analysis of organic compounds, quantitative analysis of inorganic compounds, synthesis of chemical compounds	
Course Outcomes (COs)		Mapping
CO1	To define the qualitative and quantitative analysis of inorganic and organic compounds	Skill Development
CO2	To understand the methods of analysis of components of mixtures with high accuracy	Skill Development
CO3	To apply the theoretical concept of spectroscopy to identify structure of different molecules.	Skill Development
CO4	To study the reaction rate or kinetics of a reaction	Skill Development
Prerequisites	Laboratory I	

INORGANIC CHEMISTRY PRACTICALS

1. Quantitative separation and determination of the following pairs of metal ions using gravimetric and volumetric methods. For example: Ag^{+} (gravimetrically) and Cu^{2+} (volumetrically), Cu^{2+} (gravimetrically) and Zn^{2+} (volumetrically), Fe^{3+}(gravimetrically) and Ca^{2+} (volumetrically), Mg^{2+} (gravimetrically) and Ca^{2+} (volumetrically) etc.

ORGANIC CHEMISTRY PRACTICALS

1. Preparation of compounds involving not more than two steps.
2. Identification of organic compounds in given mixture.

PHYSICAL CHEMISTRY PRACTICALS

1. Rate constant of acid catalyzed hydrolysis of sucrose by polarimetric method.
2. Rate constant of acid catalyzed hydrolysis of sucrose by chemical method.
3. Rate constant of $FeCl_3$-catalyzed H_2O decomposition by gasometric method.
4. Degree of hydrolysis of urea hydrochloride by kinetics method.

Books recommended:

1. A. Gaddamwar and P. R. Rajput; Organic and Inorganic Practical Chemistry, PragatiPrakashan, 2010
2. R. W. Helmkamp; A Text-book of Practical Organic Chemistry Including Qualitative Organic Analysis, Longman Green and Co. New York, 1956
3. J. Singh and L. D. S. Yadav; Advanced Practical Chemistry, PragatiPrakashan, 2012

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH510B	Laboratory-II	CO1	-	1	-	1	-	-	2	1	1	1	2
		CO2	-	1	-	1	-	-	1	2	1	2	1
		CO3	-	1	-	1	-	-	2	2	1	2	1
		CO4	-	1	-	1	-	-	2	1	1	1	2

Course Title/Code	SCIENTIFIC RESEARCH-I (RDO503)	
Course Type	Core	
L-T-P Structure	0-0-8	
Credits	4	
Course Objective	To impart knowledge on various analytical techniques To familiarize with the principle of analytical chemometrics	
Course Outcomes (COs)		Mapping
CO1	The student shall be able to describe research and its impact.	Skill Development
CO2	The student shall be able to identify broad area of research, analyze, the processes and procedures to carry out research.	Skill Development
CO3	The student shall be able to use different tools for literature survey	Skill Development
CO4	The student is able choose specific area of research and supervisor/mentor is finalized	Skill Development
CO5	To understand and adopt the ethical practice that are to be followed in the research activities	Employability
CO6	To work in groups with guidance	Employability
Prerequisites	Basic knowledge of Research	

SECTION A

Unit 1: What is Research and its impact?

1.1 Capturing the current research trends

1.2 Insight about scientific research performed by renowned experts in the related field (case studies)

1.3 Do's and Don'ts pertaining to research

SECTION B

Unit 2: Identification of Broad Area of research

2.1 Identification of thrust area of research for deciding broad area

2.2 Framing the research questions and hypothesis

2.3 Identification of the research gap based on feasibility of problem

2.4 Exploration of in-house and commercially available facilities related to broad area

SECTION C

Unit 3: Understanding the tools for Literature Survey

3.1 Finding research papers related to a topic

3.2 Understanding the different aspects of Literature search

3.3 Usage of different sources like Google scholar, WoS, SCI/ SCIE, PubMed, Scopus, ABDC, EBSCO etc.
3.4 Search for online journals relevant to research area
3.5 Indexing of Journals
3.5 Usage of scholarly networking sites like Research Gate, Mendeley, and Academia.edu etc.
3.6 Demo sessions on the usage of above mentioned sources

SECTION D

Unit 4: Review of research papers pertaining to broad area and specific area of research
4.1 Selection of relevant papers
4.2 Finding specific research problem from broad area of research
4.3 Literature survey and justification of specific research problem
4.4 Experimentation and data cleaning and verification
4.5 Understanding and selection of the research domain
4.6 Seeking information through published work w.r.t the problem
4.7 Reading & categorizing the downloaded/referred papers and structuring of the idea
4.8 Model design about framing the research questions

Unit 5: Report Writing and Presentation skill Development
5.1 Report making on the surveyed literature to cater the basic idea of the research papers
5.2 Compiling and analyzing the published results to justify and understand the proposed ideas
5.3 Usage of MS-PowerPoint and other technical resources for the presentation
5.4 Development of presentation skills and group addressing
5.5 Scientific/technical writing and ethical practice, project report

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
RDO503	Scientific Research-I	CO1	2	2	-	2	2	3	3	3	2	2	2
		CO2	2	2	-	2	2	2	2	2	2	2	2
		CO3	-	-	-	-	-	2	3	2	-	-	-
		CO4	-	-	-	-	-	3	2	2	-	-	-
		CO5	-	-	-	-	-	2	3	3	-	-	-
		CO6	-	-	-	-	-	3	3	3	-	-	-

Semester-III

Course Code	Course Name	Offering Department	Course Type	Structure			Credits
			Deptt./Allied Core/Elective/ Audit	L	T	P	
CHH601B	Symmetry & Group Theory	CH	Core	4	0	0	4
CHH602B/ CHH608B/ CHH613B	Specialization-I: Magneto-chemistry, Chemical Kinetics, Catalysis & ion transport/ Organometallic Chemistry of Transition Metals & Bio Inorganic Chemistry/ Statistical Stereochemistry & Asymmetric Synthesis	CH	Special Core	4	0	0	4
CHH603B/ CHH609B/ CHH614B	Specialization-II Irreversible thermodynamics, Transport Phenomenon, Photochemistry & Fast Reaction/ Supramolecular Chemistry & Metal Clusters/ Photochemistry & Pericyclic Reaction	CH	Special Core	4	0	0	4
CHH604B/ CHH605B/ CHH610B/ CHH611B/ CHH615B/ CHH616B/ CHH617B	Elective: Advanced Spectroscopy/ Advanced Chemical Kinetics/ Solid state Materials / Inorganic & Biological Catalysis/ Modern Organic Synthetic Technique / Bioorganic Chemistry/ Chemistry of Natural Products	CH	Special Core	4	0	0	4

CHH606B/ CHH612B/ CHH618B	**Physical Laboratory/ Inorganic Laboratory/ Organic Laboratory**	**CH**	**Core**	**0**	**0**	**8**	**4**
RDO603	**Scientific Research-II**	**CH**	**Core**	**0**	**0**	**4**	**4**
TOTAL (L-T-P) /CREDITS)				**16**	**0**	**8**	**24**

Course Title/Code	Symmetry & Group Theory (CHH601B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To familiarize with Symmetry elements and symmetry operations To impart knowledge on optical activity, dipole moment, symmetry and spectroscopic data of any molecules	
Course Outcomes (COs)		Mapping
CO1	Understand point group representation of various molecules	Skill Development
CO2	Apply basics of group theory to identify the symmetry operations and symmetry elements in various molecules	Skill Development
CO3	analyze reducible and irreducible representations	Skill Development
CO4	analyze direct product of various reducible and irreducible representations	Skill Development
CO5	create the co-relation diagram for terms splitting in different geometrical environment	Skill Development
CO6	apply the basics of group theory for different applications in spectroscopy, hybridization and other vibrational modes of molecules	Skill Development
Prerequisites	Basic Inorganic Chemistry	

SECTION A

Molecular Symmetry: Symmetry elements and symmetry operations, definition of group and its characteristics, subgroups, classes, similarity transformation. Products of symmetry operations, equivalent atoms and equivalent symmetry elements, relations between symmetry elements and operations, classes of symmetry operations, point groups and classification.Symmetry: Optical activity and dipole moment

SECTION B

Representation of Groups: Reducible and irreducible representations. The great Orthogonality theorem, character tables, position vector and base vector as basis for representation. Wavefunctions as bases for irreducible representations (p an d-orbitals). Direct product. Vanishing integral.

SECTION C

Coupling for Transition Metals: Russell-Saunders coupling for d_n method of states. Splitting of one-electron levels in an octahedral environment. Correlation diagram. The method of descending symmetry, selection rules, Application of group theory to chemical bonding, hybridizations

SECTION D

Application of Group Theory: Applications of group theory in Vibrational Spectroscopy: A brief idea about Infrared and Raman scattering spectroscopy. Vibrational modes as basis of group representations, Mutual exclusion principle, Classification of vibrational modes (i.e. stretching and angle deformation vibrations)

Books Recommended

1. F.A.Cotton; Chemical applications of Group Theory, 2nd ed. John Wiley & Sons, 1971
2. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Longman, 1962
3. V. H. H. Jaffe and M. Orchin; Symmetry in Chemistry, John Wiley & Sons, New York, 1965

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH601B	Symmetry & Group Theory	CO1	1	-	-	1	-	2	-	-	-	2	-
		CO2	1	2	-	-	2	-	2	-	-	1	-
		CO3	1	-	2	-	-	-	2	-	2	-	2
		CO4	1	-	2	-	-	2	-	-	-	1	-
		CO5	1	-	2	2	-	2	-	-	-	-	2
		CO6	-	1	-	-	2	2	-	-	-	2	1

Course Title/Code	Physical Special I: Magneto-chemistry, Chemical Kinetics, Catalysis & ion transport (CHH602B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To impart knowledge of magneto chemistry To impart advanced knowledge and application of kinetics and electrochemistry	
Course Outcomes (COs)		Mapping
CO1	understand the knowledge of magnetochemistry and its application	Skill Development
CO2	understand knowledge and applications of kinetics and electrochemistry	Skill Development
CO3	understand knowledge and applications of Uncatalyzed and platinum group metals	Employability
CO4	understand the concept of Ion Transport in solutions	Skill Development
Prerequisites	Physical Chemistry I&II	

SECTION-A

Magnetochemistry: Magnetic susceptibility and its determination, susceptibility equivalents, Pascal's law and its applications, Diamagnetism of elements, Compounds and its ions, Langevin's theory of paramagnetism, Curie's law, Weiss molecular field theory of paramagnetism, Curie- Weiss law, Determination of Curie point.

SECTION-B

Chemical Kinetics: Kinetics of fast reactions: Techniques of study of fast reactions with reference to stop flow, T-Jump, Flash photolysis and relaxation phenomena. Kinetics of oscillating reactions with special reference to Belousov-Zhabotinskii mechanism (B-Z mechanism)

SECTION-C

Catalysis & Kinetics: a) Oxidation of sugars by $K_3Fe(CN)_6$ and Cu^{+2} in alkaline medium, (b)Uncatalyzed and platinum group metals (Osunium, ruthenium, iridium, palladium, rhodium etc.) Catalyzed oxidation of organic and inorganic compounds by $K_3Fe(CN)_6$ and Ce (IV) etc in acidic / alkaline medium.

SECTION-D

Ion Transport in solutions: Ionic movement under the influence of an electric field , mobility of ions, ionic drift velocity and its relation with current density, Einstein relation between the absolute mobility and diffusion coefficient, the Stokes-Einstein relation , the Nernst -Einstein equation, Waldens rule, the Rate- Process approach to ionic migration , the Rate process equation for equivalent conductivity, total driving force for ionic transport, Nernst - Planck Flux equation, ionic drift and diffusion potential , the Onsager phenomenological equations, The basic equation for the diffusion, Planck-Henderson equation for the diffusion potential

Reference Books

Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).
G. W. Castellan, Physical Chemistry, 4th Ed., Narosa (2004).

G. A. McQuarrie, J. D. Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).
T. Engel, P. Reid, Physical Chemistry 3rd Ed., Prentice-Hall (2012).
M. J. Assael, A. R. H. Goodwin, M. Stamatoudis, W. A. Wakeham, S. Will, Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
S. S. Zundhal, Chemistry concepts and applications Cengage India (2011).
D. W. Ball, Physical Chemistry Cengage India (2012).
R. G. Mortimer, Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
I. N. Levine, Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
C. R. Metz, Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH602B	**Physical Special I: Magneto-chemistry, Chemical Kinetics, Catalysis & ion transport**	**CO1**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
		CO2	**1**	**-**	**2**	**-**	**-**	**2**	**-**	**-**	**-**	**-**	**1**
		CO3	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**1**
		CO4	**1**	**-**	**1**	**-**	**3**	**1**	**-**	**-**	**1**	**-**	**1**

Course Title/Code	Inorganic Special-I Organometallic Chemistry of Transition Metals & Bio Inorganic Chemistry (CHH608B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To conceptualize the concept of bonding between organic ligands and transition metals, understand their physical and chemical properties, metal ions on biological system and apply the knowledge of metal toxicity in development of chelating agents for metal detoxification	
Course Outcomes (COs)		Mapping
CO1	Understand the concept of nomenclature in organometallic compounds and identify the specific characteristics of ligands	Skill Development
CO2	Understand the various reaction types and their mechanisms in various catalysis reaction by organometallic compounds	Employability
CO3	Analyze the impact of various inorganic compounds for different biological activities by understanding the fundamentals of bioinorganic chemistry.	Skill Development
CO4	Understand the role of metal ions in organometallic compounds for various replication/ transcription processes for their applicability in biosensor and other applications.	Employability
Prerequisites	Inorganic Chemistry-I & II	

SECTION A

Organometallic compounds-I: Introduction, Stable electron configurations, Electron count preference, Electron counting and oxidation states, Nomenclature.

Ligands: Carbon monoxide, Phosphines, Hydrides and dihydrogen complexes, Alkyl, alkenyl, alkynyl, and -aryl ligands, Alkene and alkyne ligands, Nonconjugated diene and polyene ligands. Butadiene, cyclobutadiene and cyclooctatetraene, Benzene and other arenes, The allyl ligand, Cyclopentadiene and cycloheptatriene, Carbenes, Alkanes, agostichydrogens, and noble gases, Dinitrogen and nitrogen monoxide

SECTION B

Organometallic compounds-II: d-Block carbonyls (Preparation, Properties), Metallocenes, Metal -Metal bonding and metal clusters. Reactions: Ligand substitution, Oxidative addition and reductive elimination, σ -Bond metathesis, 1,1-Migratory insertion reactions, 1,2-Insertions and β –hydride Elimination, Nucleophilic and Electrophilic attack, Hydride eliminations and cyclometallations

SECTION C

Bio-Inorganic Chemistry-I: Fundamentals of inorganic biochemistry, geo-chemical effects on life systems, essential and non-essential elements in bio-systems.Role of alkali/alkaline earth metals in bio-systems, Role of 3*d* block elements and nonmetalsin bio-systems, Role of metal ions in oxygen carriers and synthetic oxygen carriers.Designing of chelating agents and metal chelates as medicines, Fixation of dinitrogenbiologically and abiologically, biotransformation of nonmetallic inorganic compounds, Environmental bioinorganic chemistry, Metal ions as probes for locating active sites, Biocatalysts

SECTION D

Bio-Inorganic Chemistry-II: Inhibitions as competitive and non-competitive, metals and metalloproteins, Metal complexes of polynucleotides, nucleosides and nucleic acids (DNA & RNA), Templatetemperature, stability of DNA, Role of metal ions in replication and transcription process of nucleic acids, Biochemistry of di oxygen, bioinorganic chips and biosensors, Biochemistry of calcium as hormonal messenger, muscle contraction blood clotting, neurotransmitter, calcification reclaiming of barren land. Cytochromes, ferrodoxins and iornsulphur proteins, ion transport across membranes, Biological nitrogen fixation, PSI, PS – II, Oxygen uptake proteins

Reference Books

1. Bioinorganic Chemistry Williams, An Introduction to Bioinorganic Chemistry
2. M. N. Hughes, Inorganic Chemistry of Biological Processes
3. Ochiai: Bioinorganic Chemistry: Allyn& Bacon Burton
4. P. L. Pauson, Organometallic Chemistry
5. T. S. Swain and D. S. T. Black, organometallic Chemistry
6. Eichhorn: Inorganic Biochemistry : Vol I , 2 Elsevier
7. Williams: an Introduction to Bioinorganic Chemistry, C.C. Thomos Spring III
8. Wallace: Decade on synthetic chelating agent in Inorganic plant nutrition, Wallace

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH608B	**Inorganic Special-I Organometallic Chemistry of Transition Metals & Bio Inorganic Chemistry**	**CO1**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**
		CO2	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**
		CO3	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**
		CO4	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**

Course Title/Code	ORGANIC SPECIAL-I: STATISTICAL STEREOCHEMISTRY & ASYMMETRIC SYNTHESIS (CHH613B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	The objective of the course is to make the student understand the concepts and get familiarized with stereochemistry principles, terminology, nomenclature and conformations of basic acyclic and cyclic organic compounds along with the various methods of asymmetric synthesis.	
Course Outcomes (COs)		Mapping
CO1	To understand the nomenclature, conformation, configuration, representation and interconversion of cyclic and acyclic. Molecules and learn and assign about relative and absolute configuration.	Skill Development
CO2	To find and assign the relationship between the molecules: homologues, conformational, configurational, epimers, anomers, geometrical, optical, enantiomers, identical, diastereomers etc.	Skill Development
CO3	To find the topicity of ligands, lone pairs and faces, their nomenclature along with the prochirality nomenclature i.e. Pro-R,Pro-S, Re and Si.	Skill Development
CO4	To learn the application of various methodologies used in asymmetric synthesis.	Employability
Prerequisites	Organic Chemistry-I & II	

SECTION A

Stereochemistry-I: Configurational Isomerism (optical and geometrical), Resolvable and non-resolvable compounds, Geometrical isomerism (single bond, multiple bond and monocyclic, bicyclic, bridging and polycyclic structure), and threo-erythro nomenclature, representation and interconversion of Fischer, Newman, Sawhorse and flying wedge formulae, Relative and absolute configuration, Epimers and anomers

SECTION B

Stereochemistry-II: Relationship between the molecules: homologues, conformational, configurational, epimers, anomers, geometrical, optical, enentiomers, identical, diastereomers etc. Axis of chirality and plane of chirality (ANSA compounds, p-cyclophanes, transcyclooctene), optical isomerism in allenes, biphenyls (atropoisomerism), bipyrolles, binapthols, spiranes, hemispiranes.elementary ideas about stereochemistry of tertiary amines, quaternary salts, sulphur and phosphorous compounds.

SECTION C

Stereochemistry-III: Topicity of ligands, lone pairs and faces, their nomenclature and prochiralcentre. Stereospecific and stereoselective reaction.Topicity in molecules Homotopic, stereoheterotopic (enantiotopic and diastereotopic) groups and faces- symmetry, substitution and addition criteria. . Prochirality nomenclature: Pro-R, Pro-S, Re and Si. Stereoselective reactions: Substrate stereoselectivity, product stereoselectivity, enantioselectivity and diastereoselectivity. Conditions for stereoselectivity: Symmetry and transition state criteria, kinetic and thermodynamic control. Analytical methods: % Enantiomeric excess, enantiomeric ratio, optical purity, % diastereomeric excess and diastereomeric ratio.

SECTION D

Methodologies in Asymmetric Synthesis: Strategies in Asymmetric Synthesis:

l.Chiral substrate controlled: Nucleophilic additions to chiral carbonyl compounds (Cram's rule), α-alkylation through oxazolines and azaenolates, α-alkylation using imines, Ender's asymmetric α-alkylation of hydrazones of aldehydesand ketones,

2.Chiral auxiliary controlled: 1, 4 Asymmetric induction (Prelog's rule), α-alkylation of amino acids via imidazolidinones, α-alkylation ofrα-hydroxyl acids via lactones, asymmetric α-alkylation of glycine, evans alkylation of S-prolinol

3.Chiral reagent controlled: enantioselective hydroboration i.e. use of chiral boronhydrides(hydroborations with diispinocampheylborane and hydroborations with monoispinocampheylborane) and Chiral trialkylboranes(Midland's reagent)

4.Chiral catalyst controlled: Jacobsen epoxidation, homogenous hydrogenation, ChiralRu and Rh catalysts for homogenous asymmetric hydrogenation.

Reference Books

1. Jonathan Clayden, Nick Geeves, Stuart Warren, Organic Chemistry, Oxford University Press, second edition
2. D. Nasipuri, Stereochemistry of Organic Compounds-Principles & Applications, New Age International.
3. P.S. Kalsi, Stereochemistry of Organic Compounds- Conformation and Mechanism: New Age International.
4. Ernest L Eliel& Samuel H. Wilen, Stereochemistry of Carbon compounds.
5. R S Ward, Stereo selectivity in organic synthesis
6. Howard, S. I.; Morrison, J. D. Asymmetric Synthesis; Academic: New York. 1983; Vol. 2.
7. Nogradi. M. Stereoselective Synthesis.

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH613B	Organic Special-I: STATISTICAL STEREOCHEMISTRY & ASYMMETRIC SYNTHESIS	CO1	3	-	2	-	2	-	-	-	3	-	3
		CO2	3	-	2	-	2	-	-	-	3	-	3
		CO3	3	-	2	-	2	-	-	-	3	-	3
		CO4	3	-	2	-	2	-	-	-	3	-	3

Course Title/Code	Physical Special II: Irreversible thermodynamics, Transport Phenomenon, Photochemistry & Fast Reaction (CHH603B)

Course Type	Core	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To impart knowledge of Irreversible thermodynamics, To impart advanced knowledge of transport phenomenon To impart photochemistry & Fast reactions	
Course Outcomes (COs)		**Mapping**
CO1	understand the knowledge of Irreversible thermodynamics	**Skill Development**
CO2	understand knowledge of transport phenomenon	**Skill Development**
CO3	understand knowledge of photochemistry & Fast reactions	**Employability**
CO4	understand the concept of Photochemistry	**Skill Development**
Prerequisites	**Physical Chemistry I&II**	

SECTION-A

Irreversible thermodynamics Meaning and scope of irreversible thermodynamics, Thermodynamic criteria for nonequilibrium states, Phenomenological laws- Linear laws, Gibbs equation, Onsager's reciprocal relations, Entropy production- specific examples of entropy production, Non-equilibrium stationary states, Prigogine's principle of maximum entropy production, Coupled phenomena. Some important applications of activation

SECTION-B

Transport phenomena: Diffusion coefficients, Fick's first and second laws, relation between flux and viscosity, relation between diffusion coefficient and mean free path, relation between thermal conductivity/viscosity and mean free path of a perfect gas, Einstein relation, Nernst-Einstein equation, Stokes-Einstein equation, Einstein-Smoluchowski equation.

SECTION-C

Photochemistry: Primary and secondary processes in photochemistry, Fate and properties of excited states, Photoluminescence and Photo stationary state, Photosensitization, Rice – Herzfeld mechanisms. Photochemical chain reactions (hyderogen and chlorine, hydrogen and bromine) Non-chain photochemical reactions (formation of phosgene, decomposition of H2O2 in presence of CO)

SECTION-D

Fast reactions: Luminescence and energy transfer processes, study of kinetics by stopped-flow technique, relaxation method, flash photolysis and magnetic resonance method, Kinetics of solid-state reactions size of a hole

Reference Books

1. Katchalsky, A. & Curren, P. F. *Non Equilibrium Thermodynamics in Biophysics* Harvard University Press: Cambridge (1965).
2. Kalidas, C. & Sangaranarayanan, M.V. Non-Equilibrium Thermodynamics: Principles & Applications, Macmillan India Ltd. (2002).
3. Laidler, K. J. *Chemical Kinetics* 3rd Ed., Benjamin Cummings (1997).
4. Thomas, J. M. & Thomas, M. J. *Principles and Practice of Heterogeneous Catalysis* John Wiley & Sons (1996).
5. Chorkendorff, Ib. & Niemantsverdriet, J. W. *Concepts of Modern Catalysis and Kinetics* Wiley-VCH (2003).
6. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH603B	Physical Special II: Irreversible thermodynamics, Transport Phenomenon, Photochemistry & Fast Reaction	CO1	1	-	1	-	-	-	-	-	-	-	1
		CO2	1	-	2	-	-	2	-	-	-	-	1
		CO3	1	-	-	-	1	-	-	-	1	-	1
		CO4	1	-	1	-	3	1	-	-	1	-	1

Course Title/Code	Inorganic Special-II Supramolecular Chemistry & Metal Clusters (CHH609B)
Course Type	Core

L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	**To identify the supramolecular interactions, macrocyclic compounds and template synthesis and understand their chemical properties along with metal clusters, carboranes, phosphazines. To understand role of silicates, aluminosilicates clays, zeolites and its applications**	
Course Outcomes (COs)		**Mapping**
CO1	**Identify the importance of macrocyclic and supramolecular compound with understanding in template synthesis**	**Skill Development**
CO2	**Investigate on molecular recognition by various bonding parameters, chelation and macrocyclic effects**	**Employability**
CO3	**Understand the chemical properties of inorganic rings, cages and metal clusters and various classifications properties and applications of silicates and aluminosilicates.**	**Skill Development**
CO4	**Familiarize in synthesis and characterization techniques of metal cluster compounds and finding there appropriate applications in Industry.**	**Employability**
Prerequisites	**Inorganic Chemistry-I & II**	

SECTION A

Supramolecular Chemistry-I: Molecules and Supramolecules, Supermolecules, Large Molecules Classification, Nomenclature, Thermodynamic and Kinetic selectivity, Supramolecular interactions, Supramolecular host design, Macrocyclic versus acyclic hosts, Chelate Macrocyclic and macro bicyclic hosts, High dilution synthesis, Template synthesis

SECTION-B

Supramolecular Chemistry-II: Molecular recognition: Receptors, design and synthesis of co-receptors and multiple recognition, Hydrogen bonds, strong, weak and very weak H-bonds, Utilisation of H-bonds to create supramolecular structures, Use of H-bonds in crystal engineering and molecular recognition, Chelate and macrocyclic effects.

SECTION C

Chemistry of Inorganic Rings, Cages and Metal Cluster Compounds-I: Chemistry of inorganic rings, cages and metal cluster compounds, borazines, phosphazenes, polyhedral boranes, carboranes, metalloboranes and metallocarboranes

Silicates and aluminosilicates: Classifications, structure, properties and applications of naturally occurring silicates andaluminosilicates.

SECTION D

Chemistry of Inorganic Rings, Cages and Metal Cluster Compounds-II: Syntheses of pillared clays and zeolites, Characterization of clays, pillared clays and zeolites from measurement of surface area, surface activity pore size, distribution and interlayer spacing, Application of clays, pillared clays and zeolites with emphasis of catalyses

Reference Books

1. Ballhausen C. J. *Introduction to Ligand Field Theory* McGraw Hill Book Co.: N.Y (1962).
2. Marshal, C. E. *The Physical Chemistry and Minerology of Soil Vol. I Soil Materials* John Wiley & Sons.
3. Wells, A. F. *Structural Inorganic Chemistry* Oxford University Press.
4. Adams, D. M. *Inorganic Solids. An Introduction to Concepts in Solid-State Structural*
1. *Chemistry* John Wiley & Sons
5. Azaroff, L. V. *Introduction to Solids* Tata McGraw Hill Publishing Co. Ltd.
6. Breck, D. W. *Zeolites Molecular Sieves- Structure, Chemistry and Use.* John Wiley & Sons.

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH609B	Inorganic Special-II Supramolecular Chemistry & Metal Clusters	CO1	2	-	-	-	1	-	-	-	-	-	1
		CO2	2	-	-	-	1	2	-	-	-	-	1
		CO3	2	-	-	-	1	-	-	-	-	-	1
		CO4	2	-	-	-	1	2	-	-	-	-	1

Course Title/Code	Organic Special-II Photochemistry & Pericyclic reactions (CHH614B)
Course Type	Core
L-T-P Structure	4-0-0

Credits	4	
Course Objective	Student (A) would be able to apply (B)the concepts of photochemistry of various electronic transitions, understand the importance of pericylic reactions (C) and understand the photochemical organic reactions(D)	
Course Outcomes (COs)		**Mapping**
CO1	Understand the Concepts of organic photochemical reactions in organic Synthesis	**Skill Development**
CO2	Develop the ability to demonstrate the mechanism of pericyclic reactions & Photochemical reactions of Alkenes & carbonyl Compounds	**Skill Development**
CO3	Suggest the Mechanism of various types of cleavages in photochemical reactions of carbonyl compounds	**Skill Development**
CO4	Explain the Pericyclic reactions with the support of various Theories	**Skill Development**
CO5	Develop confidence for self-education and ability for life-long learning	**Employability**
Prerequisites	Basic course in, stereochemistry and reaction mechanism	

Section-A

Photochemistry Of (Π-Π*) Transitions: Excited states of alkenes, cis-trans isomerisation, photostationary state, electrocyclisation and sigmatropic rearrangements, di-π methane rearrangement. Intermolecular reactions, photocycloadditions, photodimerisation of simple andconjugated olefins, addition of olefins to α, β-unsaturated carbonyl compounds,excited states of aromatic compounds, Photoisimerisation of benzene

SECTION-B

Photochemistry of (N-Π*) Transitions: Excited states of carbonyl compounds, homolytic cleavage of α- bond, Norrish type I reactions in acyclic and cyclic ketones and strained cycloalkanediones, Intermolecular abstraction of hydrogen: photoreduction - influence of temperature, solvent, nature of hydrogen donor and structure of the substrate Intramolecular abstraction of hydrogen:Norrish type II reactions in ketones, Esters and 1, 2- diketones, Addition to carbon-carbon multiple bonds, Paterno-Buchi reaction, Photochemistry of nitrites-Barton reaction.

SECTION-C

Pericyclic Reactions I Introduction - Characteristics and classification of pericyclic reactions— Electrocyclic, cycloaddition&cycloreversions and sigmatropic reactions—4ne and 4n+2e type examples, Approaches for the interpretation of mechanism of pericyclic reactions-Aromatic Transition States (ATS)/Perturbation, Molecular Orbitals (PMO) approach-Concept of Huckel –Mobius aromatic and antiaromatic transition states, Framing Woodward-Hofmann selection rules for all the pericyclic reactions by ATS approach, Solving problems based on ATS approach.

SECTION-D

Pericyclic Reactions II: Molecular orbitals-definition and their origin-Non-mathematical writing up of molecular orbitals and their symmetry properties for acyclic conjugated systems, Frontier Molecular Orbital (HOMO LUMO) approach-concept-Framing Woodward-Hofmann selection rules for all the pericyclic reactions by Frontier Molecular Orbital (FMO) approach, Solving problems based on FMO approach, Conservation of orbital symmetry (Correlation Diagrams) approach-concept- Framing Woodward-Hofmann selection rules for electrocylic and cycloadditions&cycloreversions by Conservation of orbital symmetry approach.

Reference Books

1. J. Singh and J. Singh; Photochemistry and Pericyclic reactions, 3rded. New Age International Pvt Ltd, 2005
2. S. Sankararaman;Pericyclic Reactions- A text Book, 1ST ed. Wiley VCH, 2005
3. W. Horsepool; Handbook of Organic Photochemistry and Photobiology, 1st ed. CRC Press, 1984

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH614B	Photochemistry & Pericyclic Reaction	CO1	2	-	-	-	-	-	-	-	-	2	2
		CO2	-	3	-	2	-	-	-	-	-	-	2
		CO3	-	3	-	-	-	-	-	-	2	-	2
		CO4	-	3	-	-	-	-	-	-	3	-	3
		CO5	-	-	-	-	-	-	-	2	-	3	-

Course Title/Code	Physical Elective-I: Advanced Spectroscopy (CHH604B)
Course Type	Core
L-T-P Structure	4-0-0

Credits	4	
Course Objective	To impart knowledge of qualitative treatment of spectroscopic To impart advanced knowledge and application of kinetics and electrochemistry	
Course Outcomes (COs)		Mapping
CO1	understand the knowledge of Molecular Structure and Spectroscopy Spectroscopic methods	Skill Development
CO2	understand knowledge and applications of Introduction to rotational spectroscopy	Skill Development
CO3	understand knowledge of Vibrational spectroscopy:	Employability
CO4	understand the concept of Electronic and NMR spectroscopy	Skill Development
Prerequisites	Physical Chemistry I&II	

SECTION-A

Molecular Structure and Spectroscopy Spectroscopic methods*:* Characterization of electromagnetic radiation, Born-Oppenheimer approximation, Heisenberg's Uncertainty Principle, Basic elements of spectroscopy, Time dependent perturbation, Einstein coefficients, Lambert-Beer's law, Integrated absorption coefficients, Transition dipole moments and general selection rules based on symmetry ideas

Atomic spectra: Characterization of atomic states, Microstate and spin factoring methods, Hund's rules, Derivation of spin and orbital selection rules (based on recursion relations of Legendre polynomials), Spectra of complex atoms, Zeeman and Stark effects, Atomic photoelectron spectroscopy,

SECTION-B

Introduction to rotational spectroscopy: Rotational spectroscopy of diatomic molecules based on rigid rotator approximation, Determination of bond lengths and/ or atomic masses from microwave data, Effect of isotopic substitution, Non-rigid rotator, Classification of polyatomic molecules, Energy levels and spectra of symmetric top molecules and asymmetric top molecules, First order Stark effect

Vibrational spectroscopy: Normal coordinate analysis of homonuclear and heteronuclear diatomic molecules, Extension to polyatomic linear molecules, Derivation of selection rules for diatomic molecules based on Harmonic oscillator approximation, Force constants and amplitudes. Anharmonic oscillator, Overtones and combination bands

SECTION-C

Electronic spectroscopy: Diatomic molecules, Selection rules, Breakdown of selection rules, Franck-Condon factors, Dissociation energies, Photoelectron spectroscopy of diatomic (N2) and simple polyatomic molecules (H2O, formaldehyde), Adiabatic and vertical ionization energies, Koopmans' theorem, Polyatomic molecules, Oscillator strengths, Use of Free Electron Model, HMO theory and Group theory for polyenes and carbonyl compounds (formaldehyde), Qualitativeideas of solvent effects- viscosity, polarity, hydrogen bonding

Excited states: Deactivation, Jablonskii diagram, Fluorescence and phosphorescence and factors affecting these calculations of excited state life-times from absorption data, Quenching of fluorescence, Stern-Volmer equation

SECTION-D

NMR spectroscopy: Larmor precession, Mechanisms of spin-spin and spin-lattice relaxations and quantitative treatment of relaxation, Quantum mechanical treatment of the AB system, Selection rules and relative intensities of lines

Principles of Mossbauer spectroscopy: Isomer shifts, Quadrupole and Nuclear Zeeman splittings, Applications in structure determination

Reference Books

1. Hollas. J. M. *Modern Spectroscopy* 4th Ed., John Wiley & Sons (2004).
2. Barrow, G. M. *Introduction to Molecular Spectroscopy* McGraw-Hill (1962).
3. Kakkar, R., *Atomic & Molecular Spectroscopy* Cambridge University Press (2015).
4. Brand, J. C. D. & Speakman, J. C. *Molecular Structure: The Physical Approach* 2nd Ed., Edward Arnold: London (1975).
5. Chang, R. *Basic Principles of Spectroscopy* McGraw-Hill, New York, N.Y. (1970).
6. Moore, W. J. *Physical Chemistry* 4th Ed. Prentice-Hall (1972).
7. Warren, B. E. *X-Ray Diffraction* Dover Publications (1990).
8. Bacon, G. E. *Fifty Years of Neutron Diffraction* Hilger (1987).

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH604B	Physical Elective-I Advanced Spectroscopy	CO1	1	-	1	-	-	-	-	-	-	-	1
		CO2	1	-	2	-	-	2	-	-	-	-	1
		CO3	1	-	-	-	1	-	-	-	1	-	1
		CO4	1	-	1	-	3	1	-	-	1	-	1

Course Title/Code	Physical Elective-II: Advanced Chemical Kinetics (CHH605B)
Course Type	Core

L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To impart knowledge advanced chemical kinetics	
Course Outcomes (COs)		**Mapping**
CO1	**Student will be able to understand the knowledge of advanced chemical kinetics**	**Skill Development**
CO2	**Student will be able to understand the knowledge of Enzyme kinetics:**	**Skill Development**
CO3	**understand knowledge Reaction Dynamics I:**	**Employability**
CO4	**understand the concept of Reaction Dynamics II:**	**Skill Development**
Prerequisites	**Physical Chemistry I & II**	

SECTION-A

Statistical theories of kinetics: Collision theory, Activated Complex theory, Potential energy surfaces- attractive and repulsive forces, Lindemann's theory of unimolecular reactions energy transfer, fall-off region and its limitations, Rice-Ramsperger and Kassel (RRK) model, and Marcus refinement of RRK model (RRKM) for the calculation of rate constants of simple unimolecular (isomerization) reactions.

SECTION-B

Enzyme kinetics: Michaelis-Menten mechanism - single and double intermediates, King- Altman method for working out the kinetics of complex enzyme reactions

Enzyme inhibition- reversibility and products inhibition, Computer simulation in chemical kinetics

SECTION-C

Reaction Dynamics I: Molecular beams, principle of crossed-molecular beams, Molecular encounters and principal parameters, e.g. Impact parameter, Collision cross-section, Reaction cross-section and relation between reaction cross-section and reaction rate (single velocity), Dependence of collisional cross-section on translational energy

SECTION-D

Reaction Dynamics II: Probing the transition state, Dynamics of barrier less chemical kinetics in solution, dynamics of unimolecular reactions and bimolecular reactions

Reference Books

1.Pilling, M. J. & Seakins, P. W. *Reaction Kinetics* Oxford Press (1997).
2. Laidler, K. J. *Chemical Kinetics* 3rd Ed., Benjamin Cummings (1997).

CO-PO Mapping

Course Code	Course	Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11

		Outcomes											
CHH605B	**Physical Elective-II Advanced Chemical Kinetics (CHH605B)**	**CO1**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
		CO2	**1**	**-**	**2**	**-**	**-**	**2**	**-**	**-**	**-**	**-**	**1**
		CO3	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**1**
		CO4	**1**	**-**	**1**	**-**	**3**	**1**	**-**	**-**	**1**	**-**	**1**

Course Title/Code	**Solid State Materials (CHH610B)**
Course Type	**Core**

L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	**To familiarize students with the concept of solids, their properties, preparation methods, etc.** **To gain the knowledge of the chemistry between layered structures of solids**	
Course Outcomes (COs)		**Mapping**
CO1	**Students shall be able to understand the electronic, electric and optical behaviour of inorganic materials**	**Skill Development**
CO2	**Gain knowledge of methods of synthesis of solid state materials**	**Skill Development**
CO3	**Understand the basics of inorganic polymers and solid state lasers**	**Entrepreneurship**
CO4	**Learn about the mesoporous compounds and their catalytic properties for industrial applications**	**Employability**
Prerequisites	**Inorganic Chemistry I and Inorganic Chemistry II**	

Section A

Electronic, Electric and Optical behaviour of Inorganic materials: Electronic structure of solids, band theory, band structure of metals, insulators and semiconductors, the band gap, Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism, temperature dependence of conductivity, carrier density and carrier mobility in semiconductors, synthesis and purification of semiconducting materials, single crystal growth, rectifier transistors, optical devices

Section B

Methods to synthesize solid-state materials: Ceramic method, solid-state reaction and its kinetics, hydrothermal, sol-gel, co-precipitation (precursor), vapor phase transport methods.

Amorphous inorganic materials: Glasses, refractories, materials obtained from organometallic chemical vapor deposition (MOCVD)

Section C

Inorganic Polymers: Classification, types of Inorganic polymers, Chemistry of following polymers a) Silicones b) phosphonitric halides c) condensed phosphates d) coordinated polymers e) Silicates f) Isopoly & heteropoly acids

Solid State lasers (Ruby, YAG and tunable lasers): Inorganic Phosphor materials, synthesis and advantages of optical fibers, over conducting fibers

Section D

Mesoporous materials and their catalytic applications: Various types of mesoporous materials (oxides, sulphides), tailoring of pore size, applications of mesoporous materials in heterogeneous catalysis

Intercalation chemistry: Introduction, intercalation reactions in graphite, layered double hydroxides, layered sulfides, applications of intercalation chemistry

CO-PO Mapping

Course	Course	Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11

Code		Outcomes											
CHH610B	Solid State Materials	CO1	1	-	-	1	-	2	-	2	-	-	-
		CO2	1	2	-	-	2	-	1	2	-	-	-
		CO3	1	-	2	-	-	-	1	-	-	-	2
		CO4	1	-	2	-	-	3	1	2	-	-	-
		CO5	-	-	2	3	-	2	-	2	-	-	2
		CO6	-	1	-	-	2	3	-	-	-	-	2

Course Title/Code	Inorganic Elective: Inorganic and Biological Catalysis (CHH611B)	
Course Type	Core	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To conceptualize the importance of catalyst in industrial applications and toxicology for detoxification in biological systems.	
Course Outcomes (COs)		Mapping
CO1	Understand the different homogeneous catalysis reactions with mechanisms and identifying their selectivity for variety of chemical reactions	Skill Development
CO2	Understand the concept of heterogenous catalyst, its specification and functionality for various reactions	Skill Development
CO3	Identify the industrially important reactions involved with inorganic compounds as catalyst to categorize and scale up.	Employability
CO4	Identify the problem of metal ions on their reactions with biological systems with basic fundamentals about toxification and detoxification.	Employability
Prerequisites	Inorganic Chemistry-I & II	

SECTION A

Catalysis I: ligands in homogeneous catalysis such as CO, amines, phosphines, NHC's, alkenes, alkynes, carbenes, carbynes, etc. General principles, Homogenous Catalysis (alkene metathesis, Types of metathesis such as RCM, ROM, ROMP, ADMET and EM

hydrogenation of alkenes, hydroformylation, Wacker oxidation on alkenes, asymmetric oxidation, methanol carbonylation.

SECTION B

Catalysis II: Heterogenous catalysis (nature of heterogenous catalysts, hydrogenation catalysts, catalytic cracking), electrocatalysis, Hybrid Catalysis. Grubbs I, II and III, Schrock and Schrock-Hoveyda catalysts, Fischer Tropsch process, C-H activation of alkyls and aryls uing transition metal complexes.

SECTION C

Catalysis III: Applications in Industry: Palladium and Nickel catalyzed cross coupling reactions such as Suzuki, Heck, Sonogashira, Stille Coupling, Negishi, Hiyama coupling, Buchwald-Hartwig, decarboxylative cross coupling and alpha arylation of carbonyls.

SECTION-D

Toxicology: Metal poisoning and treatment by using chelating agent, mercury, lead & cadmium poisoning & treatment. Metals in the regulation of biochemical events, Transport and storage of metal ions in vivo. Biochemistry of calcium as hormonal messenger, and neurotransmitter. Fundamentals of toxicity and detoxification.

Reference Books

1. Principles of Bioinorganic chemistry, S .J. Lippard and J. M. berg
2. Bioinorganic chemistry, I. bertini, H. B. Gray, S. J. Lippard, and J. S. Valentine
3. Progress in inorganic chemistry Vol.I and Vol.II .ed. G. L. Eichom, Elsevier
4. Progress in inorganic chemistry Vols 18 and 38 ed. J. J. Lipard, Wiley.

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH611B	Inorganic Elective: Inorganic and Biological Catalysis	CO1	1	-	-	-	1	-	-	-	-	-	1
		CO2	1	-	-	-	1	-	-	-	-	1	1
		CO3	1	-	-	-	1	-	-	-	-	-	1
		CO4	1	-	-	-	1	-	-	-	-	1	1

Course Title/Code	Modern Organic Synthetic Techniques (CHH615B)
Course Type	Core

L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To make them learn the concept of Reterosynthesis and umpolung along with the basic knowledge on phase transfer catalysis, hydride reagents and newer synthetic reagents	
Course Outcomes (COs)		Mapping
CO1	To understand the mechanisms for organic Name reactions.	Skill Development
CO2	To apply the understanding of organic mechanisms to predict the outcome of reactions	Skill Development
CO3	To evaluate the synthesis of organic molecules.	Skill Development
CO4	To analyze reactivity and stability of an organic molecule based on structure.	Skill Development
CO5	To create route of new synthetic reagents.	Employability
CO6	To evaluate the retro synthesis of Organic compounds	Employability
Prerequisites	Organic Chemistry-I & Organic Chemistry-II of MSc	

SECTION A

Hybrid Transfer Reagents: Sodium borohydride**,** lithium aluminum hydride and alkoxy substituted LAH reducing agents, DIBAL,

Common Named Reactions And Rearrangements – applications in organic synthesis

Name Reaction: Appel, Birch, Cannizzaro, claisen, Clemmenson, Curtius, Dakin-West, Eschweiler-clarke, Finkelstein, Gabriel, Heck, Mannich, Negishi cross-coupling, Prins, Ritter, Stille, Suzuki, Sonogashira coupling, Swern, Ullman, Wittig Reactions

Rearrangement: Beckmann, Cutius, The Lossen, Baeyer-Villager, Favorskii, Fries, Claisen, Benzilic acid, Wagner Meerwin rearrangement, Pinacol-pinacolone rearrangements and Wolf Rearrangement

SECTION B

Redox Reactions: Oxidation - Introduction, Different oxidative processes for the followings:Hydrocarbons- al kenes, aromatic rings, saturated C-H groups (activated andunactivated). Alcohols, diols, aldehydes, ketones, and carboxylic acids

Reduction – Introduction, Different reductive processes for followings: Hydrocarbons – alkanes, alkenes, alkynes and aromatic rings. Carbonylcompounds – aldehydes, ketones, acids and their derivateives. Nitro compounds.

SECTION C

Newer Synthetic Reactions and Reagents: Enolates, enonate equivalents and **enamines**:Applications in carbon-carbon bond formation and related reactions.

Phosphorus, **Sulphur and nitrogen ylides***:* Preparation, applications in organic synthesis andmechanism.

Principles and applications of phase transfer catalysis, crown ethers and polymer- supportedreagents in organic synthesis.

SECTION D

Philosophy of organic synthesis: Disconnection approach, one group and two groupdisconnections, reversal of polarity, chemoselectivity, one group C-C disconnection, twogroup C-C disconnections, 1,3-difunctional and 1,5-difunctional compounds. **Umpolung reactions** (sulphur compounds, nitro compounds, lithiated ethers and relatedcompounds).

Reference Books

1. 1.M. B. Smith and Jerry March; March's Advanced Organic Chemistry, 5th ed. John Wiley & Sons, New York, 2001
2. F. A. Carey and R. J. Sundberg; Advanced Organic Chemistry, 5th ed. Springer Publishers, 2008
3. R.T. Morrison and R.N. Boyd; Organic Chemistry, 6th ed. Prentice Publishing, 1992
4. H. O. House, W. A. Benjamin; Modern Organic Reactions, 2nd ed. VCH Publishers, USA, 1972
5. R. O. C. Norman and J. M. Coxon;Principles of Organic Synthesis, 3rd ed. Blackie Academic & Pro, 1993
6. S. M. Mukherji and S. P.Singh;Reaction Mechanism in Organic Chemistry, 3rd ed. Macmillan, 1984

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH615B	Modern Organic Synthetic Techniques	CO1	3	-	-	2	3	-	1	3	3	1	2
		CO2	3	-	-	2	3	-	1	3	3	1	3
		CO3	3	-	-	2	3	-	1	3	2	1	2
		CO4	3	-	-	1	3	-	1	2	3	1	2
		CO5	2	-	-	2	3	-	1	3	3	1	2
		CO6	3	-	-	2	3	-	1	3	3	1	2

Course Title/Code	Organic Special-Elective: Bioorganic Chemistry (CHH616B)
Course Type	Core
L-T-P Structure	4-0-0
Credits	4

Course Objective	To impart the knowledge of the activity of the organic biomolecules and its applications in biological systems	
Course Outcomes (COs)		Mapping
CO1	Understand the concept of enzymes, different theories of catalytic activity and typical enzyme mechanisms	Skill Development
CO2	Understand the biomimetic chemical approach to biological systems, explore some host molecules and industrially important enzymes.	Skill Development
CO3	Identify the recombinant DNA and fermentation technology, apply genetic engineering concepts for diagnosis of diseases and learn the basics of Industrial fermentation.	Skill Development
CO4	Learn the concept of coenzymes, co-factors and its classifications and their functions reactions catalyzed by the above coenzymes.	Skill Development
Prerequisites	Organic Chemistry-I & II	

SECTION-A

Enzymes and Their Action: Introduction to enzymes. Transition state theory,Acid-Base catalysis, Covalent catalysis— Binding modes of catalysis (i) Proximity effect (ii) Transition state stabilization (iii) Strain and Distortion. Examples of some typical enzyme mechanisms for (1) Triose phosphate isomerase, (ii) α-chymotrypsin and serine protease (iii) Lysozyme (iv) Carboxy peptidase-A (v) Ribonuclease.

SECTION-B

Enzyme Models & Enzymatic Transformations: Introduction — Biomimetic chemical approach to biological systems-Enzyme models Advantage of enzyme models, Requirements necessary for the design of enzyme models, Host-Guest complexation chemistry, Examples of some host molecules-Crown ether cryptanes, cyclodextrins, Cyclodextrin based enzyme models-Valixarenes, ionophores, micelles and synzymes (synthetic enzymes) — chiral recognition and catalysis.Introduction to industrial enzymes, Enzymatic synthesis of α-amino acids and peptides, Transformations of lipases and esterases, Kinetic resolutions of catboxylic acids, esters and alcohols – Transesterification, Amine resolution-use of oxido-reductase, C-C bond formation using enzymes-asymmetric cyanohydrin formation and asymmetric aldol condensations

SECTION-C

Recombinant DNA and Fermentation Technology: Introduction to genetic engineering. Recombinant DNA technology-restriction endonuclease, cloning, linkers, adaptors, Application of recombinant DNA technology in production of pharmaceuticals, diagnosis of diseases, insect control, improved biological detergents, gene therapy-examples, Principles of finger printing technology- Site directed mutagenesis.

FERMENTATION TECHNOLOGY: Introduction to fermentation. Industrial fermentation, Advantages and limitations of fermentation, Production of drugs and drug intermediates from fermentation examples, Chiralhydroxy acids, vitamins, amino acids, β-lactam antibiotics, Precursor fermentation and microbial oxidation and reductions.

SECTION-D

COENZYMES: Introduction,Co factors — cosubstrates — prosthetic groups. Classification — Vitamin derived coenzymes and metabolite coenzymes. Structure and biological functions of coenzyme, thiamine pyrophosphate (TPP), pyridoxal phosphate (PLP), oxidized and reduced forms of I) nicotinamide adenosine dinucleotide / their phosphates (NAD), NADH, NADP+ NADPH) ii) Flavin adenine nucleotide FAD, $FADH_2$ and iii) Flavin mononucleotide (FMN, FMNH2) lipoicacid, biotin, tetrahydrofolate and ubiquinone, Adenosine triphosphate ($_{ATP}$) and adenosine diphosphate (ADP), S-adenosyl methionine (SAM) and uridinediphospho sugars (UDP-sugars) Mechanism of reactions catalyzed by the above coenzymes.

Reference Books:

I. L. Finar; Organic Chemistry, Vol. II, 5th ed. Pearson Education, 1956

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH616B	Organic Special-Elective: Bioorganic Chemistry	CO1	-	-	2	-	1	1	-	-	-	-	
		CO2	-	-	2	-	1	1	-	-	-	-	
		CO3	-	-	1	-	1	1	-	-	-	-	
		CO4	-	-	1	-	1	1	-	-	-	-	

Course Title/Code	Organic Special-Elective: Chemistry of Natural Products (CHH617B)
Course Type	Core
L-T-P Structure	4-0-0
Credits	4

Course Objective	To impart knowledge on Biosynthesis of natural products. To familiarize with Structure determination and stereochemistry of natural products by chemical methods and spectroscopic methods	
Course Outcomes (COs)		Mapping
CO1	Investigate the type of the natural products, its biosynthesis and reactions involve in biosynthesis.	Skill Development
CO2	Understand the classification, structural determination, isolation of terpenoids and structural determination of carotenoids	Skill Development
CO3	Understand the definition, nomenclature, occurrence, isolation, general methods of structure elucidation of alkaloids and its synthesis	Skill Development
CO4	Learn about the skeleton of steroids, applications, plant pigment synthesis and its structural determinations	Skill Development
Prerequisites	Organic Chemistry-I & II	

SECTION-A

Biosynthesis of secondary metabolites: Introduction to natural products, Synthesis and Biosynthesis (similarities & differences), Biogenesis, Primary and secondary metabolites, Why plant produce secondary metabolites, Charecteristics of secondary metabolites, Biosynthesis of natural products (schematic representation), methods of investigation of biosynthesis of secondary metabolites, Reactions involve in biosynthesis (primary and secondary biosynthesis);
Biosynthesis of Acetyl CoA: biosynthesis by oxidative decarboxylation, Activation of acetic acid, properties (formation of malonyl CoA); Origin of aromatic ring in secondary metabolites (Shikimic acid pathway); Biosynthesis of terpenes (NPP, GPP, citral, α-pinene, α-terpineol, borneol); Biosynthesis of steroids (cholesterol), Biosynthesis of alkaloids: formation of alkaloid derived from phenylalanine-ephedrine, Biosynthesis of piperdine alkaloid-coniine, biosynthesis of pyrrolidine-pyridine alkaloid-nicotine, biosynthesis of tropane alkaloid-atropine, biosynthesis of cinchona alkaloid-quinine. Biosynthesis of fatty acids

SECTION-B

Terpenoids& Carotenoids: Terpenoids: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Isolation of terpenes, Structure determination,
Monoterpenoids: Citral, geraniol (acyclic), α-terpeneol, menthol (monocyclic), Sesquiterpenoids: Farnesol (acyclic), zingiberene (monocyclic), santonin (bicyclic), Diterpenoids: Phytol and abietic acid.
Carotenoids: General methods of structure determination of Carotenes: β- carotene, lycopene

SECTION-C

Alkaloids: Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure and synthesis of the following: Ephedrine, Coniine, Nicotine, Atropine, Quinine and Morphine

SECTION-D

Steroids: Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol, Androsterone, Testosterone, Progestrone
Plant Pigments: Occurrence, nomenclature and general methods of structure determination, Isolation and synthesis of Anthocyanins (Cyanin and pelargonidin), polyphenols: Flavones (chrysin), Flavonols (quercitin) and isoflavones (daidzein) coumarin, Quinones (lapachol), Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway

Books Recommended:

1. J. Mann, R. S. Davidson, J. B. Hobbs, D. V. Banthrope and J. B. Harborne; Natural Products- Chemistry and Biological Significance, 1st ed. Longman group U. K. limited, Essex, 1994

2. I. L. Finar; Organic Chemistry, Vol. II, 5th ed. Pearson Education, 1956
3. M. Nogradi; Stereo selective synthesis- A Practical Approach, 2nd ed. Wiley-VCH, 1994
4. K. Hostettmann, M. P. Gupta and A. Marston; Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Harwood Academic Publishers, 1999

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH617B	Organic Special-Elective: Chemistry of Natural Products	CO1	2	-	1	-	1	-	-	-	2	-	
		CO2	2	-	1	-	1	-	-	-	2	-	
		CO3	1	-	1	-	1	-	-	-	2	-	
		CO4	2	-	1	-	1	-	-	-	2	-	

Course Title/Code	Physical Laboratory (CHH606B)
Course Type	Core
L-T-P Structure	0-0-8

Credits	4	
Course Objective	**To make student able to understand the practical aspects of kinetics of the reactions & different potentiometric titrations**	
Course Outcomes (COs)		**Mapping**
CO1	**Student will be able to the exposure of practical aspects of kinetics of the reactions & different potentiometric titrations.**	**Skill Development**
CO2	**Student will be able to understand the Kinetics of oxidation of alcohols/diols by aqueous alkaline**	**Skill Development**
CO3	**Student will be able to understand the Kinetics of oxidation of aliphatic/cyclic alcohols/glycols by alkaline hexacyanoferrate(III) catalyzed by ruthenium (III) chloride**	**Employability**
CO4	**Student will be able to understand the Kinetics of iridium (III) catalyzed oxidation of aromatic aldehydes/aromatic**	**Skill Development**
Prerequisites	**Laboratory work-II**	

List of Experiments

1. Determine the concentration or percentage of one or two optically activesubstances in the given solution polarimetrically.
2. Kinetics of oxidation of reducing sugars by potassium ferricyanide/ copper(II) in presence of ammonium hydroxide or sodium hydroxide.
3. Kinetics of oxidation of alcohols/diols by aqueous alkaline hexacyanoferrate (III) ions.
4. Potentiometric titration of weak/strong acid and strong /weak base.
5. Study of the oxidation of cyclic alcohols by cerium(IV) sulphate in acidic medium in presence of Iriduum(III) chloride.
6. Kinetics of iridium (III) catalyzed oxidation of aromatic aldehydes/aromatic alcohols/hydrocarbons by cerium (IV) in aqueous acidic medium.
7. Kinetics of Ru(III) catalysed oxidation of alcohols/diols by Ce(IV) sulphate in acidic medium .
8. Kinetics of oxidation of aliphatic/cyclic alcohols/glycols by alkaline hexacyanoferrate(III) catalyzed by ruthenium (III) chloride

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH606B	**Physical**	**CO1**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**

	Laboratory	**CO2**	**1**	**-**	**2**	**-**	**-**	**2**	**-**	**-**	**-**	**-**	**1**
		CO3	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**1**
		CO4	**1**	**-**	**1**	**-**	**3**	**1**	**-**	**-**	**1**	**-**	**1**

Course Title/Code	**Inorganic Laboratory (CHH612B)**
Course Type	**Core**
L-T-P Structure	**0-0-8**

Credits	4	
Course Objective	To impart the laboratory exposure to the synthesis of coordination complexes and quantitative analysis of the inorganic mixtures	
Course Outcomes (COs)		**Mapping**
CO1	Students will be able to hands on laboratory exposure to the synthesis of coordination complexes and quantitative analysis of the inorganic mixtures	**Employability**
CO2	Learn the analysis of inorganic ions present in a matrix	**Employability**
Prerequisites	**Inorganic Chemistry I and Inorganic Chemistry II**	

List of Experiments

1. Quantitative separations and determinations of following pairs of metal ions using gravimetric and volumetric methods
   (a) Ag^{+}/Cu^{2+} (b) Cu^{2+}/Zn^{2+} (c) Fe^{3+}/Ca^{2+} (d) Ba^{2+}/Cu^{2+}
   (e) Ni^{2+}/Zn^{2+} (f) Ag^{+}/Ni^{2+} (g) Fe^{3+}/Ni^{2+}
2. Inorganic Preparations of the following compounds
   (a) Prussian Blue (b) Trisacetylacetonato Iron (III)
   (c) Tetraammine copper (II) sulphate monohydrate
   (d) Hexamine cobalt (III) hexanitritocobaltate (III)
   (e) Sodium hexanitritocobaltate (III)

Reference Books

1. J. Singh, R. K. P. Singh, J. Singh, L. D. S. Yadav, I. R. Siddiqui and J. Srivastava; Advanced Practical Chemistry, 2nd ed. PragatiPrakashan, 2010
2. A. I. Vogel; Vogel's textbook of Practical Inorganic Analysis, 5th ed. Longman Scientific and technical Publisher, UK, 1989

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH612B	**Inorganic Chemistry Lab**	**CO1**	**1**	**-**	**-**	**-**	**-**	**2**	**-**	**3**	**-**	**3**	**-**
		CO2	**1**	**-**	**-**	**-**	**2**	**-**	**3**	**-**	**-**	**3**	**-**

Course Title/Code	Organic Laboratory (CHH618B)
Course Type	**Core**

L-T-P Structure	**0-0-8**	
Credits	**4**	
Course Objective	**The objective of the course is to familiarize with synthesis of organic compounds and separation of organic compounds**	
Course Outcomes (COs)		**Mapping**
CO1	**To understand the isolation of natural products.**	**Skill Development**
CO2	**To familiarize with synthesis of organic compounds**	**Skill Development**
CO3	**To familiarize with separation of organic compounds**	**Employability**
CO4	**To understand the reaction mechanism involved during synthesis of organic compounds**	**Skill Development**
Prerequisites	**Organic Chemistry-I & II**	

LIST OF EXPERIMENTS

SEPARATION& ANALYSIS OF ORGANIC COMPOUNDS

1. Mixture of mannitol and p-toluidine
2. Mixture of glucose and cinnamic acid
3. Mixture of oxalic acid and m-dinitrobenzene or p-dinitrobenzene
4. Mixture of urea and acetanilide
5. Mixture of benzyl and p-toluidine
6. To prepare Hexammine cobalt (II) Chloride
7. To prepare Copper tetra iodide mercurate
8. To prepare Vanadylacetyloacetonate

LIST OF EXPERIMENTS

TO SEPARATE AND ANALYSE THE ORGANIC COMPOUNDS

9. Mixture of benzoic acid and β-naphthol
10. Mixture of m-notroaniline and hydroquinone
11. Mixture of tetrahydrofuran and cinnamic acid
12. Mixture of chloroform and benzidine
13. Mixture of aniline and benzamide
14. To prepare Chalcone (Benzene acetophenone)
15. To extract caffeine from tea leaves
16. To extract piperine from Black pepper
17. To prepare Dichlorodipyridinocobalt (II)
18. To prepare ammonium diamminetetrathiocyanato chromate (III)

Reference Books:

1. J. Singh, R. K. P. Singh, J. Singh, L. D. S. Yadav, I. R. Siddiqui and J. Srivastava; Advanced Practical Chemistry, 2nd ed. PragatiPrakashan, 2010
2. A. I. Vogel; Vogel's textbook of Practical Organic Chemistry, 5th ed. Longman Scientific and technical Publisher, UK, 1989

3. H. L. FieserandF. L. Fieser, Organic Chemistry, Vol 1-11, Trade ed. 1944
4. B. M. Trost, I. fleming and S. L. Scheiber; Comprehensive Organic Synthesis, 1st ed. Pergamon Press, 2007

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHH618 B	Organic Laboratory	CO1	3	2	2	-	2	-	-	-	3	-	1
		CO2	3	2	2	-	2	-	-	-	3	-	1
		CO3	3	2	2	-	2	-	-	-	3	-	1
		CO4	3	2	2	-	2	-	-	-	3	-	1

Course Title/Code	SCIENTIFIC RESEARCH-II (RDO603)

Course Type	Core	
L-T-P Structure	0-0-8	
Credits	4	
Course Objective	To impart knowledge on various analytical techniques To familiarize with the principle of analytical chemometrics	
Course Outcomes (COs)		Mapping
CO1	The students will be able to critically evaluate the work done by various researchers relevant to the research topic	Skill Development
CO2	To integrate the relevant theory and practices followed in a logical way and draw appropriate Conclusions	Skill Development
CO3	To understand the research methodologies/approaches/techniques used in the literature	Skill Development
CO4	To structure and organize the collected information or findings through an appropriate abstract, headings, reference citations and smooth transitions between sections	Skill Development
Prerequisites	Basic knowledge of Research	

SECTION A

Unit-1 Literature Survey (LS)/Design of Experiment

1.1 Collection of research papers related to previously identified gap/problem (15 papers or more)

1.2 Comprehend and arrange the literature based on the idea framed

1.3 Presenting the collected data and inferring it with the further scope of expansion and Designing the experiment wherever applicable.

SECTION B

Unit-2 Structuring of Review Paper and setting up of experimental facility

2.1 Analysis of different approach/methodology adopted by various researchers

2.2 Listing out the components of the paper/ setting up experimental facility w.r.t the problem

2.3 Identification of suitable Journal or Conference

2.4 Formatting/Styling the paper according to the respective template

SECTION C

Unit-3 Planning of experiments

3.1 Formulate experimental procedures with Modification of the experimental set-up, if required

3.2 Procurement of materials

Unit-4 Execution of experiments/simulations

4.1 Conduct experiments/ build prototype
4.2 Tabulating and recording data
4.3 Analysis and interpretation of the data
4.4 Comparison of the results with other reported experiments
4.5 Interpretation of observations
4.6 Integration of relevant theory, findings in a structured way and draw appropriate conclusions

SECTION D

Unit-5 Departmental Presentation

5.1 Structuring and preparation of PPT
5.2 Mock presentation
5.3 Review on presentation skills and content delivered both
5.4 Incorporating the review comments in the slides

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
RDO603	Scientific Research-II	CO1	-	-	-	-	-	3	2	3	-	-	-
		CO2	-	-	-	-	-	2	3	3	-	-	-
		CO3	-	-	-	-	-	3	3	2	-	-	-
		CO4	-	-	-	-	-	3	3	3	-	-	-

Semester-IV

Course Code	Course Name	Offering Department	Course Type	Structure			Credits
			Deptt./Allied Core/Elective/ Audit	L	T	P	
CHN619B	Major Project (Industrial or Research Lab Training)	CH	CORE	0	0	12	12
TOTAL (L-T-P) /CREDITS)				0	0	12	12

Course Title/Code	Major project (CHN619B)	
Course Type	Core	
L-T-P Structure	0-0-12	
Credits	12	
Course Objective	To impart understanding of research papers/articles in specific areas, improve the communication skills by presentation on specific subjects, improve the team work and improve the research and practical approach	
Course Outcomes (COs)		Mapping
CO1	To apply theoretical knowledge and practical skills to a research project and on the collection and analysis of scientific data	Skill Development
CO2	Work independently and collaboratively with peers to bring the project to satisfactory completion	Employability
CO3	Communicate a scientific argument convincingly at a level and style appropriate to the audience	Employability
Prerequisites	Basic knowledge of laboratory practices	

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CHN619B	Major Project	CO1	3	3	1	-	3	3	-	-	2	2	-
		CO2	3	3	1	-	3	3	-	-	2	2	-
		CO3	3	3	2	-	3	3	-	-	2	2	-
		CO4	3	3	2	-	3	3	-	-	2	2	-

Manav Rachna University

Department of Chemistry

Mapping of Course Outcomes with Program Outcomes

Program: MSc. Chemistry

Subject code	Subject Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
SEMESTER I												
CHH501B	Physical Chemistry-I	1	0	3	0	1	1	0	0	1	0	1
CHH502B	Inorganic Chemistry-I	1	0	3	0	1	1	0	0	1	0	1
CHH503B	Organic Chemistry-I	3	2	0	3	3	0	0	0	2	2	3
CHH504B	Analytical Chemistry	3	3	0	0	3	3	2	2	2	2	2
CHH505B	Laboratory-I	0	1	0	1	0	0	2	2	1	2	1
SEMESTER II												
CHH506B	Physical Chemistry-II	1	0	2	0	1	1	0	0	1	0	1
CHH507B	Inorganic Chemistry-II	1	2	1	1	2	3	3	3	3	0	1
CHH508B	Organic Chemistry-II	1	2	2	3	3	0	1	3	0	3	3
CHH509B	Molecular Spectroscopy	0	3	0	0	0	3	1	2	0	2	3
CHH510B	Laboratory-II	0	1	0	1	0	0	2	2	1	2	2
RDO503	Scientific Research-I	2	2	0	2	2	3	3	3	2	2	2
Semester III												
CHH601B	Symmetry & Group Theory	1	2	2	2	2	2	2	0	2	2	2
CHH602B	Physical Special-I (Magneto-chemistry, Chemical Kinetics, Catalysis & ion transport)	1	0	2	0	3	2	0	0	1	0	1
CHH608B	Inorganic Special-I (Organometalic Chemistry of Transition Metals & Bio Inorganic Chemistry)	1	0	0	0	1	0	0	0	0	0	1
CHH613B	Organic Special-I (Statistical Stereochemistry & Asymmetric Synthesis)	3	0	2	0	2	0	0	0	3	0	3
CHH603B	Physical Special-II (Irreversible thermodynamics, Transport Phenomenon, Photochemistry & Fast Reaction)	1	0	2	0	3	2	0	0	1	0	1
CHH609B	Inorganic Special-II (Supramolecular Chemistry & Metal Clusters)	2	0	0	0	1	2	0	0	0	0	1
CHH614B	Organic Special-II (Photochemistry & Pericyclic Reaction)	2	3	0	2	0	0	0	2	3	3	3
CHH604B	Physical Elective:Advanced Spectroscopy	1	0	2	0	3	2	0	0	1	0	1
CHH605B	Physical Elective: Advanced Chemical Kinetics	1	0	2	0	3	2	0	0	1	0	1
CHH610B	Inorganic Elective: Solid state Materials	1	2	2	3	2	3	1	2	0	0	2
CHH611B	Inorganic Elective: Inorganic & Biological Catalysis	1	0	0	0	1	0	0	0	0	1	1
CHH615B	Organic Elective:Modern Organic Synthetic Technique	3	0	0	2	3	0	1	3	3	1	3
CHH616B	Organic Elective: Bioorganic Chemistry	2	0	1	0	1	0	0	0	2	2	0
CHH617B	Organic Elective: Chemistry of Natural Products	3	0	2	2	3	1	1	3	3	1	3
CHH606B	Physical Laboratory	1	0	2	0	3	2	0	0	1	0	1
CHH612B	Inorganic Laboratory	1	0	0	0	2	2	3	3	0	3	0
CHH618B	Organic Laboratory	3	2	2	0	2	0	0	0	3	0	1
RDO603	Scientific Research-II	1	0	2	0	3	2	0	0	1	0	1
Semester IV												
CHN619B	Major Project (Industrial or Research Lab Training)	3	3	1	0	3	3	0	0	2	2	0