DEPARTMENT OF CHEMISTRY

CHOICE BASED CREDIT SYSTEM (CBCS)
Learning Outcome-based Curriculum Framework (LOCF) SYLLABUS

M. Sc Chemistry
(2023 – 2024 onwards)

MADRAS CHRISTIAN COLLEGE (AUTONOMOUS)
Affiliated to University of Madras
Tambaram
Chennai – 600 059

July 2023

MADRAS CHRISTIAN COLLEGE

VISION

Madras Christian College aspires to be an Institution of excellence transforming lives through education with a commitment to service.

MISSION

The Madras Christian College (MCC), with the inspiration of the love of God, offers to people of all communities education of the whole person, which is congruous with God's revelation in Christ of the true nature of humanity and is appropriate to the needs of India and of the world.

Graduate Attributes

The Madras Christian College defines the philosophy underpinning its academic programmes and student life experience on campus through the Graduate Attributes (GA), that describe the knowledge, competencies, values and skills students imbibe for holistic development and contribution to society. These attributes encompass characteristics that are transferable beyond the domain of study into the national and international realm fostered through curricular, co-curricular and extra-curricular engagements.

GA 1: Intellectual Competencies

- Graduates of MCC have a comprehensive and incisive understanding of their domain of study as well as the capability for cross-disciplinary learning.
- They have the ability to apply the knowledge acquired through the curriculum as well as self-directed learning to a broad spectrum ranging from analytical thinking to synthesise new knowledge through research.
- Forming independent individual opinions regarding academic cores and socially relevant issues

GA 2: Professional Ethics

- Graduates of MCC develop ethical and professional behaviour, which will be demonstrated in their chosen careers and constructive citizenship roles.
- They imbibe intellectual integrity and ethics in scholarly engagement and develop a spirit of inclusiveness through interactions with people of special needs and diversity.

GA3: Leadership Qualities

- Graduates of MCC inculcate leadership qualities & attitudes, and team behaviour along democratic lines through curricular, co-curricular and extra-curricular activities
- They develop managerial and entrepreneurial skills to ideate and create new opportunities along with career readiness and capacity to take up various competitive exams.

GA 4: Holistic Skill Development

- Graduates of MCC develop critical thinking, problem-solving, effective communication, emotional and social skills
- They develop digital competency to live, learn and serve in society.

GA 5: Cross-Cultural Competencies

- Graduates of MCC imbibe cross-cultural competencies through engaging with diverse linguistic, ethnic and religious communities providing scope to understand, accept and appreciate individuals at local, national and international levels.
- They develop a global perspective through contemporary curriculum, culture, language and international exchange programmes

GA 6: Service-Oriented Focus

- Graduates of MCC have sensitivity to social concerns and a conviction toward social justice through a commitment to active social engagement.
- They are endowed with a strong sense of environmental awareness through the curriculum and campus eco-system.

GA 7: Value-Based Spiritual Development

- Graduates of MCC are rooted in the principles of ethical responsibility and integrity permeated with Christian values leading to the building of character.
- They develop virtues such as love, courage, unity, brotherhood, industry and uprightness.

Programme Outcomes

Programme Outcomes (POs) of Madras Christian College define the minimum level that students are expected to do, achieve and/or accomplish in order to graduate from a particular programme. These Outcomes are a framework to assess the nature of learning activity experienced within the programme.

POs for Post Graduate Programmes

Upon completion of a Postgraduate programme, the student will be able to			
PO#	PO	Description of PO	Mapped with GA#
PO1	Domain Knowledge	Develop intensive and extensive knowledge and expertise in their respective domains	GA1, GA3, GA4
		Evaluate and create/construct domain specific knowledge in areas of learning, research and industry	
		Formulate and extrapolate the knowledge gained to apply in real – life situations and competitive examinations	
		Develop an aptitude for self-directed learning for excellence in their chosen area within the domain of study	
PO2	Applicative knowledge and Lateral Thinking	Translate theoretical understanding to experimental knowledge and solve complex problems using Systems/Design Thinking	GA1, GA3, GA4
		Apply advanced knowledge and approaches to solve concrete and abstract problems in domain-related and multi-disciplinary issues.	
		Able to solve problems using unconventional and creative approaches	
PO3	Innovation and Research	Develop aptitude for innovation and entrepreneurship	GA1, GA4, GA5, GA6
		Identify contemporary research problems, analyze data and propose solutions	
PO4	Scientific Communication skills	Document, prepare and present scientific work as reports and research articles in academic forums	GA1, GA4, GA5, GA6
		Critically assess, review and present theories, principles and concepts	
PO5	Digital skills	Use of domain-related advanced software resources, computational skills and digital tools for data analysis, visualization and interpretation	GA1, GA2, GA3, GA4
		Ethically apply digital skills to creatively communicate a wide range of ideas and issues related to academic experiences	
PO6	Ethical practices	Apply domain specific ethical principles and practices in academic, professional and social engagements	GA2, GA6, GA7
PO7	Career readiness and higher education	Choose from diverse career options available in local, national and international realms.	GA1, GA2, GA5
		Carry out further research or pursue higher education in the country or abroad	

M. Sc. (Chemistry)

PROGRAM SPECIFIC OUTCOMES (PSO's)*

At the time of graduation they would be able to

PSO #	Statement	Mapped with PO#
PSO 1	Recollect the fundamental concepts of chemistry learnt from undergraduate program and to connect them to perceive advanced concepts.	PO1
PSO 2	Recognize and analyse various structural features and characteristics of chemical compounds, solids & bio-surfaces.	PO1, PO2
PSO 3	Understand the theoretical principles of various physical & chemical processes/reactions and relate them to realistic situations	PO2
PSO 4	Connect the concepts from Physical, Inorganic and Organic chemistry in solving analytical problems in chemistry.	PO2, PO3
PSO 5	Use molecular modeling tools to enhance their understanding of basic concepts in Chemistry (or enhance/widen their chemistry knowledge) and appreciate the principles & applications of cheminformatics.	PO5
PSO 6	Use bench skills and psychomotor skills to translate the theoretical knowledge to experimental chemistry.	PO2, PO4
PSO 7	Apply research methodologies to a given research problem in chemistry to critically review, synthesize information, interpret data, draw conclusions and write scientific report.	PO4
PSO 8	Apply critical & creative thinking, communication & interpersonal, and problem-solving skills to pursue career in industry, research and academics.	PO2, PO7

M.Sc. Course Articulation Matrix

Correlation of POs/PSOs to each CO to make

a corresponding mapping table.

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1																K1
CO 2																K2
CO 3																K3
CO 4																K4
CO 5																K5
Wt. Avg.																
Overall Mapping of the Course								PO: PSO:								

Weightage for Correlation		
0 ≦C ≦ 5%	No correlation	-
5% <C ≦ 40%	Low / Slight	1
40% <C < 60%	Moderate	2
60% ≦C < 100%	Substantial / High	3

Curriculum Template for M.Sc. Chemistry

Effective from – 2023-24

SEM	NATURE OF COURSE	COURSE CODE	COURSE TITLE	HOURS /CYCLE	CREDIT	ICA MARKS	ESE MARKS	TOTAL MARKS
I	CORE THEORY	CT 1	BASIC CONCEPTS IN ORGANIC CHEMISTRY	5	4	50	50	100
	CORE THEORY	CT 2	STRUCTURAL INORGANIC CHEMISTRY	5	4	50	50	100
	CORE THEORY	CT 3	THERMODYANMICS AND CHEMICAL KINETICS	5	4	50	50	100
	ELECTIVE	E 1	METALS IN LIFE	3	5	50	50	100
	ELECTIVE	E 2	INORGANIC MATERIALS FOR ENERGY					
	ELECTIVE	E 3	INORGANIC ANALYTICAL CHEMISTRY					
	CORE PRACTICAL	CP 1	ORGANIC CHEMISTRY PRACTICAL I	4	-	-	-	-
	CORE PRACTICAL	CP 2	INORGANIC CHEMISTRY PRACTICAL I	4	-	-	-	-
	CORE PRACTICAL	CP 3	PHYSICAL CHEMISTRY PRACTICAL I	4	-	-	-	-
			Total	30	17	200	200	400

SEM	NATURE OF COURSE	COURSE CODE	COURSE TITLE	HOURS /CYCLE	CREDIT	ICA MARKS	ESE MARKS	TOTAL MARKS
II	CORE THEORY	CT 4	ORGANIC REACTION MECHANISM	4	4	50	50	100
	CORE THEORY	CT 5	COORDINATION AND BIOINORGANIC CHEMSITRY – I	4	4	50	50	100
	CORE THEORY	CT 6	GROUP THEORY AND QUANTUM CHEMISTRY	4	4	50	50	100
	ELECTIVE	E 4	HETEROCYCLIC & POLYMER CHEMISTRY_	4	5	50	50	100
	ELECTIVE	E 5	GREEN & ENVIRONMEMNTAL CHEMISTRY					
	ELECTIVE	E 6	NATURAL PRODUCTS & MEDICINAL CHEMISTRY					
	CORE PRACTICAL	CP 4	ORGANIC CHEMISTRY PRACTICAL I	4	4	100	-	100
	CORE PRACTICAL	CP 5	INORGANIC CHEMISTRY PRACTICAL I	4	4	100	-	100
	CORE PRACTICAL	CP 6	PHYSICAL CHEMISTRY PRACTICAL I	4	4	100	-	100
	-	SS	SOFTSKILLS	2	-	-	-	-
			Total	30	29	500	200	700

SEM	NATURE OF COURSE	COURSE CODE	COURSE TITLE	HOURS /CYCLE	CREDIT	ICA MARKS	ESE MARKS	TOTAL MARKS
III	CORE THEORY	CT 7	ORGANIC SPECTROSCOPY AND SYNTHETIC STRATEGIES	4	4	50	50	100
	CORE THEORY	CT 8	COORDINATION AND BIOINORGANIC CHEMSITRY – II	4	4	50	50	100
	ELECTIVE	E 7	BIOPHYSICAL CHEMISTRY	3	5	50	50	100
	ELECTIVE	E 8	LABORATORY & MANUFACTURING PRACTICES					
	ELECTIVE	E 9	INTRODUCTION TO CHEMINFORMATICS					
	CORE PRACTICAL	CP 7	ORGANIC CHEMISTRY PRACTICAL II	4	-	-	-	-
	CORE PRACTICAL	CP 8	INORGANIC CHEMISTRY PRACTICAL II	4	-	-	-	-
	CORE PRACTICAL	CP 9	PHYSICAL CHEMISTRY PRACTICAL II	4	-	-	-	-
	CORE PROJECT	PROJECT	PROJECT	5	-	-	-	-
	-	SS	SOFTSKILLS	2	8	-	-	-
				30	21	150	150	300

SEM	NATURE OF COURSE	COURSE CODE	COURSE TITLE	HOURS /CYCLE	CREDIT	ICA MARKS	ESE MARKS	TOTAL MARKS
IV	CORE THEORY	CT 9	ELECTROCHEMISTRY AND SPECTROSCOPY	5	4	50	50	100
	CORE THEORY	CT 10	SCIENTIFIC RESEARCH METHODOLOGY	4	4	50	50	100
	ELECTIVE	E 10	ADVANCED CHEMISTRY	4	5	50	50	100
	ELECTIVE	E 11	ENTREPRENEURSHIP FOR CHEMISTS					
	CORE PRACTICAL	CP 10	ORGANIC CHEMISTRY PRACTICAL II	4	2	100	-	100
	CORE PRACTICAL	CP 11	INORGANIC CHEMISTRY PRACTICAL II	4	2	100	-	100
	CORE PRACTICAL	CP 12	PHYSICAL CHEMISTRY PRACTICAL II	4	2	100	-	100
	CORE PROJECT	PROJECT	PROJECT	5	6	50	50	100
				30	25	500	200	700

Curriculum Overview Table		
Part	Credits	Hours
I Core (Theory + Practical _ Elective)	90	116
II Internship	2	-
II Soft Skill	8	4
Total	**100**	**120**

BASIC CONCEPTS IN ORGANIC CHEMISTRY

Course Code			
Credits	**4**		
Hours / Cycle	**5**		
Category	**Part NA**	**Core**	**Theory**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To study the concept of aromaticity associated with organic compounds in the light of molecular orbital theory 2. To gain insight on the importance of stereochemistry in stability and reactivity of organic compounds 3. To study the various non-kinetic, kinetic and linear free energy relationships in speculating reaction mechanisms		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall (i) the fundamental principles of aromaticity and the features of reactive intermediates (ii) the concepts of stereochemistry, kinetic/non-kinetic methods, free energy relationship and structural effects.	PSO 1, PSO2	K1
CO2	Explain (i) the aromatic/non-aromatic/anti-aromatic nature of species and the features of reactive intermediates (ii) the concepts of stereochemistry, kinetic/non-kinetic methods, free energy relationship and structural effects.	PSO3	K2
CO3	Apply the concepts (i) to distinguish the aromatic/non-aromatic/anti-aromatic compounds/ions, (ii) in the study of reactive intermediates (iii) of stereochemistry and physical organic chemistry.	PSO4	K3
CO4	Analyse (i) the stability/reactivity of compounds and ions in line with the concepts of aromaticity, stereochemistry and other physical aspects	PSO 8	K4
CO5	Evaluate the various factors responsible for the stability, reactivity and mechanistic pathways.	PSO 8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Aromaticity** 1.1 Benzenoid and non-benzenoid compounds – Aromatic, non-aromatic, anti-aromatic, super aromatic and homo-aromatic compounds – Hückel's and Craig's rule – Molecular orbital treatment (Example for aromatic, antiaromatic and non-aromatic compounds) – Frost circles – Alternant and non-alternant hydrocarbons 1.2 Study of cyclopropenyl, cyclobutenyl, cyclopentadienyl, cycloheptatrienyl and cyclooctatetraenyl ions 1.3 Annulenes [10], [12], [14], [16], [18], [20] and [22] – Tropolone – Azulene – Fused ring systems (Naphthalene, Anthracene, Phenanthrene) – Heterocyclic compounds (Pyrrole, Pyridine) – Fulvenes and Fullerenes (One example each)	15	CO1-CO5	K1 – K5
II	**Stereochemistry I – Optical isomerism** 2.1 Criteria – Chirality, asymmetry, dissymmetry – Optical isomerism due to chiral centre (Acyclic and alicyclic compounds), chiral axis (allenes, biphenyls, spiro-compounds) and chiral plane (trans-cyclooctene, Hexahelicene) – Optical isomerism of disubstituted cyclopropane, cyclobutane, cyclopentane and cyclohexane – Optical activity of cis- and transdecalin. 2.2 D & L notations for simple carbohydrates, Erythro-Threo nomenclature – examples. Newmann, Sawhorse, wedged, Fischer projection and their interconversions – Absolute configuration and Relative configuration – R, S Notation of molecules with chiral centre and chiral axis – Identification of homotopic, enantiotopic, diastereotopic atoms and faces – Prochiral carbon atoms 2.3 Asymmetric synthesis: Classification and examples only– Cram's rule. Sharpless epoxidation - dihydroxylation, aminohydroxylation of alkenes – Jacobsen's catalysts – Evans' catalyst. 2.4 Stereospecific and stereoselective reactions – Definition, importance and examples	15	CO1-CO5	K1 – K5
III	**Stereochemistry – II Geometrical and Conformational isomerism** 3.1. Geometrical isomerism: Cis-trans isomerism and E-Z nomenclature in acyclic systems 3.2. Geometrical isomerism in disubstituted cyclopentane and cyclohexane	15	CO1-CO5	K1 – K5

	3.3. Conformational isomerism: Differences between configuration and conformation, Conformational analysis of ethylene glycol and ethylene chlorohydrin. 3.4. Conformational analysis in cyclic systems – cycloheptane and cyclooctane. Conformational analysis of disubstituted cyclohexanes – Conformational analysis of cis- and trans-decalin. 3.5. Dynamics of cyclohexanols (oxidation and acylation), cyclohexanones (reduction) and cyclohexane carboxylic acid derivatives (esterification and hydrolysis)			
IV	**Reaction Mechanism-I (Non-kinetic and kinetic methods)** 4.1 Non-kinetic methods: Energy profile diagrams (for one step and two step reactions) intermediate versus transition state, identification of products, trapping of intermediates, crossover experiments, stereochemical studies- uses of isotopes. 4.2 Kinetic methods: Kinetic isotopic effects, salt effects, solvent effects - solvent isotopic effects, kinetic and thermodynamic controlled products – Hammond's postulates – Curtin-Hammett principle.	15 h	CO1-CO5	K1 – K5
V	**Reaction Mechanism-II (Structural effects and intermediates)** 5.1 Structural effects: Correlation of structure with reactivity - Inductive, hyperconjugation, mesomeric, steric effects, steric inhibition of resonance - Acidity of aliphatic and aromatic carboxylic acids and phenols - Basicity of aliphatic and aromatic bases. 5.2 Linear free energy relationship - Hammett equation (Significance of rho, sigma and nonlinear Hammett plot) Taft equation (basic level) 5.3 Organic reaction intermediates: Generation, detection, stability and reactivity of carbocations, carbanions, free radicals, carbenes, arynes and nitrenes.	15	CO1-CO5	K1 – K5

Textbooks

1. Michael B Smith, Jerry March, March's Advanced Organic Chemistry, 7th Edition, Wiley Students Edition, Wiley India Pvt. Ltd., India, 2015
2. V K Ahluwalia, Rakesh Kumar Parashar, Organic Reaction Mechanism, 4th Edition, Alpha Narosa Publishing House, India, 2019
3. P S Kalsi, Stereochemistry: Conformation and Mechanism, 10th Edition, New Age International Publisher, India, 2019

References

1. Ernest L Eliel, Stereochemistry of Carbon Compounds, Tata McGraw Hill Edition, India, 2008
2. Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford University Press, India, 2019
3. Francis A Carey and Richard J Sundberg, Advanced Organic Chemistry Part (A & B) 5th

Edition, Springer, New York, USA, 2007
4. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, 4th Edition, New Age International Publishers, India, 2020

Suggested Reading

1. N.S. Isaacs, Physical Organic Chemistry, ELBS Publication, Longman, UK, 1987
2. S. H. Pine, Organic Chemistry, 5th Edition, McGraw Hill International Edition, USA, 1987
3. T. H. Lowry K. S. Richardson, Harper and Row, Mechanism and theory in organic chemistry, 2nd Edition, New York, 1981

Online Resources (accessed on 28 June 2022)

1. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_pg/660
2. http://epgp.inflibnet.ac.in/

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	2	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	-	2	-	-	-	-	-	-	-	3	-	-	-	-	-	K2
CO 3	-	2	-	-	-	-	-	-	-	-	3	-	-	-	-	K3
CO 4	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	K4
CO 5	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	K5
Wt. Avg.	3	2	-	-	-	-	2	3	3	3	3	-	-	-	1	
Overall Mapping of the Course														PO: 2.3 PSO: 2.6		

STRUCTURAL INORGANIC CHEMISTRY

Course Code			
Credits	**4**		
Hours / Cycle	**5**		
Category	**Part NA**	**Core**	**Theory**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To determine the structural properties of molecules, main group clusters, rings, and cages. 2. To grasp the fundamental concepts and principles that emphasize solid state chemistry 3. To apprehend the structural information of crystal systems by means of XRD		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall (i) structural features of main group clusters, rings & cages and ionic crystal systems (ii) principles of solid state chemistry	PSO1, PSO2	K1
CO2	Explain structural features of main group compounds and principles of solid state chemistry	PSO1, PSO2	K2

CO3	Apply the electron counting scheme to predict the structural information of main group compunds and XRD principles to interpret structural features of ionic crystals	PSO2, PSO4	K3
CO4	Analyze the structure of the molecules, ions, main group cluster, rings and cages and ionic crystals	PSO2, PSO4	K4
CO5	Compare various structural features of main group compounds and ionic crystals	PSO2, PSO3, PSO4	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Electron counting scheme and structure of main group inorganic compounds** 1.1 Lewis Dot Structure & Formal charge calculation; VSEPR theory –Steric number or hybridization number and Effect of lone pair on the geometry of molecules (problems only) 1.2 Borane cluster: Wade's rule, classification – boranes, carboranes, hetero and metalloboranes; main group clusters –zintl ions and mno rule. (problems only) 1.3 Structure and bonding in ring and cage compounds of main group elements: Silicates – types, examples and structures, Silicones and their types, B – N compounds (borazole and boron nitride), Phosphonitrile polymers, polyphosphazenes; Polyacids.	15	CO1-CO5	K1 – K5
II	**Electron counting scheme and structure of metal clusters** Parallels between main group compounds and organometallic compounds: Isolobal analogy; Metal clusters − Definition of metal clusters, Low nuclearity carbonyl clusters –calculation of number of M-M bonds based on 18 electron rule; High nuclearity carbonyl clusters – Poly Skeletal Electron Pair theory (Mingo's rule); Non-carbonyl clusters – metal-metal triple and quadruple bond formation.	15	CO1-CO5	K1 – K5
III	**Solid state chemistry - I** 3.1 Ionic crystals – Packing of ions, packing efficiency and radius ratio rule; Miller indices and Unit cells; Crystal Systems and Bravais lattices; Symmetry Operations in crystals − Proper and improper axis, Mirror planes, Glide planes, Screw axis, Space groups; Symmetry operations in cubic crystal system; Structural features of crystal systems − rock salt, zinc blende & wurtzite, fluorite & anti-fluorite, rutile & anatase and perovskites	15	CO1-CO5	K1 – K5

	3.2 Point Defects – Schottky & Frenkel defects, Metal excess and Metal deficiency defects (Definitions, Explanation and Examples)			
IV	**Solid state chemistry - II** 4.1 Preparation methods for inorganic solids − Solid state synthesis, combustion synthesis, Low temperature methods – Alkoxide sol-gel method and Solvothermal method; Gas-phase methods – Principles and examples. 4.2 X-ray diffraction technique: Bragg's law, Powder diffraction method – Principle and Instrumentation; Interpretation of XRD data – JCPDS files, Phase purity, Scherrer formula, calculation of lattice constants; Systematic absence of reflections. Single Crystal – Differences between powder and single crystal XRD, Growth by slow evaporation method, instrumentation and sampling technique.	15	CO1-CO5	K1 – K5
V	**Solid state chemistry – III** 5.1 Electron and Neutron Diffraction techniques – Principle and instrumentation 5.2 Electron microscopy – difference between optical and electron microscopy, theory, principle, instrumentation, sampling methods and applications of SEM and TEM.	15	CO1-CO5	K1 – K5

Prescribed Books/Textbooks

1. G L Meissler and D ATarr, Inorganic Chemistry, 3rd Edition, Pearson Education Inc., 2008
2. B D Gupta and A K Elias, Basic Organometallic Chemistry: Concepts, Syntheses and Applications, University Press, 2013
3. A K Bhagi and G R Chatwal, A textbook of inorganic polymers, Himalaya Publishing House, India, 2001
4. A R West, Solid state Chemistry and its applications, 2ndEdition (Students Edition), John Wiley & Sons Ltd., 2014

References

1. R J D Tilley, Understanding Solids - The Science of Materials, 2nd edition, Wiley Publication, 2013
2. C N R Rao and J Gopalakrishnan, New Directions in Solid State Chemistry, 2nd Edition, Cambridge University Press, 1997.

Suggested Reading

1. L Smart, E Moore, Solid State Chemistry – An Introduction, 4th Edition, CRC Press, 2012
2. Charles Kittel, Introduction to Solid State Physics, 8th Edition, John Wiley & Sons, Inc, United Sates, 2005

Web Resources (accessed on 28 June 2022)

1. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
3. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	-	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	3	-	-	-	-	-	-	3	3	-	-	-	-	-	-	K2
CO 3	-	2	2	-	-	-	-	-	3	-	3	-	-	-	-	K3
CO 4	-	-	2	-	-	-	-	-	3	-	2	-	-	-	-	K4
CO 5	-	2	-	-	-	-	-	-	3	2	2	-	-	-	-	K5
Wt. Avg.	3	2	2					3	3	2	2.3					
Overall Mapping of the Course														PO: 2.3 PSO: 2.6		

THERMODYNAMICS AND CHEMICAL KINETICS

Course Code			
Credits	**4**		
Hours / Cycle	**5**		
Category	**Part NA**	**Core**	**Theory**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To understand parameters utilized to study the deviation from ideal behaviour. 2. To grasp the principles behind application of thermodynamics at molecular level. 3. To appreciate the mechanism of unimolecular, biomolecular and catalytic reactions. 4. To understand the influence of reaction conditions on the rate of various reactions.		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the principles of thermodynamics and chemical Kinetics	PSO1	K1
CO2	Explain the fundamentals of (i) chemical, statistical and non-equilibrium thermodynamics (ii) reactions in solutions and gas phase (iii) catalysed reactions (iv) photochemical, polymerisation and fast reactions & reactions caused by high energy radiation (v) phase diagrams	PSO2, PSO3, PSO4	K2
CO3	Apply (i) thermodynamic principles to solutions, three component systems and molecules (ii) kinetic principles to chemical reactions	PSO2, PSO3, PSO4	K3
CO4	Analyse (i) thermodynamic behaviour of ideal and non-ideal systems (iii) molecular properties to predict the behaviour of macroscopic systems (ii) factors influencing reaction kinetics	PSO2, PSO3, PSO4	K4
CO5	Evaluate (i) the parameters causing deviation from ideal nature (ii) the behaviour of three component systems(iii) application of thermodynamics at molecular level (iv) mechanistic aspects of chemical reactions	PSO2, PSO3, PSO4, PSO8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Thermodynamics-I** 1.1 Chemical Thermodynamics: Partial molal properties. Fugacity and its determination. Activity and activity coefficient, determination of activity coefficients. 1.2 Three component systems – graphical representation. Solid-liquid equilibria- hydrate formation, compound formation. 1.3 Non-equilibrium Thermodynamics: Postulates of non-equilibrium thermodynamics. Entropy production. Linear laws relative to fluxes and forces. Curie's theorem. Onsager's reciprocity	15	CO1 - CO5	K1 – K5
II	**Thermodynamics – II** 2.1 Statistical Thermodynamics: Permutation and combination. Laws of probability. Distribution laws. Gaussian distribution. Microstates and macrostates for distinguishable and indistinguishable particles. Thermodynamic probability. Maxwell Boltzmann distribution for molecular velocities. Maxwell-Boltzmann statistics -Partition functions-Translational, rotational, vibrational and electronic partition function – Calculation of thermodynamic parameters and equilibrium constants in terms of partition function - Bose-Einstein and Fermi-Dirac statistics 2.2 Heat capacities of monoatomic gases and solids- Einstein and Debye Models. Classical limit. Liquid helium and BE condensation. Fermi energy. Negative absolute temperature.	15	CO1 - CO5	K1 – K5
III	**Chemical Kinetics – I** 3.1. Reaction Mechanisms. CTST Potential energy surfaces, reaction coordinate. Kinetic isotope effect. Principle of microscopic reversibility-detailed balancing. Unimolecular – Lindemann, Hinshelwood, Rice–Ramsperger–Kassel (RRK), Slater and Rice Ramsperger–Kassel–Marcus (RRKM) theory. and Termolecular reactions. 3.2. Reactions in Solution. Comparison of gas phase reactions with reactions in solutions, factors influencing reaction rates in solution effect of dielectric constants primary and secondary salt effects. Application of CTST to reactions in solution, diffusion controlled reactions in solutions (cage effect).	15	CO1 - CO5	K1 – K5

IV	Chemical Kinetics – II (15 hours) 1.1 Homogeneous Catalysis. Bronsted Acid-Base Catalysis: Specific Catalysis & General Catalysis (kinetic expression and kinetic plots) - Bronsted Catalysis Law , acidity functions, Zucker-Hammett and Bunnet hypothesis. Enzyme catalysis – Michealis Meten equation, Lineweaver-Burk plot, Eadie plot. Effect of temperature and pH on enzyme catalyzed reactions 1.2 Heterogeneous Catalysis. Physical adsorption and chemisorption – Lennard-Jones plots- Adsorption isotherms -Langmuir and BET equation - Surface area measurement. Role of surface in catalysis-Langmuir-Hinshelwood, and Rideal-Eley mechanisms. Semiconductor Catalysis	15	CO1 - CO5	K1 – K5
V	**Chemical Kinetics – III (15 hours)** 5.1 Kinetics of Photochemical Reactions: Comparative study of thermal and photochemical mechanisms in hydrogen-halogen reactions. Decomposition of carbonyl compounds Rice- Herzfeld mechanisms. 5.2 Kinetics of Polymerisation Reactions: Principle of polymerisation kinetics-molecular and free radical mechanisms. 5.3 Fast reactions: Methods of studying fast reactions-flow methods – relaxation technique- flash photolysis. 5.4 Radiation Chemistry: Source-Interaction of high energy radiation with matter -primary and secondary processes-G-value- Radiolysis of water and aqueous solutions Dosimetry		CO1 - CO5	K1 – K5

Textbooks

1. S. Glasstone, Thermodynamics for Chemists, 1st Edition, East West Press, 2008.
2. B J McClelland, Statistical thermodynamics, Chapman and Hall, London, 1973.
3. Leonard K Nash, Elements of statistical thermodynamics, 2nd Edition, Dover Publications2012.
4. K J Laidler, Chemical Kinetics, 3rd edition, Pearson, 2003.
5. Eric V Anslyn, Dennis A Dougherty, Modern Physical Organic Chemistry, University Science Books, 2005
6. C Kalidas, M V Sangaranarayanan, Non-Equilibrium Thermodynamics: Principles &Applications, Macmillan India Ltd., 2002**.**

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1. J F Lee, F.W. Sears, D.L. Turcottee, Statistical Thermodynamics, 2nd Edition, 1973.
2. M. C. Gupta, Statistical Thermodynamics, New Age International, 2007.
3. R.P. Rastogi, R.R. Misra, An Introduction to Chemical Thermodynamics, Vikas publishing house, 1996.
4. J. Rajaram, J. C. Kuriakose, Thermodynamics, Pearson, 2013.
5. P. W. Atkins, Physical Chemistry, Oxford University Press, 8th Edition, 2006

Suggested Reading

1. M.W. Zemansky, R.H. Dittman, Heat and Thermodynamics, Tata McGraw Hill, 1981.

2. M. F .Granville, Student Misconceptions in Thermodynamics, J. Chem. Edu. 62 (1985) 847.
3. L. S. Bartell, Stories to Make Thermodynamics and Related Subjects More Palatable, J. Chem. Edu. 78 (2001) 1059.
4. D. N. Hague, Fast Reactions, Wiley- Interscience, New York, 1971.
5. J. W. Moore and R. G. Pearson, Kinetics and Mechanisms, John Wiley & Sons, New York, 1981.
6. M. R. J. Dack, The Influence of Solvents on Chemical Reactivity, J. Chem. Educ. 51 (1974) 231

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2. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
3. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO 6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	3	2	-	-	-	-	3	-	-	-	-	-	-	-	K1
CO 2	3	3	2	-	-	-	-	-	3	3	2	-	-	-	-	K2
CO 3	3	3	2	-	-	-	-	-	3	3	2	-	-	-	-	K3
CO 4	3	3	2	-	-	-	-	-	3	3	2	-	-	-	-	K4
CO 5	3	3	2	-	-	-	-	-	3	3	2	-	-	-	1	K5
Wt. Avg.	3	3	2	-	-	-	-	3	3	3	2	-	-	-	1	
Overall Mapping of the Course														PO –2.6 PSO – 2.4		

METALS IN LIFE

Course Code			
Credits	**5**		
Hours / Cycle	**3**		
Category	**Part NA**	**Elective**	**Theory**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To comprehend the coexistence of metals in human life and environment 2. To recognize the emerging problems caused by metal pollution 3. To grasp the various analytical techniques to detect metal in air and water 4. To appreciate the practicality of metals in the field of medicine, industry and art.		

CO#	**Course Outcome(s)**	**PSO Addressed**	**Bloom's Taxonomy Levels (K1 to K5)**
On completing the course successfully, the student will be able to			
CO1	Understand role of the essential and non-essential metals in biological processes and categorize their importance in medicine, industry, Art and civilization	PSO 1, PSO3	K1
CO2	Identify the toxicity of various metals on different segments of environment (Air, Water, soil) and explore the remediation techniques to sustain clean and safe environment	PSO3	K2

CO3	Familiar with standard air, water and soil quality parameters and correlate metals excess and deficiency with human diseases.	PSO4, PSO 7	K3
CO4	Equipped and familiar with various analytical techniques used for air, water, and soil analysis and select appropriate one for the specific requirement	PSO4, PSO 7	K4
CO5	Innovate new ideas for the use of metals in developing new medicines, and pave the way to protect the environment by finding alternate of hazardous substances	PSO6, PSO 8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Metals in life's existence** 1.1 Essential and non-essential metals – Role of Na, K, Ca, Mg, Zn, Co, Fe, Cr, Mo and CuSource- dietary requirement, biological importance and diseases caused by deficiency/excess; Sodium-potassium ion pump 1.2 Structure and functions of Metalloenzymes: Iron containing enzymes such as methane monoxygenase, nitric oxide reductase; Molybdenum containing enzymes such as xanthane, sulphite oxidase and nitrate	9	CO1-CO5	K1 – K5
II	**Metals in Environment** 2.1 Heavy metals and toxicity –Toxicology: Definition and scope, acute and chronic toxicity, selective toxicity, toxicology and biological effects of arsenic, cadmium, chromium, mercury and nickel, Bio-accumulation and bio-magnification, Remediation technologies– Basic principles of phyto-bioremediation of heavy metals from soil. 2.2 Radiation toxicology: Sources –Radiation from natural and manmade activities; Terminologies: radionuclides, radiation emissions and radioactive decay; Ionizing and nonionizing radiation; Effects of radioactive toxicology of Cesium-137, Krypton-85 Iodine-131 and Strontium-90; Biological and environmental effects–storage and disposal of radioactive wastes; Detection and monitoring of radioactive pollutants 2.3 Metals in E-waste–Definition and types, E-waste management	9	CO1-CO5	K1 – K5
III	**Metals in water and air** 3.1 Water quality parameters, Hardness– cause of temporary and permanent hardness, analysis of hardness; Metallic pollutants in water and trace metal analysis –cause of metal pollution in water, analysis of arsenic by Atomic absorption spectroscopy	9	CO1-CO5	K1 – K5

	(AAS), cadmium and mercury by dithizone method, chromium by diphenyl carbazide method, lead by polarographic method. 3.2 Air sampling and monitoring techniques: settle-able and suspended particulate matter; monitoring of air quality by dust fall jar and impingement method			
IV	**Metals in Medicines** 4.1 Metal-dependent diseases: Deficiency diseases of Zn, Hg, Cd, Pb and Cu 4.2 Metals in therapy: Metals in radiodiagnosis and Chemotherapy; Metal based drugs - Li, Pt, Rh, Ru and Au; Detoxification by chelation therapy 4.3 Bio-compatible metals and their applications – Ti, Ca and alloys	9	CO1-CO5	K1 – K5
V	**Metals in Industry, Civilization and Art** 5.1 Role of metals in paints, oil and gas industry, pharmaceutical industry, battery industry, fireworks industry and in soldering 5.2 Role of metals in jewelry – Role of Cu, Al, Au, Nb, Pd, Pt, Ag, Ti, brass, Pewter and stainless steel–unique chemical and physical properties 5.3 Role of metals in civilization, culture and art–Three major periods of metal age (copper, bronze and iron age), traditional Indian iron making technology, Rust-less wonders – QutubMinar and iron pillar of Delhi	9	CO1-CO5	K1 – K5

Textbooks

1. Asim K. Das, Bioinorganic Chemistry, Books & Allied Ltd., 2007
2. K Hussain Reddy, Bioinorganic Chemistry, New Age International, 2007
3. A K De, Environmental Chemistry, 5th Edition,New Age International, 2003
4. P S Sindhu, Environmental Chemistry, New Age International, 2002
5. Sharada Srinivasan, SrinivasaRanganathan, Alessandra Giumlia-Mair, Metals and Civilizations, National Institute of Advanced Studies, Bengaluru, 2015

References

1. G J Hussain, Elements of Environmental Chemistry, Anmol Publications Pvt. Ltd., 2011
2. S SPurohit and B Kakrani, Air Environment and Pollution, Agrobios (India), 2018
3. M Noor, Environment and Water Pollution (Cause, Effect and Control), Cyber Tech Publications, 2012
4. M A Subramanian, Toxicology: Principles and Methods, 2nd revised Edition, MJPPublishers, 2010

Suggested Reading

1. Cassius M. Riley, Toxicology: The Nature, Effects and Detection of Poisons, with the Diagnosis and Treatment of Poisoning, Andesite Press, 2017
2. Q A Acton, Issues in Radiation Biology and Toxicology Research, Scholarly Editions, 2013
3. C S Smith, Materials and the Development of Civilization and Science, Science (1965) 148, 908-917

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1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO 1	PO 2	PO 3	PO 4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	3	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	-	3	-	-	-	-	-	-	-	3	-	-	-	-	-	K2
CO 3	-	3	-	-	-	-	-	-	-	-	3	-	-	-	-	K3
CO 4	-	3	-	-	-	-	-	-	-	-	3	-	-	-	-	K4
CO 5	-	-	-	-	-	-	3	-	-	-	-	-	3	3	-	K5
Wt. Avg.	3	3					3	3	3	3	3		3	3		
Overall Mapping of the Course														PO: 3 PSO: 3		

INORGANIC MATERIALS FOR ENERGY

Course Code			
Credits	**5**		
Hours / Cycle	**3**		
Category	**Part NA**	**Elective**	**Theory**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To recognize the properties and importance of inorganic materials in energy 2. To appreciate the fundamental concepts and principles underlying energy storage and conversion devices 3. To expound the significance of CO_2 conversion to beneficial products		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall (i) optical, conducting and magnetic properties of inorganic materials (ii) basics and governing principles of electrochemical water splitting, CO_2 reduction, operation of batteries, fuel cells and super capacitors	PSO1, PSO2	K1
CO2	Comprehend (i) optical, conducting and magnetic properties of inorganic materials and mechanisms involved in the operation of electrochemical water splitting, CO_2 reduction, batteries, fuel cells and super capacitors	PSO1, PSO2	K2
CO3	Apply the knowledge the interpret (i) the optical, conducting and magnetic properties of inorganic materials (ii) selection of anode cathode materials of energy storage and conversion devices	PSO2, PSO4	K3
CO4	Analyse the (i) factors affecting the optical, conducting, and magnetic properties of inorganic materials (ii) performance of the energy storage and conversion materials.	PSO2, PSO4	K4
CO5	Compare optical, conducting, and magnetic properties of inorganic materials (ii) performance of the energy storage and conversion materials.	PSO2, PSO3, PSO4	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Opto-electronic materials** 1.1 Colour centres (F, F', V and H) – Definition and examples; Photophysical processes – Jablonski diagram, chemiluminescence; 1.2 Photo-luminescent inorganic materials – presence of defects and dopants; Lasers – ruby laser, neodymium laser and inorganic LEDs.	9	CO1 - CO5	K1 – K5
II	**Solid electrolytes** 2.1 General Characteristics of solid electrolytes; Ionic Conductors – Factors affecting ionic conductors, types of ionic conductors – alkali halide ion conductors, alumina, silver and copper ion conductors; Proton ion conductors; 2.2 Super conductors – Types, BCS theory, Meissner effect and applications of super conductors.	9	CO1 - CO5	K1 – K5
III	**Magnetic Materials** 3.1. Terminologies: Atomic Magnetism, magnetic domains, magnetization and magnetic saturation, hysteresis loop; Types of Magnetic Materials–soft and hard magnetic materials, spinels and garnets; 3.2. Applications of magnetic materials in/as permanent magnets, transformer core, magnetic information storage; Magnetoresistance materials and their applications	9	CO1 - CO5	K1 – K5
IV	**Materials for electrochemical energy storage** 4.1 Batteries – Primary and secondary batteries, operational principles, anode and cathode materials for Lithium and Lithium-ion batteries. 4.2 Supercapacitors – Types and operational characteristics; Anode and cathode materials–Types and basic mechanisms	9	CO1 - CO5	K1 – K5
V	**Materials for electrochemical energy conversion** 5.1 Electrochemical water splitting: Principle, Electrocatalyts for hydrogen production; Electrocatalysts for oxygen evolution – Transition metal based electrocatalysts (Ni, Co, Fe), perovskites oxides and transition metal chalcogenides. 5.2 Fuel cells: Principle, Transition metal catalysts–binary and ternary metal catalysts. 5.3 CO_2 reduction: Carbon cycle, greenhouse effect, Challenges in the selection of catalysts, Noble and Non-noble metal catalysts.	9	CO1 - CO5	K1 – K5

Textbooks

1. A. R West, Solid State Chemistry and its Applications 2nd Edition (Student Edition), John Wiley & Sons Ltd., 2014.
2. L. Smart, E. Moore, Solid State Chemistry – An Introduction, 4th Edition, CRC Press, 2012.
3. M. Aulice Scibioh and B. Viswanathan, Materials for Supercapacitor Applications, Elsevier Publications, 2020
4. B. Viswanathan and M. Aulice Scibioh, Photoelectrochemistry– Principles and Practices, Alpha Science International Ltd., 2014

References

1. M. Winter and R. J. Brodd, What Are Batteries, Fuel Cells, and Supercapacitors? Chem. Rev. 2004, 104, 4245-4269.

Suggested Reading

1. M. Aulice Scibioh & B. Viswanathan, Electrocatalytic reduction of carbon dioxide: A status report, Proc. Indn. Natl. Acad. Sci., 70 A (3), 2004, 407-462

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1. https://www.sciencedirect.com/science/article/pii/S223878541500112X

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	3	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	3	3	-	-	-	-	-	3	3	-	-	-	-	-	-	K2
CO 3	-	3	2	-	-	-	-	-	3	-	3	-	-	-	-	K3
CO 4	-	1	2	-	-	-	-	-	3	-	2	-	-	-	-	K4
CO 5	-	3	2	-	-	-	-	-	3	1	2	-	-	-	-	K5
Wt. Avg.	3	2.6	2					3	3	1	2.3					
Overall Mapping of the Course														PO:2.5 PSO: 2.3		

INORGANIC ANALYTICAL CHEMISTRY

Course Code			
Credits	**5**		
Hours / Cycle	**3**		
Category	**Part NA**	**Elective**	**Theory**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To recognize the fundamentals and theoretical principles of analytical tools used for qualitative and quantitative analysis 2. To grasp the fundamentals and instrumentation of analytical tools 3. To identify the analytical techniques and significance of radiometric analysis		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the fundamental principles of various analytical techniques and spectroscopic techniques like atomic absorption and emission spectroscopy & photo electron spectroscopy	PSO1, PSO2	K1
CO2	Explain the principles, instrumentation and applications of various analytical techniques and spectroscopic techniques like atomic absorption and emission spectroscopy & photo electron spectroscopy	PSO1, PSO2	K2

CO3	Apply the principles of various analytical techniques and spectroscopic techniques like atomic absorption and emission spectroscopy & photo electron spectroscopy in qualitative and quantitative analysis of inorganic elements / ions / compounds	PSO2, PSO4	K3
CO4	Analyse and compare the principles of analytical techniques involved in analysis of inorganic elements / ions / compounds	PSO2, PSO4	K4
CO5	Compare and evaluate the analytical techniques to be used for analysis of inorganic elements / ions / compounds	PSO2, PSO3, PSO4	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Atomic Spectroscopy** 1.1. Atomic Absorption Spectroscopy (AAS): Principles of AAS, Instrumentation – flame AAS and furnace AAS, resonance line sources, sensitivity and detection limits in AAS, interferences – chemical and spectral, evaluation methods in AAS; Applications in qualitative and quantitative analysis. 1.2. Atomic Emission Spectroscopy (AES): Principle of AES, Instrumentation, Interferences, evaluation methods, Applications in quantitative analysis	9	CO1-CO5	K1 – K5
II	**Electroanalytical methods** 2.1 Polarography: Principle, Ilkovic's equation, Dropping Mercury Electrode (DME), Rotating Disc electrode, role of supporting electrolyte, factors affecting polarographic wave and applications in qualitative and quantitative analysis 2.2 Cyclic Voltammetry: Principle of cyclic voltammetry, conditions for reversibility of electrochemical reactions, quasi-reversible and irreversible processes, cyclic voltammogram of $K_3[Fe(CN)_6]$; applications in inorganic analysis 2.3 Amperometric titrations: Difference between polarography and amperometric titration; dead stop end point method (bi amperometry), Chrono-amperometry; Amperometric titration - (i) mixture of halides, (ii) Fe(II) vs Fe(III) and (iii) Ti(IV) vs Ti (III)	9	CO1-CO5	K1 – K5
III	**Thermoanalytical methods** 3.1. Thermogravimetric analysis (TGA): Principle, Factors affecting thermograms, Derivative thermogravimetric curves, Instrumentation – Honda's balance; applications of thermogravimetry – calcium oxalate monohydrate and dolomite ore 3.2. Differential Thermal Analysis (DTA): Principle, Instrumentation, DTA curves for calcium oxalate	9	CO1-CO5	K1 – K5

	monohydrate, phase transition of sulphur and manganese phosphinate 3.3. Differential Scanning Calorimetry (DSC): Principle, Instrumentation, DSC analysis for carbon tetrachloride			
IV	**Radiochemical methods** 4.1. Hot atom chemistry, The Szilard-Chalmers process, chemistry of recoil atoms, chemical effects of radioactive decay, solvated electron. 4.2. Uses of radiations in the study of matter, neutron activation analysis, dilution analysis, dosimetry, synthesis of organic and inorganic compounds by irradiation radiometric analysis, radiography.	9	CO1-CO5	K1 – K5
V	**Photo electron spectroscopic techniques** 5.1 X-ray photoelectron spectroscopy (XPS), Ultra-violet photoelectron spectroscopy (UPS), Auger electron spectroscopy (AES), Principles of XPS and AES, Chemical shift, Depth profiling, 5.2 Instrumentation, Applications of XPS and AES	9	CO1-CO5	K1 – K5

Textbooks

1. Hobart H. Willard, John A. Dean, Lynne L. Merritt, Instrumental methods of analysis, D. VanNostrand Co., 1953
2. Gary D. Christian, Analytical Chemistry, 6th Edition, Wiley India Pvt. Ltd., 2007

References

1. D A Skoog, Principles of Instrumental Analysis, 6th Edition, Cengage Learning, 2016
2. J H Kennedy, Analytical Chemistry: Principles, 2nd Edition, Cengage Learning (India edition), 2011

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1. S M Khopkar, Basic Concepts of Analytical Chemistry, 4th Edition, New Age International Publishers, 2020

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2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=1+p0z2ZbAGSfsyfLITzgZQ==

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	-	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	3	-	-	-	-	-	-	3	3	-	-	-	-	-	-	K2
CO 3	-	2	2	-	-	-	-	-	3	2	2	-	-	-	-	K3
CO 4	-	-	2	-	-	-	-	-	3	-	2	-	-	-	-	K4
CO 5	-	2	-	-	-	-	-	-	3	2	2	-	-	-	-	K5
Wt. Avg.	3	2	2	-	-	-	-	3	3	2	2					
											Overall Mapping of the Course			PO: 2.3 PSO: 2.5		

ORGANIC CHEMISTRY PRACTICAL – I

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part III**	**Core**	**Practical**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To achieve the separation of organic mixtures with two and three components and identify each component through systematic qualitative analysis 2. To develop bench and psychomotor skills in organic preparations involving two and three stages		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall and tabulate the experimental procedure for the separation and identification of organic compounds.	PSO1	K1
CO2	Compile the report of the experiments in an organized way.	PSO1	K2
CO3	Tabulate/present the experimental observations in a systematic manner related to qualitative organic analysis and in the organic synthesis.	PSO1, PSO6	K3
CO4	Tabulate the inferences and present the report in a systematic manner related to qualitative organic analysis and in the organic synthesis during regular classes	PSO1, PSO6	K4
CO5	Tabulate the inferences and present the report in a systematic manner of the qualitative organic analysis and in the organic synthesis during ICA.	PSO1, PSO6	K5

CONTENT

I. Separation and analysis of *two component* organic mixture by chemical methods

II. Separation and analysis of *three component* organic mixture by chemical methods

(Benzoic acid, Cinnamic acid, Phthalic acid, α and β-Naphthol, Aniline, N, N-Dimethylaniline, Glucose, Sucrose, Fructose, Benzaldehyde, Acetophenone, Benzophenone, Nitrobenzene, Benzamide, Acetanilide, Urea)

III. Two Stage Organic Synthesis (Any Five)

Synthesis of organic compounds based on the following types of reactions: Acetylation, Bromination, Oxidation, Reduction, Dehydration, Cyclization, Benzoylation, Hydrolysis, Condensation and Esterification

1. p-Bromoacetanilide from Aniline (Acetylation, Bromination)
2. p-Aminobenzoic acid from p-Nitrotoluene (Oxidation, Reduction)
3. Benzil from Benzaldehyde (Condensation, Oxidation)

4. 1,2,3,4-tetrahydrocarbazole from Cyclohexanone (Condensation, Cyclization)
5. Phthalimide from Phthalic acid (Dehydration, Substitution)
6. 4-Methyl-7-acetoxy coumarin from Resorcinol (Cyclization, Acetylation)
7. Acetyl salicyclic acid from Methyl salicylate (Hydrolysis, Esterification)
8. Stilbene from Benzaldehyde (Condensation, Reduction)

IV. Three Stage Organic Synthesis: (Any Three)

1. p-Bromoaniline from Aniline (Acetylation, Bromination, Hydrolysis)
2. Ethyl p-aminobenzoate from p-Nitrotoluene (Oxidation, Reduction, Esterification
3. Benzilic acid from Benzaldehyde (Condensation, Oxidation, Rearrangement)
4. Anthranilic acid from Phthalic acid (Dehydration, Substitution, Hydrolysis)
5. 5. Stilbene dibromide from Phthalic acid Benzaldehyde (Condensation, Reduction, Addition)

Textbooks

1. N. S. Gnanapragasam and G. Ramamurthy, Organic Chemistry – Lab manual, S. Viswanathan Co. Pvt. Ltd, 1998.
2. J. N. Gurtu and R. Kapoor, Advanced Experimental Chemistry, S. Chand and Co., 1987
3. Monograph on Green Chemistry Laboratory Experiments, Green Chemistry Task Force Committee, Department of Science & Technology, GoI, 2009

References

1. Vogel's Text Book of Practical Organic Chemistry, 5th Ed, ELBS/Longman, England, 1984.
2. V K Ahluwalia, Sunitha Dhingra, Adarsh Gulati, College Practical Chemistry, University Press, India, 2008.
3. Jag Mohan, Organic Analytical Chemistry, Narosa Publishing House, India, 2003

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	K1
CO 2	-	-	-	2	-	-	-	2	-	-	-	-	-	-	-	K2
CO 3	-	2	-	2	-	-	-	2	-	-	-	-	3	-	-	K3
CO 4	-	2	-	2	-	-	-	2	-	-	-	-	3	-	-	K4
CO 5	-	2	-	2	-	-	-	2	-	-	-	-	3	-	-	K5
Wt. Avg.	-	2	-	2	-	-	-	2	-	-	-	-	3	-	-	
-Overall Mapping of the Course														PO: 2.0 PSO: 2.5		

INORGANIC CHEMISTRY PRACTICAL I

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part III**	**Core**	**Practical**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	To apply physical and inorganic chemistry concepts in identifying the metal ions through semi-micro analysis		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall (i) the semimicro qualitative analysis techniques to identify the familiar and less familiar cations in the given mixture (ii) Photo colorimetric estimation of metal ions(Fe, Cu, Ni and Mn) (iii) procedure for the preparation of various metal complexes/compounds	PSO1, PSO2	K1
CO2	Comprehend the principles and concepts behind semimicro qualitative analysis, photocolorimetric estimation of metal ions and process & chemical reactions involved in the preparation of complexes.	PSO2. PSO3	K2
CO3	Apply (i) the principles and concepts behind semimicro qualitative analysis for identifying the familiar & less familiar cations (ii) quantitative estimation of metal ions by photo colorimetric method (iii) the knowledge of complex preparation to prepare the complexes /compounds	PSO4, PSO6	K3
CO4	Analyse (i) to identify and separate the cations from the given mixture (ii) the results of the photocolrimetric estimation of metal ions and interpret the data (iii) the mechanism involved and purity of the compound	PSO6	K4
CO5	Evaluate the accuracy of the semimicro qualitative analysis results for mixture containing familiar and less familiar cations.(ii) comparison of colorimetric estimation of metal ions	PSO6, PSO7	K5

CONTENT

I. Semimicro qualitative analysis of mixtures containing two common cations and two cations of the following less familiar elements.
Tl, W, Se, Te, Mo, Ce, Th, Ti, Zr, V, Be and U and Li

II. Photo-colorimetric estimation of metal ions:
1. Colorimetric Estimation of Iron by Fe-NH4SCN complex
2. Colorimetric Estimation of Copper by Cu-NH3 complex
3. Colorimetric Estimation of Nickel by Ni-DMG complex
4. Colorimetric Estimation of Manganese

III. Complex preparations (any FIVE):
1. Preparation of Tetramminecopper(II) sulphate.
2. Preparation of Tris(thiourea)copper(I) sulphate
3. Preparation of Potassium tris(oxalato)chromate (III)
4. Preparation of Sodium hexanitrocobaltate(III)
5. Preparation of Potassium bis(oxalato)cuprate(II) dihydrate
6. Preparation of Sulphatotris(thiourea)zinc(II)
7. Preparation of Hexamminenickel(II) Chloride
8. Preparation of cis-Potassium dioxalatodiaqua chromate(III)
9. Preparation of soidum trioxalato ferrate(III)

IV. Green synthesis:
Preparation of manganese dioxide nano-particles, Preparation of iron oxide nanoparticles

Textbooks
1. Semimicro qualitative analysis of inorganic ions by V. V. Ramanujam
2. Vogel's textbook of Macro and Semimicro qualitative analysis, 5th Edition, Revised by G. Svehla, Longman GroupLimited, London, 1979

References
1. Experimental Inorganic Chemistry, W.G. Palmer, Cambridge University Press, Cambridge, 1965

Online Resources (accessed on 28 June 2022)
1. https://www.frontiersin.org/articles/10.3389/fnano.2021.655062/full
2. https://jnanobiotechnology.biomedcentral.com/articles/10.1186/s12951-018-0408-4

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	2		-	-	-	-	-	3	-	-	-	-	3	-	-	K1
CO 2	-	3	-	-	-	-	-	3	3	-	-	-	3	-	-	K2
CO 3	2	3	-	-	-	-	-	-	-	3	3	-	3	-	-	K3
CO 4	2	3	-	-	-	-	-	-	-	-	-	-	3	1	-	K4
CO 5	2	3	-	-	2	-	-	-	-	-	-	-	3	1	-	K5
Wt. Avg.	2	3			2			3	3	3	3		3	1		
Overall Mapping of the Course														PO: 2.3 PSO: 2.7		

PHYSICAL CHEMISTRY PRACTICAL I

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part III**	**Core**	**Practical**
Semester	**I**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	To apply the theoretical concepts of physical chemistry in determining and understanding various physical parameters		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the basic physical chemistry concepts through hands-on experiments and tabulate the results of the experiments	PSO 1	K1
CO2	Compile the results of the experiment in a organised manner	PSO7	K2
CO3	Calculate various physical quantities using the principle of electrochemistry, thermodynamics, spectroscopy and phase rule.	PSO4, PSO6	K3
CO4	Present the report of the experiments in a scientific manner	PSO4, PSO 6	K4
CO5	(i) Develop 21st century skills such as critical thinking, creativity, collaboration, and communication through project based learning (ii) Tabulate the inferences and present in a systemic manner in ICA.	PSO4, PSO6, PSO7, PSO 8	K5

CONTENT

I. Experiments

1. Determination of integral and differential heat of solution by calorimetry.
2. Determination of heat of neutralization of a strong acid by a strong base using calorimetry.
3. Determination of phase diagram for two component solid systems.
4. Determination of phase diagram for three component liquid systems.
5. Determination of bond refractions by refractometry.
6. Understanding the interaction between the components of a binary mixture using refractometry.
7. Determination of equivalent conductance of a strong electrolyte at infinite dilution using conductometry.
8. Determination of equivalent conductance of a weak electrolyte at infinite dilution using conductometry.
9. Determination of dissociation constant of a weak acid by conductometry.
10. Determination of solubility of sparingly soluble salt by conductometry.
11. Verification of Beer Lambert's law.
12. Beer Lambert's law - Simultaneous estimation of Mn and Cr in a solution containing $KMnO_4$ and $K_2Cr_2O_7$.
13. Conductometric Titration – Strong acid vs Strong base
14. Conductometric Titration – Mixture of strong acid and weak acid vs Strong base
15. Conductometric Titration – Mixture of halides vs silver nitrate
16. Conductometric Titration - CuSO4 vs NaOH or MgSO4 vs BaCl2
17. Determination of standard electrode potential.
18. Determination of solubility of AgCl from emf measurements.
19. Determination of pKa of a weak acid from emf measurements.
20. Determination of pH of buffer solutions from emf measurements.

II. Project Based Learning

1. Spectrophotometric analysis of coloured samples (dyes, natural pigments, metal ions etc.)
2. Study of interaction between samples by refractometry.
3. Use of conductance measurements to study interactions, determine physical quantities, etc.

Textbooks

1. A. Findlay, J.A. Kitchener, Findlay's Practical Chemistry, 8th Edition, Prentice Hall Press,1954.

B. Viswanathan and P.S. Raghavan, Practical Physical Chemistry, Viva Books, 2012.

References

1. R.C. Das and B. Behera, Experimental Physical Chemistry, McGraw-Hill Education, 1984.

Suggested Reading

Farrington Daniels, Experimental Physical Chemistry, 7th Edition, McGraw-Hill Inc., US, 1970.

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	2	-	-	-	-	-	3	-	-	-	-	3	-	-	K1
CO 2	3	2	1	-	-	-	-	-	-	-	2	-	3	2	-	K2
CO 3	3	2	1	-	-	-	-	-	-	-	2	-	3	2	-	K3
CO 4	3	2	1	-	-	-	-	-	-	-	2	-	3	2	-	K4
CO 5	3	3	3	3	1	-	2	-	-	-	2	-	3	3	3	K5
Wt. Avg.	3	2.2	1.5	3	1	-	2	3	-	-	2	-	3	2.2	3	
Overall Mapping of the Course														PO- 2.1 PSO – 2.6		

ORGANIC REACTION MECHANISM

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part I NA**	**Core**	**Theory**
Semester	**II**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To gain mechanistic insight on substitution, addition, elimination and rearrangement reactions in aliphatic and aromatic compounds. 2. To understand the basics of pericyclic reactions and photochemical reactions with reference to stereoselectivity or regioselectivity 3. To understand the role played by certain reagents in functional group transformation		

CO#	**Course Outcome(s)**	**PSO Addressed**	**Bloom's Taxonomy Levels (K1 to K5)**
On completing the course successfully, the student will be able to			
CO1	Recall (i) the definitions and the reaction sequences associated with certain organic reactions (ii) the characteristics of reagents employed in organic reactions	PSO1	K1
CO2	Explain (i) the reaction conditions and mechanistic aspect of certain organic reactions (ii) the utility of reagents for organic conversions	PSO2	K2
CO3	Identify (i) the reaction pathway of organic reactions (ii) the reagents for organic transformation	PSO2 PSO3 PSO4	K3
CO4	Analyse (i) the regioselectivity and stereoselectivity of organic reactions (ii) the proper choice of reagents for organic transformation	PSO4 PSO8	K4

CO5	Determine the proper choice of reagents and reaction conditions employing substitution, elimination, addition, coupling, rearrangement, photochemical and pericyclic for organic synthesis/functional group transformations	PSO4 PSO8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Substitution and Elimination Reactions** 1.1 Aliphatic substitution: S_N1, S_N2, S_Ni, S_N1', S_N2' and tetrahedral mechanisms, neighboring group participation, ambident nucleophile - Mitsunobu reaction 1.2 Aromatic substitution: Unimolecular and bimolecular mechanism, benzyne mechanism 1.3 Elimination Reactions: E1, E2 and E1cB mechanisms, substitution vs elimination, orientation of product formation, stereochemical criteria of E2 reactions, Peterson elimination, Julia olefination, Mc-Murry reaction - Pyrolytic eliminations: Pyrolysis of esters, Chugaev reaction, Cope elimination	12	CO1-CO5	K1 – K5
II	**Addition and Coupling Reactions** 2.1 Electrophilic Addition: Hydration, halogenations and hydrohalogenation of alkenes, dienes, alkynes and allenes. 2.2 Nucleophilic addition to multiple bonds: Mannich reaction, Stobbe, Darzens, Thorpe, Wittig reaction, Robinson annulations, Acyloin condensation, Henry reaction 2.3 Coupling reactions: Heck Reaction, Sonogashira coupling, Suzuki coupling, Stille coupling	12	CO1-CO5	K1 – K5
III	**Molecular Rearrangements** 3.1 Classification – Whitmore 1,2-shift 3.2 Rearrangement to electron deficient carbon: Arndt-Eistert Homologation, Benzylic acid, Semipinacol, Wagner-Meerwein, Demjanov, dienone-phenol and Wolff rearrangements 3.3 Rearrangement to electron deficient nitrogen: Stieglitz rearrangement 3.4 Rearrangement to electron deficient oxygen: Baeyer-Villiger and Daikin rearrangements. 3.5 Rearrangement to electron rich carbon: Stevens, Sommerlet-Hauser, Wittig and Favorskii rearrangements	12	CO1-CO5	K1 – K5
IV	**Pericyclic and Photochemistry** 4.1 Pericyclic reactions: Electrocyclic (butadiene-cyclobutene interconversion), cyclo-addition (2+2) and (4+2) systems only,	12	CO1-CO5	K1 – K5

	sigmatropic (1,2; 1,3; 1,4 & 3,3) and cheletropic reactions, FMO and orbital correlation diagrams. 4.2 Organic photochemistry: General principles, photochemistry of carbonyl compounds, Norrish Type I and Type II reactions, Photoreduction, Photo-oxidation, Paterno-Buchi reaction, di-π-methane rearrangement, Barton rearrangement, Photoisomerization			
V	**Pericyclic and Photochemistry** 5.1 Tri-n-butyl tin hydride, Sn/HCl, alkyl Lithium, organo Zinc reagent, organo palladium reagent, organo tin reagent, organo magnesium reagent, and Schwartz reagent 5.2 Lithium diisopropylamide, trimethylsilyl iodide, benzyltriethylammonium halides and crown ethers	12	CO1-CO5	K1 – K5

Textbooks

1. V K Alhuwalia and Rakesh Kumar Parashar, Organic Reaction Mechanism, 4th Edition, Alpha Narosa Publishing House, India, 2019.
2. Michael B Smith, Jerry March, March's Advanced Organic Chemistry, 7th Edition, Wiley Students Edition, India, 2016.
3. Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford University Press, India, 2019,
4. Peter Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Edition, Pearson India Education Services, India, 2020

References

1. William Carruthers, Iain Coldham, Modern Methods of Organic Synthesis, 4th Edition, Cambridge University Press, India, 2020.
2. Francis A Carey and Richard J Sundberg, Advanced Organic Chemistry Part (A & B) 5th Edition, Springer, New York, USA, 2007
3. Michael B Smith, Organic Synthesis, 3rd Edition; Elsevier, USA, 2010.

Suggested Reading

1. S. H. Pine, Organic Chemistry, 5th Edition, Tata McGraw Hill, Special Indian Edition, India, 2007.
2. T. H. Lowry K. S. Richardson, Harper and Row, Mechanism and theory in organic chemistry, 2nd Edition, New York, 1981.

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http://epgp.inflibnet.ac.in/

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M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	2	-	-	-	-	-	-	3	-	-	-	-	-	-	-	K1
CO 2	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	K2
CO 3	2	2	-					-	2	3	2	-	-	-	-	K3
CO 4	-	2	-	-	-	-	-	-	-	-	2	-	-	-	3	K4
CO 5	-	2	-	-	-	-	2	-	-	-	2	-	-	-	3	K5
Wt. Avg.	2	2	-	-	-	-	2	3	2	3	2	-	-	-	3	
Overall Mapping of the Course														PO: 2.0 PSO: 2.4		

COORDINATION AND BIOINORGANIC CHEMISTRY – I

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part NA**	**Core**	**Theory**
Semester	**II**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To understand the fundamental concepts and geometrical configurations of coordination complexes 2. To identify the splitting of d orbitals based on the magnetic property of coordination complexes 3. To appreciate the various reaction mechanisms of coordination complexes 4. To realize the significance of trace elements in life and metal complexes in nucleic acids		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the fundamental concepts and definition of important terminologies of coordination chemistry and bio-inorganic chemistry	PSO1, PSO2	K1
CO2	Explain (i) fundamental concepts of coordination and bio-inorganic chemistry (ii) the bonding and reaction kinetics in complexes and (iii) significances and functions of important bio-inorganic compounds	PSO1, PSO2	K2

CO3	Apply fundamental concepts and theories of coordination and bio-inorganic compounds to explain the reactions of complexes and biological processes	PSO2, PSO3, PSO4	K3
CO4	Analyse the behaviour and reactivity of coordination and bio-inorganic compounds based on the fundamental concepts	PSO2, PSO4	K4
CO5	Compare and evaluate the behaviour and chemical processes of coordination and bio-inorganic compounds	PSO2, PSO3, PSO4	K5

SYLLABUS

UNIT	CONTENT	HOURS	COs	BLOOM'S TAXONOMY LEVEL
I	**Coordination chemistry – Introduction** 1.1 Terminologies; Preparation of complexes; Detection of complex formation; Stability constants-types and determination, solubility method, electrochemical method, spectrophotometric method and Job's method; Factors affecting the stability constants; Chelates – chelate effect, factors affecting the stability of chelates and importance of chelates in biology. 1.2 Isomerism – Structural and Stereo isomerism (Geometrical isomerism in square planar and octahedral complexes; Optical isomerism in tetrahedral and octahedral complexes) 1.3 Application of coordination complexes in analytical chemistry, medicinal chemistry, industrial processes and water softening.	12	CO1-CO5	K1 – K5
II	**Advanced Theories of coordination complexes and Magnetism** 2.1 Limitations of Valence Bond Theory; Crystal Field Theory – splitting of *d* orbitals in tetrahedral, octahedral and square planar field, Calculation of CFSE for high spin and low spin complexes; Determination of Δ_o, Factors affecting Δ_o, Spectrochemical series, Evidences favouring CFSE; Jahn – Teller distortion (static and dynamic) and its consequences. 2.2 MOT for octahedral complexes (σ and π bonding), σ donor, π donor and π acceptor ligands; Δ_o for strong field and weak field ligands based on MOT. 2.3 Magnetic property of the complexes: Spin-orbit coupling, effect of spin-orbit coupling on magnetic moments, quenching of orbital magnetic moments.	12	CO1-CO5	K1 – K5
III	**Kinetics and reaction mechanisms of complexes** 3.1 Substitution reactions in octahedral complexes: Inert and labile nature of complexes; different types of substitution reactions; SN1, SN2 and SNCB mechanisms. 3.2 General mechanism of square planar substitution reactions, Trans effect and theories of trans effect. 3.3 Mechanism of electron transfer reactions: Outer sphere electron transfer reactions and Marcus-Hush theory; inner sphere	12	CO1-CO5	K1 – K5

	electron transfer reactions; nature of the bridging ligand in inner sphere electron transfer reactions. 3.4 Photo-redox reaction in complexes and its applications			
IV	**Bio-inorganic Chemistry − I** 4.1 Introduction to metal – porphyrin (heme), metal – chlorin (chlorophyll) and metal – corrin (Vitmain B12) bio-molecules – general structural features only 4.2 Fe in biology: Storage and transport of Fe – ferritin, transferrin and siderophores 4.3 Oxygen transport proteins - Hemoglobin and myoglobin – structural features and functions of Hb and Mb, oxygen binding modes in Hb, Hill plot and Bohr effect. Oxygen uptake metalloproteins – Hemerythrin (Hr) and hemocyanin (Hc) – structural features and functions	12	CO1-CO5	K1 – K5
V	**Bio-inorganic chemistry – II** 5.1 Essential elements, inorganic micronutrients, trace and ultra-trace elements in bio-inorganic chemistry – definition, examples and their biological significance. 5.2 Ion transport across cell membranes – Active and passive transports, membrane potential, Na and K channels and Na-K pump 5.3 Transition metal complexes as nucleic acid structural probes: Metal-Nucleic acids interaction: fundamental interactions with nucleic acids - coordination, intercalation and hydrogen bonding; fundamental reactions with nucleic acids-redox chemistry and hydrolytic chemistry.	12	CO1- CO5	K1 – K5

Textbooks

1. R Gopalan and V Ramalingam, Concise Coordination Chemistry, Vishal Publishing House Pvt. Ltd., 2001
2. J E Huheey, EA Keiter, RL Keiter and O K Medhi, Inorganic Chemistry – Principles of structure and reactivity, 4th Edition, Pearson Education Inc., 2006
3. K Burger, Coordination Chemistry: Experimental methods (English translation edited by I.T. Miller and D.W. Allen), Butterworths & Co Publishers, 1973.
4. Asim K. Das, Bioinorganic Chemistry, Books & Allied Ltd., 2007
5. K Hussain Reddy, Bioinorganic Chemistry, New Age International, 2007

References

1. Keith F. Purcell and John C. Kotz, Inorganic Chemistry, Saunders Publications, USA, 1977
2. I Bertini, H B Gray, S J Lippard and Valentine, Bioinorganic Chemistry, University Science Books, 1994
3. Rosette M. Roat-Malone,Bioinorganic Chemistry: A Short Course, John Wiley and Sons Inc., 2007

Suggested Reading

1. G L Meissler and D ATarr, Inorganic Chemistry, 3rd Edition, Pearson Education Inc., 2008
2. Peter Atkins and Tina Overton, Shriver and Atkins' Inorganic Chemistry, 5th Edition, Oxford University Press, 2010

Online Resources (accessed on 28 June 2022)

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3. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO 1	PO 2	PO 3	PO 4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	-	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	3	-	-	-	-	-	-	3	3	-	-	-	-	-	-	K2
CO 3	-	2	2	-	-	-	-	-	3	2	3	-	-	-	-	K3
CO 4	-	-	2	-	-	-	-	-	3	-	2	-	-	-	-	K4
CO 5	-	2	-	-	-	-	-	-	3	2	2	-	-	-	-	K5
Wt. Avg.	3	2	2	-	-	-	-	3	3	2	2					
Overall Mapping of the Course														PO:2.3 PSO:2.5		

GROUP THEORY AND QUANTUM CHEMISTRY

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part NA**	**Core**	**Theory**
Semester	**II**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To identify symmetry elements in molecules and arrive at their point group. 2. To utilize the knowledge of symmetry to predict electronic transitions and to recognize IR and Raman active vibrations. 3. Acquire a finite insight into quantum chemistry by applying its principles to simple systems and developing the solutions. 4. Introduce basic ideas for the application of quantum chemistry to complex systems and thereby developing approximate solutions.		

CO#	**Course Outcome(s)**	**PSO Addressed**	**Bloom's Taxonomy Levels (K1 to K5)**
On completing the course successfully, the student will be able to			
CO1	Recall the fundamentals of predicting structure of molecules, spectroscopy and quantum chemistry	PSO1	K1
CO2	Classify molecules based on their structure and demonstrate the application of group theory and quantum chemistry to simple systems and molecules	PSO2, PSO3, PSO4	K2
CO3	(i) Identify point groups of molecules and construct character tables (ii) Solve the Schrodinger wave equation for simple systems directly and by using approximation methods.	PSO2, PSO3, PSO4	K3

CO4	Examine the (i) relation between symmetry elements and point group, structure and possible spectroscopic transitions (ii) results of the solution to the Schrodinger wave equation	PSO2, PSO3, PSO4	K4
CO5	Assess the significance of applications to group theory/quantum chemistry to molecules/systems	PSO2, PSO3, PSO4, PSO8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	1.1 Fundamentals of group theory- Symmetry elements and symmetry operations in molecules, Products of symmetry operations, equivalent operations, Sub-groups, Classes of symmetry operations, Group multiplication tables. Abelian and non-Abelian point groups. 1.2 Molecular point groups; Matrix representation of groups, Great orthogonality theorem, Reducible and irreducible representations, Application of orthogonality theorem 1.3 Character tables- Construction of character tables for point groups C_{2V}, C_{3V} and D_{2h}, Use of character tables in predicting hybridization and IR & Raman active vibrations.	12	CO1-CO5	K1 – K5
II	2.1 Application of group theory to electronic spectra of ethylene, formaldehyde, benzene and butadiene. 2.2 Postulates of quantum mechanics. 2.3 Functions and operators - Operator algebra, linear and non-linear operators, Laplacian operator, commuting and non-commuting operators, Hermitian operators and their properties, eigen functions, eigen values - commutation of operators. 2.4 Quantum mechanical treatment of particle in a one-dimensional box-Particle in a three-dimensional box-Degeneracy- Bohr's correspondence principle	12	CO1-CO5	K1 – K5
III	3.1 One dimensional simple harmonic oscillator (complete quantum mechanical treatment) 3.2 Rigid rotor (complete quantum mechanical treatment) 3.3 Quantization of angular momentum, Operators corresponding to angular momenta (L_x, L_y, L_z and L^2) and their commutation relations. Spherical harmonics as eigen functions of angular momentum operators L_z and L^2. Ladder operators 3.4 Solution of the Schrodinger equation for the hydrogen atom, radial and angular probability distributions, atomic orbitals-Orbital approximation	12	CO1-CO5	K1 – K5
IV	4.1 Approximation Methods-Variation method (Application to particle in a 1D box and He atom) and Perturbation method (Application to particle in a slanting 1D box and He atom)-Atomic units 4.2 Many electron atoms- Born-Oppenheimer approximation - Helium atom- General principle of setting up wave function for	12	CO1-CO5	K1 – K5

	other many electron atoms -Slater type orbitals – Hartree and Hartree-Fock SCF methods. 4.3 Spin orbitals: Construction of spin orbitals from orbitals and spin functions, spin orbitals for many electron atoms, symmetric and antisymmetric wave functions. Pauli's exclusion principle, Slater determinants.			
V	5.1 VB Theory and MO Theory –Basics-MO configuration of simple diatomic molecules 5.2 Bonding-VB treatment of H_2 and MO treatment of H_2^+ 5.3 Hybridization involving *s* and *p* orbitals - quantum mechanical treatment *(sp, sp^2, sp^3)* 5.4 HMO Calculations-evaluation of coefficients and eigen values for ethylene, 1,3-butadiene, benzene and cyclopentadienyl – electron density-bond order and free valence index.	12	CO1-CO5	K1 – K5

Textbooks

1. F. A. Cotton, Chemical Applications of Group Theory, John Wiley and Sons, 2008.
2. K. Veera Reddy, Symmetry and Spectroscopy of Molecules, 2nd edition, New Age Publishers, India, 2020.
3. Donald A. McQuarrie, Quantum Chemistry, Viva Books, UK, 2016.
4. I.N. Levine, Quantum Chemistry, 5th edition, Pearson Education, Inc., India, 2000.
5. R K Prasad, Quantum Chemistry, New Age International Publisher, India, 2020

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1. D. M. Bishop, Group Theory and Chemistry, Dover Publications, USA, 1993.
2. A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw Hill, India, 1994.
3. P.W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, 1998.

Suggested Reading

1. P.J. Delahay, Double Layer and Electrode Kinetics, Interscience Publishers, New York, 1965.
2. A. J. Bard and L. R. Faulkner, Electrochemical Methods, Wiley, New York, 2000.
3. A. G. Briggs, Vibrational Frequencies of Sulfur Dioxide, J. Chem. Edu. 47 (1970) 391.
4. F. E. Stafford, C. W. Holt, and G. L. Paulson, Vibration-Rotation Spectrum of HCl, J. Chem. Edu. 40 (1963) 245.
5. H. H. R. Schor and E. L. Teixeira, The Fundamental Rotational-Vibrational Band of CO and NO, J. Chem. Edu. 71 (1994) 771.

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M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	-	-	-	-	-	-	3	-	-	-	-	-	-	-	K1
CO 2	3	3	2	-	-	-	-	-	2	3	2	-	-	-	-	K2
CO 3	3	3	2	-	-	-	-	-	2	3	2	-	-	-	-	K3
CO 4	3	3	2	-	-	-	-	-	2	3	2	-	-	-	-	K4
CO 5	3	3	2	-	-	-	-	-	2	3	2	-	-	-	2	K5
Wt. Avg.	3	3	2	-	-	-	-	3	2	3	2	-	-	-	2	
Overall Mapping of the Course														PO – 2.7 PSO -2.4		

HETEROCYCLIC AND POLYMER CHEMISTRY

Course Code			
Credits	**5**		
Hours / Cycle	**4**		
Category	**Part NA**	**Elective**	**Theory**
Semester	**II**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To understand the classification, nomenclature, synthesis and reaction of some heterocyclic compounds 2. To learn the characteristic of polymers, and different types of polymerization techniques with its mechanism.		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall (i) the classification, nomenclature and structure of heterocycles and (ii) the classification, nomenclature and fundamental aspects of polymers	PSO1	K1
CO2	Explain (i) the synthesis and reactivity of certain heterocycles with one or more heteroatoms (ii) the synthesis, properties, fundamental aspects and application of polymers	PSO2	K2
CO3	Apply the knowledge (i) of organic chemistry in the synthesis/reactions of certain heterocycles. (ii) of chemistry in explaining the mechanistic aspects and other aspects related to polymers.	PSO4	K3
CO4	Analyse (i) the chemical reactions involved in the synthetic protocol/reactions of certain heterocycles (ii) the characteristics of polymer based on various fundamental aspects.	PSO4, PSO8	K4
CO5	Evaluate (i) the synthetic protocols and reactions of certain heterocycles (ii) the utility of polymers to a specific purpose based on their characteristics.	PSO4, PSO8	K5

SYLLABUS

UNIT	CONTENT	HOURS	COs	BLOOM'S TAXONOMY LEVEL
I	**Heterocyclic Chemistry-I** 1.1 Classification and nomenclature of the heterocyclics based on the nature of the heteroatom and size of the ring. 1.2 Synthesis and reaction of furan, pyrrole, thiophene and pyridine. 1.3 Synthesis and reaction of five-membered heterocycles with two or more heteroatoms: Pyrazole from diazomethane, Imidazole from dinitro tartaric acid, Conforth method of preparation of oxazole,	12	CO1 - CO5	K1 – K5

	Isoxazoles from tetraethoxypropane, Thiazole from chloro acetaldehyde, Triazole from formyl hydrazide and Tetrazole from hydrazoic acid.			
II	**Heterocyclic Chemistry-II** 2.1 Synthesis and reaction of six-membered heterocycles with two or more heteroatoms: Preparation of Pyridazine from maleic dialdehyde, Pyrimidine from barbituric acid, Uracil from urea, and Pyrazine from ethylene diamine. 2.2 Fused heterocycles: Synthesis and reaction of indole, quinoline, isoquinoline and benzofurans.	12	CO1 - CO5	K1 – K5
III	**Polymer Chemistry– I** 3.1 Nomenclature and classification of polymers, Degree of polymerization and Functionality 3.2 Mechanism of Polymerization: Addition (radical, ionic and coordination), condensation, copolymerization and their mechanisms. 3.3 Ziegler-Natta polymerization with mechanism, Stereo regular polymers - syndiotactic, isotactic and atactic polymers	12	CO1 - CO5	K1 – K5
IV	**Polymer Chemistry– II** 4.1 Molecular weight of polymers: Number average, weight average, viscosity average – Inter-relationship. Polydispersity - molecular weight distribution in polymers. 4.2 Techniques of polymerization: emulsion, bulk, solution and suspension. 4.3 Polymer degradation: Types of degradation- thermal, mechanical, photo, hydrolytic and oxidative degradations. Photo-stabilizers. 4.4 Glass transition temperature- Basics and factors affecting T_g	12	CO1 - CO5	K1 – K5
V	**Polymer Chemistry– III** 5.1 Plastics: Thermoplastics, ABS plastics: Synthesis, properties and applications – Thermosetting, Bakelite: Synthesis, properties and applications – Compounding of plastics – Biodegradable plastics. 5.2 Rubber: Classification – Preparation, properties and applications of SBR rubber, Silicon rubber, neoprene, nitrile rubber and vulcanization.	12	CO1 - CO5	K1 – K5

Textbooks

1. I L Finar, Organic Chemistry, Volume 2: Stereochemistry and the Chemistry Natural Products, 5th Edition, Pearson Education India, India, 2002.
2. Raj K Bansal, Heterocyclic Chemistry, 6th Edition, New Age Publishers, India, 2019.
3. Fred W Billmeyer, Textbook of Polymer Science, 3rd Edition, Wiley Student Edition, India, 2007.

References

1. Thomas L Gilchrist, Heterocyclic Chemistry, 3rd Edition, Pearson Publishers, India, 2005.
2. John Joule, K Mill, Smith, Heterocyclic Chemistry, 3rd Edition, CRC Press, USA, 2018.
3. V R Gowariker, N V Viswanathan, Jayadev Sreedhar Polymer Science, 3rd Edition, New Age International Publishers, India, 2019.

Suggested Reading

1. R. Sanghi and M. M. Srivastava, Green chemistry: Environment Friendly Alternatives, Alpha Science International Ltd, India, 2003.
2. V. K. Ahluwalia, Green Chemistry, 2nd Edition, Ane Books Pvt. Ltd., 2016.
3. B. Michael Smith, Organic synthesis, McGraw Hill International Edition, 1994.

Online Resources (accessed on 28 June 2022)
1. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_pg/667
2. http://epgp.inflibnet.ac.in/

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO 1	PO 2	PO 3	PO 4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	K1
CO 2	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	K2
CO 3	-	2	-	-	-	-	-	-	-	-	2	-	-	-	-	K3
CO 4	-	2	-	-	-	-	1	-	-	-	1	-	-	-	1	K4
CO 5	-	2	-	-	-	-	1	-	-	-	1	-	-	-	1	K5
Wt. Avg.	1.5	2	-	-	-	-	1	2	1	-	1.3	-	-	-	1	
Overall Mapping of the Course														PO: 1.5 PSO: 1.3		

GREEN AND ENVIRONMENTAL CHEMISTRY

Course Code			
Credits	**5**		
Hours / Cycle	**4**		
Category	**Part NA**	**Elective**	**Theory**
Semester	**II**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To gain insight on the basic principles of green chemistry and the preparation of certain specific organic compounds by adopting green methods 2. To impart knowledge on environmental Chemistry		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels
On completing the course successfully, the student will be able to			
CO1	Recognize the fundamental principles of green and environmental chemistry	PSO1	K1
CO2	Explain (i) the principles of green chemistry with examples ii) the chemistry of the various components of the environment and the measures to protect it	PSO3	K2
CO3	Apply i) the green chemistry principles in synthesis of organic compounds ii) the knowledge of environmental chemistry, and analytical methods in pollution control	PSO4	K3
CO4	Analyse i) qualitatively the greenness of a given organic reaction (ii) the significance of various components of atmosphere (iii) sources, sinks, and environmental hazards posed by pollutants	PSO4, PSO8	K4

CO5	Determine the greenness of a given organic reaction based on certain principles of green chemistry. Assess qualitatively the implications of various pollutants on environment.	PSO4, PSO8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Introduction to Green Chemistry** 1.1 Green chemistry: Need for green chemistry, Twelve principles of green chemistry with examples, calculation of atom economy of substitution, elimination, addition and rearrangement reaction with examples. 1.2 Synthesis involving basic principles of green chemistry - paracetamol, Ibuprofen, and ω−caprolactam	12	CO1-CO5	K1 – K5
II	**Green Chemical Reactions** 2.1 Multi-component reactions (Biginelli, Ugi and Passerini reaction) Prevention or minimization of hazardous products and choice of solvents. 2.2 Sonochemistry (Simmon-Smith reaction), microwave induced reactions (Hydrolysis of esters, oxidation of toluene and alcohols), reactions in organic solvents (Decarboxylation and Diels Alder reaction) polymer supported reagents, reactions in aqueous medium and ionic liquid supported reaction. 2.3 Limitations of green organic syntheses	12	CO1-CO5	K1 – K5
III	**Environmental Chemistry – I** 3.1 Atmospheric chemistry – Structure of the earth's atmosphere – Chemistry of lower atmosphere - Formation of greenhouse gases - Thermochemical & photo chemical reactions in atmosphere – Photochemical smog, PAN- Acid rain – Dioxins – Greenhouse effect - Climate change 3.2 Chemistry of upper atmosphere – Ozone layer formation & depletion – The Chapman cycle - The reactions in the polar stratospheric clouds and the mechanism of ozone hole formation 3.3 Lithosphere – Zonal structure of the earth - Chemical composition of the crust, mantle & core – Physico-chemical characteristics of soil - organic carbon, cation exchange capacity, C/N ratio, soil acidity & salinity	12	CO1-CO5	K1 – K5
IV	**Environmental Chemistry – II** 4.1 Hydrosphere – Formation & chemistry of water – Anomalous properties of water – Hydrogen bonding in	12	CO1-CO5	K1 – K5

	biological systems – The Frank-Wen model - Marine chemistry - Chemical constituents of sea water – Hydrological cycle - Fresh water chemistry – Aeration – Water additives – Isotopes 4.2 The Biosphere – The chemistry of life - Aerobic & anaerobic processes – Photosynthesis – Respiration & decay – Fermentation – Biodegradation - The bio geo chemical cycles – Carbon cycle – Nitrogen cycle – Nitrification & denitrification – Phosphorous cycle & Sulphur cycle 4.3 Lithosphere – Biosphere - Hydrosphere interaction - Solid Waste - Radioactive waste - Plastic waste - Microplastics – Marine pollution - Thermal pollution - Agricultural Pollution			
V	**Environmental Chemistry – III** 5.1 Analysis of air, soil & water pollutants - Sampling of air pollutants – SOx NOx ozone hydrocarbons & particulates – Soil analysis – pH – Electrical conductivity – CEC – OM – Percentage of N, P, K, Ca, Mg, S, Na - Water quality standards — DO, BOD, COD – TDS & TSS – Analysis of heavy metals – pH - Turbidity 5.2 Air pollution control – Soil pollution control – Bio remediation – Phyto remediation - Treatment of water at the discharge points – Domestic waste water – Industrial waste water – Water from atomic power plants – Agricultural waste water – The primary, secondary & tertiary treatments 5.3 Application of remote sensing in environmental studies – Pollution studies – Soil conservation – Watershed management – Vegetation mapping – Drought & flood studies – Forest survey – Environmental impact assessment – Environmental auditing; Green tribunal bench, Role of an individual in conservation of environment.	12	CO1-CO5	K1 – K5

Textbooks

1. V K Ahluwalia, Green Chemistry: A Textbook, Alpha Science International Ltd, India, 2013
2. A. K. De, Environmental Chemistry, New Age Publisher International, India, 2006.
3. B. K. Sharma, Environmental Chemistry, Krishna Prakashan Media Pvt. Ltd., India, 2014.

References

1. P S Sindhu, Environmental Chemistry, New Age International Private Limited, India, 2010.
2. Gary. W. Van Loon, Environmental Chemistry, 3rd Edition, OUP Oxford, 2010.
3. H. Kaur, Environmental Chemistry, Pragati Prakasan Meerut, India, 2016.

Suggested Reading

1. R. Sanghi and M. M. Srivastava, Green chemistry: Environment Friendly Alternatives, Alpha Science International Ltd, India, 2003.
2. V. K. Ahluwalia, Green Chemistry, 2nd Edition, Ane Books Pvt. Ltd., India, 2016.
3. P Tundo, A Perosa, F Zacchini, Methods and Reagents in Green Chemistry, Edited by Wiley-Interscience, 2007
4. G. S. Sodhi, Fundamental concepts of Environmental Chemistry, Alpha Science International Ltd, India, 2000.
5. Julian E Andrew, An introduction to Environmental Chemistry, Wiley-Blackwell, UK, 2003.

6. James E. Girald, Principle of Environmental Chemistry, 3rd Edition, Jones and Bartlett Publishers, Inc, USA, 2013.

Online Resources (accessed on 28 June 2022)

1. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_pg/667
2. http://epgp.inflibnet.ac.in/

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO 1	PO 2	PO 3	PO 4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	K1
CO 2	2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	K2
CO 3	-	3	-	-	-	-	-	-	-	-	3	-	-	-	-	K3
CO 4	-	3	-	-	-	-	2	-	-	-	3	-	-	-	1	K4
CO 5	-	3	-	-	-	-	2	-	-	-	3	-	-	-	1	K5
Wt. Avg.	2	3	-	-	-	-	2	2	-	2	3	-	-	-	1	
Overall Mapping of the Course														PO: 2.0 PSO: 2		

NATURAL PRODUCTS AND MEDICINAL CHEMISTRY

Course Code			
Credits	**5**		
Hours / Cycle	**4**		
Category	**Part NA**	**Elective**	**Theory**
Semester	**II**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To understand the classification of the biomolecules like carbohydrates, terpenoids, alkaloids, steroids, vitamins, nucleic acids and lipids 2. To gain insight on the essential basic principles of medicinal chemistry, classification of drugs and the preparation of certain specific drugs		

CO#	**Course Outcome(s)**	**PSO Addressed**	**Bloom's Taxonomy Levels (K1 to K5)**
On completing the course successfully, the student will be able to			
CO1	Recall the fundamental aspects and concepts related to natural products and medicinal chemistry	PSO1	K1
CO2	Explain the (i) classification, structural features and structural elucidation of certain natural products (ii) the fundamental aspects/concepts of medicinal chemistry	PSO2, PSO3	K2
CO3	Apply (i) the knowledge of organic reactions in the structural elucidation and synthesis of certain natural products (ii) the	PSO4	K3

	concepts of medicinal chemistry to mechanism of action of drugs		
CO4	Analyse (i) the various steps involved in the structural elucidation and synthesis of certain natural products (ii) the qualitative and quantitative effects of structural modifications on drug activity	PSO4, PSO8	K4
CO5	Evaluate (i) the synthetic protocol related to the structural elucidation and synthesis of certain natural products (ii) the activity of the drugs qualitatively based on the fundamental concepts of medicinal chemistry	PSO4, PSO8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Natural Products-I** 1.1 General methods of structural elucidation of natural products 1.2 Carbohydrates: Classification, structural features of starch and cellulose. 1.3 Terpenes: Classification, isoprene and special isoprene rules, structural elucidation of β-carotene. 1.4 Alkaloids: Classification, structural elucidation of papaverine, synthesis of quinine from ethyl quininate	12	CO1-CO5	K1 – K5
II	**Natural Products-II** 2.1. Steroids: Classification of steroids, synthesis of cholesterol from cholestanol, testosterone and progesterone from cholesterol 2.2 Nucleic acids: Watson-Crick model of DNA, RNA and its types. Synthesis of adenine and guanine from trichloropurine, cytosine from malondialdehyde acetal, thymine from ethyl acrylate 2.3: Vitamins: Classification, synthesis of vitamin C from D-glucose	12	CO1-CO5	K1 – K5
III	**Medicinal Chemistry-I** 3.1 Basic concepts in medicinal chemistry: Definition of Drug (WHO), Stereo chemical aspects of drugs, Classification of drugs - Mechanism of drug action - Physical and Chemical action. 3.2 Terminology: Therapeutic Index, Quantal dose, Graded dose, Efficacy, Potency, LD_{50}, ED_{50}, IC_{50}, GI_{50} and EC_{50}. 3.3 Pharmacokinetics and pharmacodynamics: Definition and differences, Absorption, Distribution, Metabolism, Excretion and Toxicity (ADMET) properties, Lipinski rule of five	12	CO1-CO5	K1 – K5

IV	**Medicinal Chemistry-II** 4.1 Enzymes: Binding interactions – Lock & Key and Induced Fit models; Types of inhibitions – competitive, non-competitive and uncompetitive; Kinetics – Michaelis-Menten equation and its extension: Plots and applications. (Derivation not included) 4.2 Receptors: Types of receptors – Agonist, Antagonist, Partial and Inverse agonist; Ion channels 4.3 Interaction of nucleic acids with drugs: Modes of targeting DNA – Intercalating drugs, non-intercalating drugs, alkylating and metalating agents; Modes of targeting RNA-antisense therapy and inhibition of ribosomes	12	CO1-CO5	K1 – K5
V	**Medicinal Chemistry-III** 5.1 Classification of Drugs: Anesthetics, Analgesics, Sedatives, Antibiotics, Antivirals, Anticancer, Antipyretic, Antidiabetics, Drugs for cardiovascular disease, Drugs for metabolic disorders (Definitions with examples). 5.2 Structure Activity Relationship (SAR) and Quantitative Structure Activity Relationship (QSAR): Effect of Physico-chemical properties, Hansch Equation, Craig's Plot and Topliss Scheme; Bioisosteres. 5.3 Mechanism of action of selected drugs: Remdesivir, Propranolol, Doxorubicin; Prontosil – prodrug	12	CO1- CO5	K1 – K5

Textbooks

1. I L Finar, Organic Chemistry, Volume 2: Stereochemistry and the Chemistry Natural Products, 5th Edition, Pearson Education India, India, 2002.
2. Ashutosh Kar, Medicinal Chemistry, 7th Edition, New Age Publishers, India, 2008.
3. Bijoy Kundu, An Introduction to Medicinal Chemistry, Wiley, India, 2020.
4. G.L. Patrick, An introduction to medicinal chemistry, 4th Edition, Oxford University Press, UK, 2013.

References

1. Gurdeep R Chatwal, Organic Chemistry of Natural Products (Volume 1 & 2), 5th Edition, Himalaya Publishing House Pvt. Ltd, India, 2019.
2. O P Agarwal, Natural Products (Volume 1 & 2), 38th Edition, 2010, Krishna Prakashan Media Pvt. Ltd, India, 2010.
3. Gareth Thomas, Medicinal Chemistry An Introduction, 2nd Edition, Wiley, UK, 2007.

Suggested Reading

1. G. K. Chatwal, Organic Chemistry on Natural Products, Vol. 1, Himalaya Publishing House, Mumbai, 2009.
2. G. K. Chatwal, Organic Chemistry on Natural Products, Vol. 2, Himalaya Publishing House, Mumbai, 2009.
3. O. P. Agarwal, Chemistry of Organic Natural Products, Vol. 1, Goel Publishing House, Meerut, 1997.
4. O. P. Agarwal, Chemistry of Organic Natural Products, Vol. 2, Goel Publishing House, Meerut, 1997.
5. Balkishen Razdan, Medicinal Chemistry, 2nd Edition, CBS Publishers and Distributors, India, 2019.

Online Resources (accessed on 28 June 2022)

1. http://epgp.inflibnet.ac.in/
2. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_pg/671

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO 1	PO 2	PO 3	PO 4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	K1
CO 2	2	-	-	-	-	-	-	-	2	1	-	-	-	-	-	K2
CO 3	-	2	-	-	-	-	-	-	-	-	2	-	-	-	-	K3
CO 4	-	2	-	-	-	-	1	-	-	-	2	-	-	-	1	K4
CO 5	-	2	-	-	-	-	1	-	-	-	2	-	-	-	1	K5
Wt. Avg.	1.5	2	-	-	-	-	1	2	2	1	2	-	-	-	1	
Overall Mapping of the Course														PO:1.5 PSO:1.6		

ORGANIC SPECTROSCOPY AND SYNTHETIC STRATEGIES

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part NA**	**Core**	**Theory**
Semester	**III**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	• To understand the fundamental concepts of spectroscopy and to apply for predicting the structures of organic molecules • To learn the principles of retro synthesis for proposing synthetic strategies of target molecules • To learn the functional group transformation using oxidation, reduction and coupling agents		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall i) the fundamental concepts and significant terms of various spectroscopic techniques ii) the basic terminologies of retrosynthetic analysis iii) structure and uses of oxidation, reduction and coupling reagents	PSO1 PSO2	K1
CO2	Explain i) the concepts and spectral data of organic molecules ii) the fundamental concepts of retrosynthetic analysis iii) the reactions using oxidation, reduction and coupling reagent	PSO2 PSO3	K2
CO3	Apply i) the concepts and spectral data for structural predictions ii) retro synthetic analysis for proposing reaction	PSO3 PSO4	K3

	schemes for target molecules iii) the knowledge to choose a proper reagent for functional group transformation		
CO4	Analyse i) the UV-Vis, IR, NMR and Mass spectral behaviour of organic molecules based on the fundamental concepts ii) the proper choice of schemes of a target molecule based on the knowledge of retro synthetic analysis iii) the proper choice of reagent for functional group transformation	PSO4 PSO8	K4
CO5	Interpret the structure of organic molecules from the spectral data of UV-Vis, FTIR, NMR and Mass Construct a synthesis of simple molecules based on the principles of retro synthesis and other reagents used for functional group transformation	PSO3 PSO4 PSO8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Absorption Spectroscopy and Mass Spectrometry** 1.1 UV-Visible Spectroscopy: Calculation of λmax for conjugated dienes & trienes, α,β-unsaturated carbonyl compounds, carboxylic acids & esters using Woodward – Fieser rules - UV visible spectrum of benzene and pyridine; Influence of chromophore and auxochrome; Solvent Effects 1.2 FT-IR spectroscopy: Vibrational frequency of alkanes, alkenes, alkynes, halides, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines and amides, Factors affecting the vibrational group frequency. 1.3 Mass spectrometry: Nitrogen rule - McLafferty rearrangement - Fragmentation pattern of aliphatic and aromatic organic compounds such as alkanes, alkenes, alkynes, halides, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines and amides. Factors affecting fragmentation pattern.	12	CO1-CO5	K1 – K5
II	**NMR Spectroscopy** 2.1 Proton NMR Spectroscopy: Chemical Shift, Factors affecting chemical shift - Spin-spin coupling, spin-spin splitting, coupling constant, Factors affecting coupling constant - geminal coupling, vicinal coupling, long range coupling (Allylic, homoallylic and aromatic coupling), Nuclear Overhauser Effect (NOE) - Chemical equivalence and magnetic equivalence, 1H-NMR absorption of aliphatic and aromatic hydrocarbons, halides, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, nitro compounds, amines and amides – Aromaticity and NMR spectroscopy	12	CO1-CO5	K1 – K5

	2.2 13C-NMR Spectroscopy: Proton decoupled 13C-NMR spectrum - 13C-NMR chemical shift, Factors affecting 13C-NMR chemical shift - Characteristic chemical shifts of common organic compounds and functional groups and assignment of chemical shifts 2.3 Combined Spectroscopic problems: Elucidation of simple organic compounds (ethyl acetate, propionaldehyde, diethyl ether, butyl amine, pentanols, mono-halogenated anisoles, benzoic acid, aniline, acetanilide, β-naphthol, vanillin) using UV-Vis, FT-IR, NMR and Mass spectral data.			
III	**Retrosynthetic Analysis** 3.1 Protection and deprotection of functional groups like hydroxyl, amino, carbonyl and carboxylic acid group. 3.2 Terminology: target molecule, disconnection, retrosynthetic arrow, synthons, synthetic equivalent, reagent, and functional group transformation - Guidelines for the order of events. 3.3 One group C-X disconnection of propanil, chlorbenside and gardenia perfume – Two group C-X disconnection: 1,1-Difunctionalized 1-aminomethylcyclohexanol, 1,2-difunctionalized proparacaine, 1,3-Difunctionalized 2-(cycloheptyloxy)ethanamine: Cyclisation reaction in 4-phenyl morpholine 3.4 Reversal of polarity (Umpolung) in α-chloro-p-nitroacetamide 3.5 One group C-C disconnection: 1,1 C-C disconnection in 1-Phenylcyclohexyl propionate and 1,2 C-C disconnection in 3-Methylpentanoic acid – Two group C-C disconnection in Diels-Alder reaction and Claisen condensation.	12	CO1-CO5	K1 – K5
IV	**Oxidation and Coupling reagents** 4.1 Oxidation reagents: KMnO4/H2SO4, K2Cr2O7/H2SO4, Jones reagent, PCC, Collins reagent, MnO2, OsO4, Pb(OAc)4, Fenton's reagent, Fetizon's Reagent, Moffatt Oxidation, Swern Oxidation, DDQ, Chloranil, NBS, Epoxidation, Dess-Martin Periodinane 4.2 Coupling reagents: EDC, DCC, HBTU, HATU	12	CO1-CO5	K1 – K5
V	**Reduction** 5.1 Catalytic hydrogenation: H2/Raney-Ni, Lindlar's catalyst, Rosenmund catalyst, Adams catalyst, H2/CuCrO4 5.2 Hydride based-reducing agents: NaBH4, LiAlH4 (mechanism for the reduction of ester and cyanide), DIBAL-H, 9-BBN, L & K-selectride 5.3 Partial and complete reduction of alkynes –Birch reduction - Clemmenson reduction, Wolff-Kishner reduction.	12	CO1-CO5	K1 – K5

Textbooks

1. Donald L. Pavia, Gary M. Lampman, George S. Kriz, and James R. Vyvyan, Introduction to Spectroscopy, 4th Edition, Cengage Learning India Private Limited, India, 2015
2. March's Advanced Organic Chemistry, Michael B Smith, Jerry March, 7th Edition, Wiley Students Edition, India, 2013.
3. Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford University Press, New Delhi, India, 2019.

References

1. Organic Spectroscopy, William Kemp, 3rd Edition, Palgrave, USA, 2017.
2. Stuart Warren, Organic Synthesis: The Disconnection Approach: Wiley India Pvt. Ltd., India, 2019.
3. Francis A Carey and Richard J Sundberg, Advanced Organic Chemistry Part (A & B) 5th Edition, Springer, New York, USA, 2007
4. Michael B Smith, Organic Synthesis, 3rd Ed.; Elsevier, USA, 2010.

Suggested Reading

1. L D Field, S Sternhell, J R Kalman, Organic Structures from Spectra, 3rd Edition, John Wiley & Sons Ltd, England, 2003

2. Jack K. Becconsall, Basic one and two dimensional NMR Spectroscopy, 4th Edition, Wiley – VCH, 2005.
3. G C Barret, K W Bentley and G W Rirty Elucidation of Organic structures by Physical and Chemical Methods Part I, Chapter VIII, John Wiley, 1972.

Online Resources (accessed on 28 June 2022)

1. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_pg/667
2. http://epgp.inflibnet.ac.in/
3. https://www.biocis.universite-paris-saclay.fr/IMG/pdf/Coupling_Reagents.pdf

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO7	PSO 8	
CO 1	3	2	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	2	3	-	-	-	-	-	3	3	-	-	-	-	-	-	K2
CO 3	1	3	3	-	-	-	-	-	2	3	3	-	-	-	-	K3
CO 4		3	3	3	-	-	-	-		2	3	-	-	-	3	K4
CO 5	1	3	3	-	-	-	-	-	1	2	3	-	-	-	3	K5
Wt. Avg.	1.75	2.8	3	3	-	-	-	3	2.25	2.33	3	-	-	-	3	
Overall Mapping of the Course														PO: 2.64 PSO: 2.71		

COORDINATION AND BIOINORGANIC CHEMISTRY – II

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part I**	**Core**	**Theory**
Semester	**III**		
Year of Implementation	**From 2023-24 onwards**		
Course Objectives	1. To recognize the fundamental concepts and structural aspects of organometallic compounds 2. To identify coordination compounds using spectroscopic tools. 3. To predict inorganic structures using spectroscopy and ORD techniques To comprehend the structural characteristics of metalloenzymes		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the fundamental concepts and principles of (i) Organometallic Chemistry (ii) Inorganic Spectroscopy and (iii) Redox and non-redox metalloenzymes	PSO1, PSO2	K1
CO2	Explain the concepts and principles of (i) Organometallic Chemistry (ii) Inorganic Spectroscopy and (iii) Redox and non-redox metalloenzymes	PSO1, PSO2	K2
CO3	Apply (i) the concepts and principles of Organometallic Chemistry explain the catalytic reactions; (ii) the principles of inorganic spectroscopy to understand the structure of inorganic complexes and (iii) concepts of coordination chemistry to understand the reactions of metalloenzyems	PSO2, PSO3, PSO4	K3
CO4	Analyse (i) the catalytic cycles of oranganometallic compounds based on chemical concepts (ii) the spectroscopic behaviour of coordination compounds and (iii) the biological processes of metalloenzymes.	PSO2, PSO3, PSO4	K4
CO5	Compare and evaluate the behaviour and chemical processes of coordination, organometallic and bio-inorganic compounds	PSO2, PSO3, PSO4	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Organometallic compounds – Bonding** 1.1 18 and 16 electron rule and stability of organometallic compounds 1.2 Bonding in metal – olefin complexes, bonding in Ziese's salt, metal-acetylene and metal – allyl complexes; Metal – cyclopentadienyl complexes – Examples and MO approach to bonding in metallocenes; fluxional isomerism 1.3Metal – carbonyl complexes: MO diagram of CO; Structure and bonding − bonding modes, DCD model and MO approach of M-CO bonding, π-acceptor nature of carbonyl group, synergistic effect (stabilization of lower oxidation states of metals) and IR spectroscopy of metal carbonyls. 1.4 Phosphines as Neutral spectator ligands in M-CO complexes –effect of electronic parameter of phosphines on π-back bonding and IR stretching frequency of CO in carbonyls.	12	CO1-CO5	K1 – K5
II	**Organometallic chemistry – Reactions and Catalysis** 2.1 Oxidative addition, reductive elimination (α and β eliminations), migratory insertion reaction and metathesis reaction 2.2 Organo-metallic catalysis: Hydrogenation of olefins (Wilkinson's catalyst), hydroformylation of olefins using cobalt or rhodium catalysts (oxoprocess), oxidation of olefin (Wacker process), olefin isomerisation, water gas shift reaction, cyclo-oligomerisation of acetylenes using Reppe's catalysts, Monsonto process.	12	CO1-CO5	K1 – K5
III	**Inorganic Spectroscopy – Absorption spectroscopy** 3.1 Electronic spectroscopy – Ground state Term symbol for d electronic configurations, characteristics of d-d transitions, charge transfer transitions, selection rules for electronic spectra, Orgel correlation diagrams, Racah Parameters, nephelauxetic series and Sugano-Tanabe energy level diagrams. Prediction of transitions in various complexes and calculation of Δo and B (or B') based on the correlation diagrams. 3.2 Optical Rotatory Dispersion – Principle of CD and ORD; Δ and λ isomers in complexes, Assignment of absolute configuration using CD and ORD techniques. 3.3 Application of IR spectroscopy in identification of linkage isomerism and geometrical isomerism.	12	CO1-CO5	K1 – K5
IV	**Inorganic Spectroscopy – Magnetic Resonance spectroscopy** 4.1 Applications of Nuclear Magnetic Resonance (H, C, P and F) spectroscopy in understanding the structure of inorganic compounds and coordination complexes.	12	CO1-CO5	K1 – K5

	4.2 Applications of ESR to coordination compounds with one and more than one unpaired electron – hyperfine and secondary hyperfine splitting and Kramer's doublets. 4.3 Mossbauer spectroscopy – Mossbauer effect, Recoil energy, Mossbauer active nuclei, Doppler shift, Isomer shift, quadrupole splitting and magnetic interactions. Applications of Mössbauer spectra to Fe and Sn compounds.			
V	**Bio-inorganic Chemistry – III** 5.1 Redox and non-redox metalloenzymes – Introduction and examples 5.2 Redox metalloenzymes: Fe containing enzymes – Classification and structural features of cytochromes and Fe-S proteins; Copper blue proteins – Classifications and examples, structure and mechanistic action of ascorbic acid oxidase; Peroxide and superoxide scavenger enzymes: Structure and Reactivity of superoxide dismutase, catalase and peroxidase; Molybdenum enzymes – Xanthine oxidase and nitrogenase 5.3 Non-redox metalloenzymes: Structure and reactivity of carboxy peptidase and carbonic anhydrase and calmodulin	12	CO1-CO5	K1 – K5

Textbooks

1. B D Gupta and A K Elias, Basic Organometallic Chemistry: Concepts, Syntheses and Applications, University Press, 2013
2. G L Meissler and D A Tarr, Inorganic Chemistry, 3rd Edition, Pearson Education Inc., 2008
3. J E Huheey, E A Keiter, R L Keiter and O K Medhi, Inorganic Chemistry – Principles of structure and reactivity, 4th Edition, Pearson Education Inc., 2006
4. Asim K. Das, Bioinorganic Chemistry, Books & Allied Ltd., 2007
5. K Hussain Reddy, Bioinorganic Chemistry, New Age International, 2007

References

1. Rosette M. Roat-Malone, Bioinorganic Chemistry: A Short Course, John Wiley and Sons Inc., 2007
2. I Bertini, H B Gray, S J Lippard and Valentine, Bioinorganic Chemistry, University Science Books, 1994

Suggested Reading

1. P Gütlich, E Bill, A X Trautwein, Mossbauer Spectroscopy and Transition Metal Chemistry: Fundamentals and Applications, 1st edition, Springer-Verlag Berlin Heidelberg, 2011
2. M Gielen, R Willem and B Wrackmeyer, Advanced Applications of NMR to Organometallic Chemistry, John Wiley and Sons Ltd., 1996

Online Resources (accessed on 28 June 2022)

1. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	2	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	3	2	-	-	-	-	-	3	3	-	-	-	-	-	-	K2
CO 3	2	3	2	-	-	-	-	-	3	2	3	-	-	-	-	K3
CO 4	2	3	2	-	-	-	-	-	3	2	2	-	-	-	-	K4
CO 5	2	3	2	-	-	-	-	-	3	2	2	-	-	-	-	K5
Wt. Avg.	2.4	2.6	2	-	-	-	-	3	3	2	2.3					
Overall Mapping of the Course														PO: 2.3 PSO: 2.58		

BIOPHYSICAL CHEMISTRY

Course Code			
Credits	**5**		
Hours / Cycle	**3**		
Category	**Part NA**	**Elective**	**Theory**
Semester	**III**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To understand the physical laws that regulate biological processes. 2. To gain insights into the intermolecular forces acting in biological molecules		

CO#	**Course Outcome(s)**	**PSO Addressed**	**Bloom's Taxonomy Levels (K1 to K5)**
On completing the course successfully, the student will be able to			
CO1	Recall the fundamental concepts of physical chemistry in relation to biology.	PSO1	K1
CO2	Explain the chemistry beyond biological processes occurring in plants and animals.	PSO1, PSO2, PSO3	K2
CO3	Apply the fundamental concepts and theories of physical chemistry in study of physical properties of biological systems.	PSO2, PSO3, PSO4	K3
CO4	Analyse the reactivity of biomolecules in relation to their structure and physical properties	PSO2, PSO3, PSO4	K4
CO5	Evaluate the performance of biophysical systems and propose refinements in the existing models and systems.	PSO2, PSO3, PSO4	K5

SYLLABUS

UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**1.1 Ionic Activity**: Debye-Hückel theory of electrolytes - The salting-in and salting-out effects **1.2 Membranes:** Lipid molecules, lipid bilayers, phase transitions in lipids, bilayers, and membranes, surface tension, surface free energy, vapour pressure and surface tension, biological membranes	9	CO1-CO5	K1 – K5

	1.3 Colligative properties of electrolyte solutions: The Donnan effect, Biological membranes, membrane transport, simple diffusion, facilitated diffusion, active transport **1.4 Electrostatics:** Dielectric Constant ($\varkappa$) and Capacitance (C) and Membrane Capacitance			
II	**2.1 Bioenergetics:** Standard state in biochemistry ATP, currency of energy, principles of coupled reactions glycolysis; limitations of thermodynamics in biology **2.2 Biochemical applications of thermodynamics:** Isothermal titration calorimetry , double strand formation in nucleic acids and ionic effect on protein–nucleic acid interactions	9	CO1-CO5	K1 – K5
III	**3.1 Biological Oxidation:** The Chemiosmotic Theory of Oxidative Phosphorylation - Membrane Potential - The Goldman Equation - The Action Potential **3.2 Role of intermolecular forces in biology:** Types of Intermolecular Forces - dipole-dipole interaction, ion-dipole interaction, ion-induced dipole and dipole-induced dipole interactions, London forces. Repulsive and total Interactions. Role of dispersion forces in sickle-cell anaemia. **3.3 Protein stability:** Hydrophobic interaction, denaturation and protein folding	9	CO1-CO5	K1 – K5
IV	**4.1 Physical aspects of photosynthesis:** Chloroplast, chlorophyll and other pigment molecules, the reaction center, photosystems I and II, dark reactions **4.2 Vision:** Structure of rhodopsin and mechanism of vision **4.3 Biological effects of radiation: S**unlight and skin cancer, photomedicine **4.4 Macromolecules:** Methods of determining size, shape, and molar mass (sedimentation, ultracentrifuge, viscosity and electrophoresis) of macromolecules.	9	CO1-CO5	K1 – K5
V	**5.1 Structure of synthetic polymers:** Configuration & Conformation and The random-walk model **5.2 Enzyme kinetics in multi-substrate systems:** Sequential mechanism and non-sequential Mechanism - Enzyme Inhibition – Types; Oxygen Binding to Myoglobin and Hemoglobin (cooperative effect and conformational changes) Hill equation, concerted model and sequential model.	9	CO1-CO5	K1 – K5

Textbooks

1. K. E. van Holde, W. C. Johnson and P. S. Ho, Principles of physical biochemistry, 2nd edition, Pearson Prentice Hall, New Jersey, 2006.
2. R. Chang, Physical Chemistry for the Biosciences, 5th edition, University Science Books, California, 2005

References

1. D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry, 7th edition, W H Freeman & Co., New York, 2017.
2. I. Tinoco, Jr., K. Sauer, J. C. Wang, J. D. Puglisi, G. Harbison, D. Rovnyak, Physical Chemistry-Principles and Applications in Biological Sciences, 5th edition, Pearson Education, Inc., New Jersy, 2014.
3. M. L. Bender, L. J. Braubacher, Catalysis and Enzyme Action, McGraw-Hill, New York, 1973.

Suggested Reading

1. I. M. Klotz, Energy Changes in Biochemical Reactions, Academic Press, New York, 1967.
2. D. G. Nicholls, S. J. Ferguson, Bioenergetics, Academic Press, New York, 1992.
3. A. Orstan, J. F. Wojcik, Spectroscopic Determination of Protein-Ligand Binding Constants, J. Chem. Edu. 64 (1987) 814.
4. A. F . Huxley, Energetics of Muscle, Chem. Brit. 6 (1970) 477.
5. W. G. Nigh, A Kinetic Investigation of an Enzyme-Catalyzed Reaction, J. Chem. Educ. 53 (1976) 668
6. A. Ault, An Introduction to Enzyme Kinetics, J Chem. Educ. 51 (1974) 381.

Online Resources (accessed on 28 June 2022)

1. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	-	-	-	-	-	-	3	-	-	-	-	-	-	-	K1
CO 2	3	3	-	-	-	-	-	2	2	2	-	-	-	-	-	K2
CO 3	-	3	-	-	-	-	-	-	3	3	3	-	-	-	-	K3
CO 4	-	3	-	-	-	-	-	-	3	3	3	-	-	-	-	K4
CO 5	-	3	-	-	-	-	-	-	3	3	3	-	-	-	-	K5
Wt. Avg.	3	3	-	-	-	-	-	2.5	2.75	2.75	3	-	-	-	-	
Overall Mapping of the Course														PO: 3.0 PSO: 2.75		

LABORATORY AND MANUFACTURING PRACTICES

Course Code			
Credits	**4**		
Hours / Cycle	**3**		
Category	**Part III**	**Core**	**Theory**
Semester	**III**		
Year of Implementation	**From the academic year 2023-24 onwards**		
Course Objectives	To acquire knowledge of good laboratory practices and safety procedures for experiment conduct/design, understand procedures and protocols in product development, and gain insights into Manufacturing Practices for production processes.		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the basic principles, etiquettes and terms involved in handling chemicals in laboratory and industry	PSO3	K1
CO2	Understand the procedure and protocols to be followed in laboratory and industry.	PSO3, PSO6	K2
CO3	Apply the knowledge to provide a safer laboratory environment through proper handling and disposal of hazardous chemicals.	PSO4, PSO7	K3
CO4	Analyse the good laboratory practices with standard protocols and gain insights into the good manufacturing practises	PSO7, PSO8	K4
CO5	Utilize the knowledge gained to become a successful chemist, scientist and an entrepreneur by providing a safer environment in laboratory or industry	PSO7, PSO8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	1.1Good Laboratory Practices (GLP): History of GLP, p rinciples and requirements of GLP (test facility organization and personnel, Quality Assurance Programme (QAP), facilities, apparatus, material and reagents. 1.2 Test systems, test and reference items, standard operating procedures (SOPs), performance of the study, reporting of study results, storage and retention of records and materials 1.3 Material Safety Data Sheet (MSDS) & Safety Data Sheet (SDS) and their significance.	9	CO1-CO5	K1 – K5
II	2.1 General safety and operational rules - Lab safety protocols: labelling and storage and safety protocols - Disposal of chemicals/reagents/unknown chemicals, spilling of chemicals, handling hazardous chemicals and waste management. 2.2 Guidelines for handling (i) Mercury Waste; (ii) Ethidium Bromide; (iii) Bis-acrylamide; (iv) Phenol/ Chloroform; (v) Cryogenic liquids; (vi) Dry Ice; (vii) Radioactive Material; (ix) corrosive materials.	9	CO1-CO5	K1 – K5
III	3.1 Good Manufacturing Practices (GMP) - Principles and requirements (location and surroundings, water system, warehousing area, production area, ancillary areas, quality control area, personnel, raw materials, equipment,	9	CO1-CO5	K1 – K5

	documentation and records, labels and other printed materials) 3.2 Quality Assurance, Quality Control system, product containers and closures, master formula records, packing records, product recalls, complaints and adverse reactions, aseptic areas, garments 3.3 Installation of a pilot plant - concept, significance, design, layout of pilot plant scale up study, operations, large scale manufacturing techniques (formula, equipment, process, stability and quality control) of solids, liquids, semisolid and parenteral dosage forms.			
IV	4.1 Laboratory safety symbols and their significances - The pyramid of the hierarchy of controls. 4.2 Case Studies: (i) An Accident with Acetic Acid and Bromine; (ii) Injury and Fire Resulting from Benzene Vapor Explosion in a Chemistry Laboratory; (iii) Mercury Spill Decontamination Incident at the Rockefeller University; (iv) Texas Tech University – Laboratory Explosion; (v) Preventing Incidents from Flammable Chemicals in Educational Demonstration; (vi) A two-liter pyridine spill in an undergraduate laboratory 4.3 General Recommendations to avoid accidents in laboratory	9	CO1-CO5	K1 – K5
V	5.1 Introduction to drug designing - stages of drug designing 5.2 Clinical trials: Designing clinical trials, selection criteria – Phases in clinical trials Phase 0, I, II, III and IV 5.3 Investigational New Drugs Application (IND) & New Drug Application (NDA): requirements, informational content, procedures and protocols – Scale Up Post Approval Changes (SUPAC) - Post marketing surveillance - Product registration guidelines.	9	CO1-CO5	K1 – K5

Textbooks

1. Jürg P. Seiler, Good Laboratory Practice –the Why and the How, 2nd Edition, Springer Berlin, Heidelberg, 2005

2. Pradeep Deshmukh, Principles of Good Laboratory Practice, Adhyyan Books, India, 2020.

References

1. Good Laboratory Practice. By European Chemical Industry Ecology and Toxicology Centre (ECETOC), Monograph No. 1, Brussels October1979.

2. Good Laboratory Practice. by G.E. Paget, MTP Press Limited, Lancaster1979

Suggested Reading

1. Good Laboratory Practice. Part 1. An introduction, J. Chem. Educ. 2013, 90, 854−857.
2. Good Laboratory Practice. Part 2. Recording and Retaining Raw Data, J. Chem. Educ. 2013, 90, 858−861
3. Good Laboratory Practice. Part 3. Implementing Good Laboratory Practice in the Analytical Lab, J. Chem. Educ. 2013, 90, 862−865.

Online Resources (accessed on 28 June 2022)

1.https://www.pharmaguideline.com/2021/09/supac.html#:~:text=What%20is%20SUPAC%3F,%2C%20equipment%2C%20site%20of%20manufacturing.

2. https://www.cancer.org/treatment/treatments-and-side-effects/clinical-trials/what-you-need-to-know/phases-of-clinical-trials.html
3. https://thescholarship.ecu.edu/handle/10342/7642

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	-	3	-	-	-	-	-	-	-	3	-	-	-	-	-	K1
CO 2	-	3	-	3	-	-	-	-	-	3	-	-	3	-	-	K2
CO 3	-	3	-	3	-	-	-	-	-	-	3	-	-	3	-	K3
CO 4	-	-	-	3	-	-	3	-	-	-	-	-	-	3	3	K4
CO 5	-	-	-	3	-	-	3	-	-	-	-	-	-	3	3	K5
Wt. Avg.	-	3	-	3	-	-	3	-	-	3	3	-	3	3	3	
Overall Mapping of the Course														PO: 3 PSO: 3		

INTRODUCTION TO CHEMINFORMATICS

Course Code			
Credits	**4**		
Hours / Cycle	**3**		
Category	**Part III**	**Core**	**Theory**
Semester	**III**		
Year of Implementation	**From the academic year 2023-24 onwards**		
Course Objectives	To proficiently utilize a range of in-silico techniques and online databases/tools for designing molecules while developing a comprehensive understanding of the significance of quantum chemistry in drug design processes, and demonstrating effective prediction of molecular properties using cheminformatics tools.		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the basic principles of chemistry and its role in drug designing	PSO1, PSO2, PSO5	K1
CO2	Understand the significance of file formats involved in cheminformatics techniques	PSO1, PSO3, PSO5	K2

CO3	Apply the knowledge to predict the molecular properties of molecules using online/offline tools	PSO5, PSO7	K3
CO4	Analyse the outputs from various property calculators to gain insights into the drug design strategies.	PSO3, PSO5, PSO7	K4
CO5	Use online cheminformatics tools to evaluate, screen and tune the drug molecules	PSO2, PSO5, PSO8	K5

SYLLABUS

UNIT	CONTENT	HOURS	COs	BLOOM'S TAXONOMY LEVEL
I	1.1 Molecular representations - 2D to 3D conversions – visualization software programs - Marvin Sketch, ACD Labs (ChemSketch) 1.2 Different file formats and their construction - (SMILES, MDL number, Cartesian coordinates, Z-matrix, PDB file, CIF, Mol) 1.3 Online molecular builders - Similarity and Fingerprint Analysis - Molecular Similarity - Exact Structure Search - Substructure Search	9	CO1 - CO5	K1 – K5
II	2.1 Introduction to Databases - Types of Databases - Database Management System – database creation and management - Data storage & retrieval techniques 2.2 Chemical Structure Databases - Online cheminformatics databases - Chemspider - MOLBASE - OCHEM – Cambridge Crystallographic Data Centre (CCDC) 2.3 Protein Data Bank (PDB) – PubChem – Drug Bank - Cheminformatics.org	9	CO1 - CO5	K1 – K5
III	3.1 Structure-property relationships - Descriptors – Principle and Applications of QSAR 3.2 Introduction to computational chemistry - Geometry Optimization techniques – Methods (Molecular mechanics, molecular dynamics, semi-empirical and DFT – basic concepts only) – Potential Energy Surface - Single point energy - Frequency calculations – Conformational Analysis 3.3 Molecular property calculations - molecular orbitals (HOMO and LUMO) – Electrostatic potential maps – software programs for DFT calculations	9	CO1 - CO5	K1 – K5
IV	4.1 Introduction to drug designing - strategies & challenges – types of drug designing (ligand-based drug designing and structure-based drug designing) 4.2 Virtual screening – drug likeness - Bioavailability - ADMET (absorption, distribution, metabolism, excretion, and toxicity) properties & their calculations – Lipinski's rule 4.3 Online tools - Molecular viewers (online/offline) – Inhibitors and drugs.	9	CO1 - CO5	K1 – K5

V	5.1 Introduction to Molecular docking - principles of docking - Types of docking - preparation of protein - preparation of ligand 5.2 Molecular docking algorithms – binding energy and molecular docking scores - online docking tools - Post docking analysis 5.3 Types of interactions - hydrogen bonding, electrostatic interactions, halogen bonding, repulsive interactions, aromatic--π, cation-π and anion-π interactions	9	CO1 - CO5	K1 – K5

Textbooks

1. Muthukumarasamy Karthikeyan & Renu Vyas, Practical Chemoinformatics, 1st Edition, Springer, 2014.
2. Andrew R. Leach & Valerie J. Gillet, An Introduction to Chemoinformatics, 1st Edition, Springer, 2004

References

1. Thomas Engel, Johann Gasteiger, Applied Chemoinformatics: Achievements and Future Opportunities, 1st Edition, Wiley Publication, 2018.
2. Johann Gasteiger, Handbook of Chemoinformatics: From Data to Knowledge in 4 Volumes, 1st Edition, Wiley Publication, 2003.

Suggested Reading

1. Jürgen Bajorath, Chemoinformatics for Drug Discovery, Wiley, 1st Edition, 20013.
2. Jean-Loup Faulon and Andreas Bender, Handbook of Chemoinformatics Algorithms, 1st Edition, Chapman and Hall/CRC, 2010.

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	-	-	-	3	-	-	3	3	-	-	3	-	-	-	K1
CO 2	3	3	-	-	3	-	-	3	-	3	-	3	-	-	-	K2
CO 3	-	-	-	3	3	-	-	-	-	-	-	3	-	3	-	K3
CO 4	-	3	-	3	3	-	-	-	-	3	-	3	-	3	-	K4
CO 5	3	-	-	-	3	-	3	-	3	-	-	3	-	-	3	K5
Wt. Avg.	3	-	-	3	3	-	3		3	3	3	-	3	-	3	
Overall Mapping of the Course														PO: 3 PSO: 3		

ORGANIC CHEMISTRY PRACTICAL-II

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part III**	**Core**	**Practical**
Semester	**3 & 4**		
Year of Implementation	**From the academic year 2024-25 onwards**		
Course Objectives	To apply the concepts of quantitative estimation, identification and separation, extraction and structural elucidation of organic compounds and mixtures.		

CO#	**Course Outcome(s)**	**PSO Addressed**	**Bloom's Taxonomy Levels**
On completing the course successfully, the student will be able to			
CO1	Recall i) general tabulation of quantitative organic estimations ii) the general principles in separation and identification of organic compound using chromatographic techniques iii) general methodology for structural elucidation using spectral data	PSO1 PSO2	K1
CO2	Compile the report of the quantitative organic estimation/separation/extraction/spectral interpretation in an organized way	PSO1 PSO2	K2
CO3	i) Tabulate/present the experimental observations in a systematic manner related to organic quantitative analysis/separation/extraction ii) utilize the spectral data for structural predictions	PSO3 PSO4	K3
CO4	i) carry out calculation and arrive at the result related to organic estimations/separations/extractions during regular classes (iv) Interpret the structure of organic compounds using various spectral data during regular classes	PSO4 PSO5	K4
CO5	i) carry out calculation and arrive at the result related to organic estimations/separations/extractions during ICA (iv) Interpret the structure of organic compounds using various spectral data during ICA	PSO4 PSO5 PSO6 PSO7	K5

CONTENT

I. Estimations:

1. Phenol (bromination)
2. Aniline (bromination)
3. Methyl ketone (iodometry)
4. Glucose (redox)
5. Acetyl group (hydrolysis)
6. Methoxy group
7. Degree of unsaturation
8. Aromatic nitro groups (reduction)
9. Glycine (acidimetry)
10. Iodine value of an oil
11. Saponification number of an oil
12. Ascorbic acid (Iodometry)

II. Identification and Separation of components of an organic mixture (Any 4):

1. Thin layer chromatography (Monitoring the reaction progress)
2. Preparative Thin layer Chromatography
3. Column Chromatography (Purification of organic mixtures)
4. Gas Chromatography (Monitoring the reaction progress)

III. Project Based Learning:

Extraction/separation of:

1. Casein from milk
2. Caffeine from tea leaves
3. Vitamin C from fruits
4. Lycopene from tomatoes
5. Piperine from Pepper
6. Curcumin from Turmeric
7. Pigment from Red Chili

IV. Structural Elucidation using spectral data: (Any 10):

Phenol, Anisole, Benzoic acid, Aniline, Acetanilide, Benzaldehyde, Cinnamic acid, 1,3,5-Trimethylbenzene, n-Propylamine, p-Methoxy benzyl alcohol, Benzyl bromide, Phenylacetone, Pyridine, 4-Picoline, Cinnamaldehyde.

Textbooks

1. N. S. Gnanapragasam and G. Ramamurthy, Organic Chemistry – Lab manual, S. Viswanathan Co. Pvt. Ltd, 1998.

2. J. N. Gurtu and R. Kapoor, Advanced Experimental Chemistry, S. Chand and Co., 1987

References

1.Vogel's Text Book of Practical Organic Chemistry, 5th Ed, ELBS/Longman, England, 1984.

2. V K Ahluwalia, Sunitha Dhingra, Adarsh Gulati, College Practical Chemistry, University Press, India, 2008.

3. Jag Mohan, Organic Analytical Chemistry, Narosa Publishing House, India, 2003

4. Robert M. Silverstein, Francis X. Webster , David J. Kiemle, Spectrometric Identification of Organic Compounds, 8ed, Wiley, 2022

References

1.Vogel's elementary practical organic chemistry : quantitative organic analysis part 3, Pearson India, 2010.

2. Donald L. Pavia, Gary M. Lampman, George A. Kriz and James R. Vyvyan. Introduction to spectroscopy, 5e, Cengage India Private Ltd, 2015

Online Resources (accessed on 30th April 2024)

1. https://edu.rsc.org/practical/preparation-of-an-organic-liquid-practical-videos-16-18-students/4014326.article

M.Sc. Course Articulation Matrix																
Course Outcomes	Programme Outcomes							Programme Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	3	-	-	-	-	-	3	3		-	-	-	-	-	K1
CO 2	3	3	-	-	-	-	-	-3	3		-	-	-	-	-	K2
CO 3	-	2	3	1	-	-	-	-	-	2	3	-		-	-	K3
CO 4	-	2	3		-	-	-	-	-	-	-3	2		-	-	K4
CO 5	-	2	3	3	2	-	-	-	-	-	3	1	3	3	3	K5
Wt. Avg.	3	2.4	3	2	2	-	-	3	3	2	3	1.5	3	3	3	-
Overall Mapping of the Course														PO: 2.48 PSO: 2.69		

INORGANIC CHEMISTRY PRACTICAL II

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part III**	**Core**	**Practical**
Semester	**3 & 4**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To apply physical and inorganic chemistry concepts in quantitative estimation of metal ions by fundamental analytical techniques 2. To acquire 21st century skills such as critical, creative thinking, collaboration and communication as well as bench skills		

CO#	Course Outcomes	PSO Addressed	Bloom's Taxonomy Levels
On completing the course successfully, the student will be able to			
CO1	Recall the basic principles involved in volumetric and gravimetric methods of quantitative analysis.	PSO1	K1
CO2	Understand the basic principles involved in volumetric and gravimetric methods of quantitative analysis.	PSO3, PSO4, PSO6	K2
CO3	Apply the basic principles of volumetric and gravimetric methods for quantitative estimation of the given materials, with high precision.	PSO3 PSO4, PSO6	K3

CO4	Separate the components of the mixture and analyse individual metal components present in the mixture by using volumetric and gravimetric methods	PSO3 PSO4, PSO6	K4
CO5	(i) Summarize their findings in writing in a clear and concise manner and (ii) Draft a mini project proposal including hypothesis and design of experiments	PSO3, PSO7	K5

CONTENTS

I. Double Burette method:

a. Estimation of Iron by cerimetry
b. Estimation of Zinc by complexometric method

II. Single Burette method:

a. Estimation of nitrite
b. Estimation of calcium
c. Estimation of hardness of water

III. Quantitative separation and analysis (one by volumetric and one by gravimetric method) of **any two** the following artificial mixtures:

a. Cu and Ni, b. Cu and Fe, c. Fe and Ni & d. Zn and Cu.

IV. Project Based Learning:

a. Synthesis of a metal complex and determination of its composition
b. Estimation of the components of an alloy by green method
c. Estimation of an inorganic component in a real sample by spectrophotometric method
d. Separation of inorganic cations by paper chromatography
e. Synthesis of a photo-sensitive complex and study of its application

V. Analysis of the following (any TWO):

a. Brass, b. Bronze, c. Solder & d. Pyrolusite

Textbooks

1. Shriniwas L Kelkar, Dilip D Dhavale and Prabodh G Pol, Microscale Experiments in Chemistry - The Need of the New Millenium, Resonance (2001) 14-22
2. G H Jeffery, J Bassett, J Mendham and R C Denney, Vogel's textbook of Quantitative Chemical Analysis, 5th Edition, Longman Group Limited, London, 1989
3. S K Agarwala and Keemti Lal, Advanced Inorganic Analysis, 10th Edition, Pragati Prakashan, Uttar Pradesh, 2008

References

1. Anil J Elias, A Collection of Interesting General Chemistry Experiments, Sangam Books Ltd, 2002

Suggested Reading

1. Gurdeep Raj, Advanced Practical Inorganic Chemistry, 27th Edition, Goel Publishing House, Uttar Pradesh, 2016

Online Resources (accessed on 28 June 2022)

1. https://www.ias.ac.in/article/fulltext/reso/006/02/0014-0022
2. https://www.youtube.com/watch?v=uNhHotinlOg

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	2	2	-	-	-	-	-	2	-	2	-	-	-	-	-	K1
CO 2	2	2	-	-	-	-	-	2	-	2	-	-	-	-	-	K2
CO 3	2	2	-	2	-	-	-	2	-	2	-	-	3	-	-	K3
CO 4	2	2	-	2	-	-	-	2	-	2	-	-	3	-	2	K4
CO 5	2	2	-	3	-	-	-	2	-	2	-	-	2	-	3	K5
Wt. Avg.	2	2	-	2.3	-	-	-	2	-	2	-	-	2.67	-	2.5	
Overall Mapping of the Course														PO: 2.1 PSO: 2.29		

PHYSICAL CHEMISTRY PRACTICAL II

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**Part III**	**Core**	**Practical**
Semester	**3 & 4**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	To apply the theoretical concepts of physical chemistry in determining and understanding of various physical parameters		

CO#	To apply the theoretical concepts of physical chemistry in determining and understanding various physical parameters	**PSO Addressed**	**Bloom's Taxonomy Levels (K1 to K5)**
On completing the course successfully, the student will be able to			
CO1	To recall the basic principles of physical chemistry through hands on experience.	PSO1	K1
CO2	Demonstrate the application of conductometry, potentiometry photocolorimetry for determination of various physical parameters.	PSO3, PSO4, PSO6	K2
CO3	Make use of emf, conductance and absorbance measurements to study/verify/compare/determine/evaluate physical parameters and for detection and separation of metal ions	PSO3 PSO4, PSO6	K3
CO4	Analyse the experimental data to draw conclusions about various chemical processes in light of physical chemistry principles.	PSO3 PSO4, PSO6	K4
CO5	Conclude and summarize their findings in a clear and concise manner	PSO3, PSO7	K5

CONTENT

I. Experiments

1. Verification of Job's continuous variation method for complex formation
2. Determination of critical micelle concentration by conductometry method
3. Comparison of acid strength - Hydrolysis of methyl ethanoate
4. Determination of energy of activation for hydrolysis of methyl ethanoate.
5. Study of kinetics of iodination of acetone
6. Evaluation of rate constant for ester hydrolysis using Guggenheim's method
7. Potentiometric Titration – Strong acid vs Strong base
8. Potentiometric Titration – Mixture of strong acid and weak acid vs Strong base
9. Potentiometric Titration – Mixture of halides vs silver nitrate
10. Potentiometric Titration – Ferrous ion vs Potassium dichromate
11. Determination of thermodynamic parameters by potentiometry
12. Determination of hydrolysis constant of a weak salt from emf measurements.
13. Study of kinetics of hydrolysis of ethyl ethanoate by NaOH using conductance method
14. Determination of concentration of sodium ions by flame photometry.
15. Electrogravimetry - Separation of copper and nickel
16. Study of kinetics of oxidation of alcohols by photometry.
17. Verification of Freundlich adsorption isotherm.
18. Study of effect of ionic strength on the reaction between persulphate and iodide

Textbooks

2. A. Findlay, J.A. Kitchener, Findlay's Practical Chemistry, 8th Edition, Prentice Hall Press,1954.
3. B. Viswanathan and P.S. Raghavan, Practical Physical Chemistry, Viva Books, 2012.

References

2. R.C. Das and B. Behera, Experimental Physical Chemistry, McGraw-Hill Education, 1984.

Suggested Reading

1. Farrington Daniels, Experimental Physical Chemistry, 7th Edition, McGraw-Hill Inc., US, 1970.

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	-	-	-	-	-	-	3	-	-	-	-	-	-	-	K1
CO 2	-	3	-	3	-	-	-	-	-	3	3	-	3	-	-	K2
CO 3	-	3	-	3	-	-	-	-	-	3	3	-	3	-	-	K3
CO 4	-	3	-	3	-	-	-	-	-	3	3	-	3	-	-	K4
CO 5	-	3	-	3	-	-	-	-	-	3	-	-	-	3	-	K5
Wt. Avg.	3	3	-	3	-	-	-	3	-	3	3	-	3	3	-	
Overall Mapping of the Course														PO: 3.0 PSO: 3.0		

PROJECT

Course Code			
Credits	**6**		
Hours / Cycle	**5**		
Category	**Part NA**	**Core**	**Project**
Semester	**III & IV**		
Year of Implementation	**From the academic year 2023-24 onwards**		
Course Objectives	1. To expose students to research in chemistry thereby developing a deeper understanding of the discipline 2. To develop critical thinking, creative thinking, and communication skills 3. To analyse the data, spectra and research findings to answer the research question(s)		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Critically analyze literature to identify the knowledge gap in the research problem.	PSO6	K1
CO2	Generate hypothesis and design experiments to validate the hypothesis.	PSO 4, PSO 5, PSO 6, PSO 7	K2
CO3	Apply the basic concepts to explain the research findings	PSO3, PSO4	K3
CO4	Use domain specific technological research tools to analyze and interpret data	PSO 6	K4
CO5	Present the results as a systematic scientific report in written and verbal	PSO 6	K5

Description

- The research project in M.Sc. program will enable students to gain personal observation and knowledge or experience on a particular field of interest. This is a perfect platform to learn, unlearn and relearn new concepts and a way to move forward to add new skills.
- Research projects / review work develop and enhance the research attitude and aptitude of the students as they attempt to solve a research problem.
- A year-long project helps students to dig deep into the scientific literature to identify the research gap, to rationalize the research questions, frame hypothesis, design experiments and to validate the hypothesis. During the course of project, students will be prepared to work/learn independently.

- The execution of the research project will depict the peak of the learning process, whereby students apply all the knowledge that they have learnt from various courses including scientific research methodology.
- The department encourages students to present their project works in national/international conferences and publish them in reputed peer-reviewed research journals. Upon completion of a M.Sc. dissertation, students will be able to develop a skillset for approaching a research problem, including critical thinking, literature review, design & plan of experiments, interpretation of the results, scholarly writing, communication, time management, and presentation skills.
- The students are assessed throughout the year through periodic presentations and finally through dissertation submission and viva-voce examination. Overall, this project experience will help students to choose their career in academia or research or industry.

M.Sc. Course Articulation Matrix																
Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	2	-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	3	2	-	-	-	-	-	3	3	-	-	-	-	-	-	K2
CO 3	2	3	1	-	-	-	-	-	3	2	3	-	-	-	-	K3
CO 4	2	3	1	-	-	-	-	-	3	-	2	-	-	-	-	K4
CO 5	2	3	2	-	-	-	-	-	3	2	2	-	-	-	-	K5
Wt. Avg.	2.4	2.6	1.3	-	-	-	-	3	3	2	2.3					
Overall Mapping of the Course														PO: 2.1 PSO: 2.58		

ELECTROCHEMISTRY AND SPECTROSCOPY

Course Code			
Credits	**4**		
Hours / Cycle	**5**		
Category	**Part NA**	**Core**	**Theory**
Semester	**IV**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To give a clear approach to conceptualize ionic solvation and various interactions in electrolytes. 2. To comprehend the phenomena of electrochemistry occurring at the surface of electrodes. 3. To gain insights on the applications of electrochemistry to corrosion, electroplating and batteries. 4. To understand the physical principles of microwave, infrared and Raman Spectroscopy.		

CO #	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the basic principles and fundamental laws electrochemistry and spectroscopy	PSO1	K1
CO2	Explain (i) Interaction, transport and association of ions in solution (ii) Structure and reactions at electrodes (iii) Functioning of electrochemical devices (iv) Principles of electronic, rotational, vibrational, Raman and NMR spectroscopy	PSO2, PSO3, PSO4	K2
CO3	Apply the principles of electrochemistry to identify (i) non-ideal behavior of electrolytes and properties of different species in solution (ii) relationship between electrical potential and chemical reactions at electrodes (iii) dynamics of electrochemical devices (iv) possible transitions in molecules	PSO2, PSO3, PSO4	K3
CO4	Analyse (i) different types of ion-solvent interactions and predict properties of solutions (ii) relationship between electrical potential and chemical reactions at electrodes (iii) provide information about the electronic structure of atoms and molecules (iv) selection rules, intensity of spectral lines, and other physical aspects of microwave, infrared, NMR and Raman spectroscopy	PSO2, PSO3, PSO4	K4
CO5	Compare different models used to explain (i) interaction, transport and association of ions in solution (ii) Structure and reactivity at electrodes (iii) operating principles of electrochemical power sources	PSO2, PSO3, PSO4	K5

	Evaluate the spectra of polyatomic molecules using different spectroscopic techniques		

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	1.1 Ion-solvent interaction: Born's treatment of ion solvent interaction - its validity and modification. A brief account of the ion-dipole and ion-quadrupole models of ion solvent interactions. 1.2 Ion-Ion interactions and activity coefficients: Debye - Hückel ionic atmosphere model of the strong electrolytes - derivation of Debye - Hückel limiting law - validity of the equation- extension of Debye - Hückel equation - Significance of the activity coefficient of electrolytes. 1.3 Ion-transport in solutions: Theory of strong electrolytes for electrolytic conduction- Debye Hückel ion atmosphere model - Derivation of the Onsager equation - validity of the equation - modification of the Onsager equation. 1.4 Ion Association: Bjerrum treatment of association - Bjerrum ion association constant - factors influencing ion-association - effect of ion- association on conductivity and activity coefficient of electrolytes in solution.	15	CO1 - CO5	K1 – K5
II	2.1 Dynamic electrochemistry: The electrified interface - IHP, OHP 2.2 Thermodynamics of electrified interfaces- Electrocapillary measurements - Lipmann potential - polarisable and non-polarisable interfaces - Billiter potential. 2.3 Structure of electrified interfaces- Discussion of various models - Helmholtz- Perrin, Gouy Chapmann and Stern Models - derivations of equations and their validity. Electrokinetic phenomenona - electrophoresis, electroosmosis, streaming potential, and sedimentation potential. Electrokinetic effects - concepts and derivations of equations - Zeta potential and its determination- Tsilius method of separation of proteins - stability of colloids. 2.4 Electrodics: Charge transfer across the electrified interface - its chemical and electrical implications - the basic electrodic equation- the Butler - Volmer equation- derivation and its significance-special cases of Butler-Volmer equation. Tafel equation and plots Concept of overpotential - types of overpotential	15	CO1 - CO5	K1 – K5

	2.5 Hydrogen overpotential- factors influencing the hydrogen overpotential and the mechanism.			
III	3.1 Corrosion: Basics of corrosion. EMF and Galvanic series. Classification of corrosion – corrosion kinetics – Pourbaix diagram for Fe- H2O system – passivity. Corrosion control methods- General classification of corrosion control methods – Designing aspects in corrosion control – corrosion inhibitors – Electrochemical methods of protection such as anodic and cathodic protection. 3.2 Electroplating Principles of electroplating – Metal deposition from solutions of simple salts and complex salts – measurement of current density, throwing power and current efficiency of electroplating bath – surface preparation for electroplating. Electroplating of nickel and copper 3.3 Electrochemical power sources: Principle of electrochemical energy conversion, Classification of batteries - primary and secondary systems. Basic electrochemical reactions and performance of primary and secondary systems - Fuel cells - Introduction - Types of fuel cells, construction and principle of operations and application.	15	CO1 - CO5	K1 – K5
IV	4.1 Electronic Spectroscopy of Atoms: Hydrogen atom spectrum – Electronic angular momentum - Fine structure of Hydrogen atom spectrum – Many electron atoms – Spectrum of lithium and hydrogen like atoms- Angular momentum of many electron atoms - term symbols - Spectrum of helium and alkaline earths – Equivalent and nonequivalent electrons - Zeeman effect 4.2 Electronic spectroscopy of molecules: Electronic spectra of diatomic molecules - Frank Condon Principle -Dissociation and predissociation – Rotational fine structure of Electronic – Vibration - Electronic spectrum of polyatomic molecules. 4.3 Nuclear Magnetic Resonance Spectroscopy: Nuclear spin – Larmor frequency – Population of nuclear spin states – Relaxation processes	15	CO1 - CO5	K1 – K5
V	5.1 Microwave Spectroscopy: Classification of molecules according to their moment of inertia – Rotational spectra of rigid diatomic molecule – Intensities of spectral lines – Effect of isotopic substitution – Non-rigid rotor and its spectrum – linear polyatomic molecules. 5.2 Infra-red Spectroscopy: Simple harmonic oscillator and the anharmonic oscillator models – transitions between vibrational levels – The diatomic vibrating rotator – Breakdown of Born-Oppenheimer approximation – Vibrations of polyatomic	15	CO1 - CO5	K1 – K5

	molecules normal modes of vibrations - CO2, H2O and acetylene – Influence of rotation on the spectra of polyatomic linear molecules 5.3 Raman Spectroscopy: Quantum and classical theory of Raman effect – Pure rotational Raman of linear molecules – Vibrational Raman Spectra – Raman activity of vibrations – Vibrational Raman spectra – rotational fine structure			

Textbooks

1. J. O. M. Bockris, A. K. N. Reddy, M. E. G. Aldeco, Modern Electrochemistry, 1, 2A and 2B, Plenum Press, New York, 1998.
2. C. N. Banwell and E.McCash, Fundamentals of molecular spectroscopy, 4th Edition Tata McGraw Hill, India, 1994.
3. D. R. Crow, Principles and Applications of Electrochemistry, Springer, US, 1974.

References

1. C. M. A. Brett, and A. M. Oliveira Brett, Electrochemistry: Principles, Methods, and Applications, Oxford University Press, New York, 1993
2. P. H. Rieger, Electrochemistry, Prentice Hall, Englewood Cliffs, NJ, 1987.
3. D. T. Sawyer, A. Sobkowiak, and J. L. Roberts, Jr., Electrochemistry for Chemists, John Wiley & Sons, New York, 1995.
4. Barrow, G. M., Molecular Spectroscopy, McGraw-Hill, New York, 1962.
5. B. P. Straughan, and S. Walker, Eds. Spectroscopy, Vols. 1, 2, and 3, John Wiley & Sons, New York, 1976.

Suggested Reading

1. P.J. Delahay, Double Layer and Electrode Kinetics, Interscience Publishers, New York, 1965.
2. A. J. Bard and L. R. Faulkner, Electrochemical Methods, Wiley, New York, 2000.
3. A. G. Briggs, Vibrational Frequencies of Sulfur Dioxide, J. Chem. Edu. 47 (1970) 391.
4. F. E. Stafford, C. W. Holt, and G. L. Paulson, Vibration-Rotation Spectrum of HCl, J. Chem. Edu. 40 (1963) 245. 5. H. H. R. Schor and E. L. Teixeira, The Fundamental Rotational-Vibrational Band of CO and NO, J. Chem. Edu. 71 (1994) 771.

Online Resources (accessed on 28 June 2022)

6. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
7. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3	-	-	-	-	-	-	3	-	-	-	-	-	-	-	K1
CO 2	-	3	-	-	-	-	-	-	2	2	2	-	-	-	-	K2
CO 3	-	3	-	-	-	-	-	-	3	3	3	-	-	-	-	K3
CO 4	-	3	-	-	-	-	-	-	3	3	3	-	-	-	-	K4
CO 5	-	3	-	-	-	-	-	-	3	3	3	-	-	-	-	K5
Wt. Avg.	3	3	-	-	-	-	-	3	2.75	2.75	2.75	-	-	-	-	
Overall Mapping of the Course														PO: 2.81 PSO: 2.75		

SCIENTIFIC RESEARCH METHODOLOGY

Course Code			
Credits	**4**		
Hours / Cycle	**4**		
Category	**NA**	**Core**	**Theory**
Semester	**IV**		
Year of Implementation	**From the academic year 2023 - 24 onwards**		
Course Objectives	1. To learn the basics of research, scientific literature survey, ethics and philosophy 2. To impart skills to conduct research and stay away from scientific misconduct 3. To learn and select the appropriate technique for the data analysis 4. To understand the art of scientific writing and publication		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall (i) the definitions of philosophy and ethics of research, plagiarism, scientific misconducts (ii) different types of literature, journals, and publications. (iii) components of thesis, research articles, errors in chemical analysis, research metrics.	PSO1, 2	K1
CO2	Understand (i) the philosophy and basic ethics of research, plagiarism, scientific misconducts (ii) different types of literature survey, journals, and publications. (iii) components of thesis, research articles, errors in chemical analysis, research metrics.	PSO1,2	K2
CO3	Apply the knowledge to conduct the research considering ethical aspects and write the thesis and research articles to enhance research visibility.	PSO7,8	K3
CO4	Analyze the literature to identify the knowledge gap to design, conduct and communicate the research work with a well-structured thesis and research article	PSO7,8	K4
CO5	Evaluate the ethical considerations in scientific research and publications and judge the quality and reliability of various literature sources and publications by devising strategies to enhance research visibility and citations.	PSO7,8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	1.1 Philosophy and ethics of research – Purpose of research, significance of research, scientific Originality. Various stages of scientific research 1.2 Committee on publication ethics (COPE) - Peer Review, Types of Journals (Subscription & Open Access Journals) - Type of Open Access Journals (Gold, Green & Platinum) - Article Processing Charges 1.3 Predatory Journals and cloned journals – Be all's list - Characteristic features of predatory/cloned Journals - Identifying and avoiding predatory journals - Consequences of publishing predatory articles	12	CO1 - CO5	K1 – K5
II	Scientific Misconducts: Falsification (case studies) and Fabrication (case studies) 2.2 Plagiarism - Definition, Classification -Types (Complete Plagiarism, Source-based Plagiarism, Verbatim Plagiarism, Self or Auto Plagiarism and Accidental Plagiarism) with examples - Plagiarism detection tools - online services - causes and consequences of plagiarism. 2.3 Redundant Publications: Duplicate and overlapping publications, salami slicing – Selective Reporting and Misrepresentation of Data.	12	CO1 - CO5	K1 – K5
III	3.1 Types of literature - primary, secondary and tertiary sources (Examples) - literature review in digital era - Online tools available in literature review [Author search, Journal search and Keyword search] - Identifying research gap & framing objectives-hypothesis (definition, types and characteristic features) - designing experiments/methodology 3.2 Search Engines: SciFinder, Scopus, Scientific Technical Information Network (STN) International, Google Scholar, Scirus, Chemfinder, OJOSE, ChemIndustry and ChemSpider. 3.3 Types of publications (Letter, communication, article, review (type of reviews), viewpoint, commentary, letter to the editor, editorial, corrigendum, erratum, rebuttal with examples)- Books and book chapters - ISBN & ISSN	12	CO1 - CO5	K1 – K5
IV	4.1 Components of Thesis: Dissertation and Thesis writing: The general format, chapter format, page format, use of abbreviations, quotations, footnote, tables and figures, results and discussions, bibliography and references - Reference managers (EndNote and Mendeley as examples) 4.2 Components of research article: Title, keywords, abstract, introduction, methodology, results & discussion, figures, tables, equations, schemes and flowcharts, references, Acknowledgement	12	CO1 - CO5	K1 – K5

	4.3 Errors in chemical analysis: Classification of errors and their minimization, accuracy, precision and significant figures. 4.4 Statistical tools and simple analysis (Mean, median, mode and standard deviation; Binominal distribution and Gaussian distribution) - levels of significance and levels of confidence			
V	Research Metrics 5.1 Databases: Web of Science, Journal Citation Report, DOAJ & Scopus 5.2 Research Metrics: Journal Metrics - Impact factor, 5year impact factor, Source normalized impact per paper (SNIP), CiteScore, Scimago Journal Rank (SJR) - Author Metrics - h-index, i-10 index, g-index 5.3 Hot article, Cover article, Most read and downloaded papers - Author Profile: Google Scholar Profile, Mendeley author profile, Publons author profile, ORCID 5.4 Research visibility: Citations, self-citations, infographics, altmetrics, blogging, search engine optimization, Methods to improve citations	12	CO1 - CO5	K1 – K5

Self-study

Hands-on Training (demonstrations) not included for ICA & ESE

1. DOAJ, WoS & SCOPUS
2. Journal Finder
3. Online Plagiarism tools
4. Reference Manager
5. Scimago Journal Rank
6. Google Scholar Citation Analysis
7. Graphical Abstract/Infographic designing
8. Online Databases (CCDC, PDB, OCHEM, etc.,)
9. Misleading metrics – Analysis
10. Beall's list and predatory journals
11. Author metrics (h-index, i-10 index & g-index)
12. Journal metrics (Impact Factor, CiteScore, Scimago Journal Rank & SNIP

Textbooks

1. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International Publishers, 2004
2. S.C. Gupta, and V.K. Kapoor, Fundamentals of Mathematical Statistics. Sultan Chand & Sons, New Delhi, 2014
3. H.F. Ebel, C. Bliefert, W.E. Russcy The art of Scientific Writing, WILEY-VCH VerlasGmbh & Co, 2nd Edition, 2004
4. A.A. Fuscaldo, B. J. Erlick, B. Hindman, Laboratory Safety - Theory and Practice, Academic Press, 1980

References

1. M. L. Patten and M. Newhart Understanding Research Methods, 10th Edition, Taylor & Francis, 2017
2. K. S, Shrader-Frechette, Ethics of Scientific Research Issues in Academic Ethics, Rowman & Littlefield Publisher, 2004
3. A. M. Coghill, L. R. Garson, The ACS Style Guide Effective Communication of Scientific Information, ACS publication, 2006

Suggested Reading
1. M. J. Katz, From Research to Manuscript A Guide to Scientific Writing, Springer Publication, 2006 2. Roberts, Tim S., Student Plagiarism in an Online World: Problems and Solutions,Information Science Reference, Hershey, New York, 2008, IGI Global
3. S. B. Sigmann, L. R. McEwen, A. R. Smith, Teaching Chemical Safety and Information Skills Using Risk Assessment, ACS Symposium Series, Vol. 1232, 2016

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1. http://www.inflibnet.ac.in
2. www.pubs.acs.org
3. www.sciencedirect.com
4. http://spingerlink.com
5. http://rsc.or

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3		-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	3	3	-	-	-	-	-	3	3	3	-	-	-	-	-	K2
CO 3	-	3		3	-	-	3	-	-	3	3	-	-	3	3	K3
CO 4	-	3		3	-	-	3	-	-	-	-	-	-	3	3	K4
CO 5	-	3	-	3	3	-	3	-		-	-	-	-	3	3	K5
Wt. Avg.	3	3	-	3	3	-	3	3	3	3	3	-	-	3	3	
Overall Mapping of the Course														PO: 3 PSO: 3		

ADVANCED CHEMISTRY

Course Code			
Credits	**5**		
Hours / Cycle	**4**		
Category	**Part III**	**Elective**	**Theory**
Semester	**IV**		
Year of Implementation	**From 2023-24 onwards**		
Course Objectives	• To learn about various aspects of asymmetric synthesis of organic compounds • To understand about Lux Flood and Hard & Soft acid-base principles. • To gain knowledge about non-aqueous solvents • To understand the theory and application of advanced NMR techniques. • To appreciate the general mechanism of drug action		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels
On completing the course successfully, the student will be able to			
CO1	(i) define stereospecific and stereoselective reactions, (ii) recall Lux-flood and HSAB concepts acids, (iii) relate the properties of aqueous and non-aqueous solvents, (iv) 1D and 2D NMR and (v) structure of a drug and its physicochemical properties.	PSO1, PSO2	K1
CO2	Explain the concepts of (i) asymmetric synthesis, (ii) compare and contrast various theories of acids and bases, (iii) classify and illustrate the functions of Non-aqueous solvents, (iv) extend the concept from basic NMR to advanced techniques such as COSY and HECTOR and (v) illustrate the theories of drug action with examples	PSO1, PSO3	K2
CO3	(i) make use of chiral reagents to carry out asymmetric synthesis, (ii) apply HSAB principle to explain the stability of compounds and explain Irwing William series, (iii) identify protic and aprotic non-aqueous solvents, (iv) apply 2D NMR techniques for structure determination and (v) build a table of drugs showing similar physicochemical properties.	PSO3, PSO4	K3
CO4	(i) compare the functions of chiral reagents and chiral catalysts, (ii) analyse the relationship between HSAB principle & electronegativity, Irwing-William series & polarizability, (iii) applications of non-aqueous solvents(iv) applications of DEPT experiment and (v) examine the merits and demerits of HSAB	PSO3, PSO4	K4
CO5	(i) assess various chiral auxiliaries, chiral substrate, chiral reagent and chiral catalyst for their capacity in asymmetric synthesis, (ii) evaluate Lux-Flood and HSAB concepts of acids and bases, (iii) compare the properties of ammonia and sulphuric acid as non-aqueous solvents, (iv) to identify the structure of simple organic molecules based on advanced NMR techniques and (v) evaluate actions of drug and the theories of drug action.	PSO2, PSO4	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	Unit 1 Asymmetric Synthesis 1.1 Basic principles of Asymmetric synthesis: Definition - Stereospecific, Stereoselective – enantioselective and diastereoselective reactions. 1.2 Asymmetric synthesis using chiral auxiliary: Chiral auxiliaries derived from proline, camphor, menthol and oxazolidine-2- one. Asymmetric synthesis on chiral	12	CO1 - CO5	K1 – K5

	substrate: Nucleophilic addition to α–chiral carbonyl compounds; Asymmetric synthesis using chiral reagents: Chiral organoboranes - Application of chiral organoboranes in reduction (Ipc2BCl) and allylation reactions Asymmetric synthesis using chiral catalysts: Sharpless epoxidation, dihydroxylation, amino hydroxylation of alkenes; Jacobson catalysts – Evans catalyst – Aziridination 1.3 Analytical methods for determining enantiomeric and diastereomeric excess. Resolution of chiral ligands - BINOL, trans 1,2-diaminocyclohexane. Kinetic resolution of racemic mixtures.			
II	Unit 2 Selective concepts in Acids and Bases (12 hours) 2.1 Lux-flood concept of acids and bases: Definition, explanation and application 2.2 Hard and Soft Acids and Bases (HSAB): Symbiosis, Basic principles – Irwing Willams series, Polarization and polarizability; Classification of acids and bases as Hard or Soft; Hardness and Softness – Theoretical principles, Electronegativity and Acid-Base strength	12	CO1 - CO5	K1 – K5
III	Unit 3 Chemistry of Non-Aqueous solvents (12 hours) 3.1 Introduction to Non-aqueous solvents, Protic and non-protic solvents – Definition and Examples, importance of non-aqueous solvents, leveling effect. 3.2 Behaviour of Ammonia and Sulphuric acid as non-aqueous solvents: Autodissociation, Chemical reactions taking place in ammonia and sulphuric acid medium	12	CO1 - CO5	K1 – K5
IV	Unit 4 Advanced NMR techniques (12 hours) 4.1 Pulse sequences, pulse width, spins, and magnetization vectors, DEPT experiment, Determining the number of attached hydrogens in methine carbons (CH), methylene carbons (CH2), methyl carbons (CH3) and quaternary carbons carbons (C) 4.2 2D NMR: COSY technique and HETCOR technique 4.3 Magnetic resonance imaging	12	CO1 - CO5	K1 – K5
V	. Unit 5 Physico-medicinal chemistry (12 hours) 5.1 Phases of drug action: Pharmacokinetic Phase- Structure of eucaryotic cell (Cell components and their functions, Cell membrane models, Passive and Active transport of materials across cell membranes, Pinocytosis) 5.2 Drug action and physiochemical properties - hydrophobicity, electronic effect, steric effect. 5.3 Pharmacodynamic Phase- Drug action at receptors (the concept of receptors, structurally specific and structurally non-specific drugs, radiochemical studies of receptor sites,	12	CO1 - CO5	K1 – K5

	Agonists and Antagonists, binding force between drug and receptors). 5.4 Drug - receptor theories: Occupancy theory, Rate theory, Induced fit theory, Activation-aggregation theory.			

Textbooks

1. Advanced Organic Chemistry Part (A & B) Francis A Carey and Richard J Sundberg, V Edition, Springer, New York, USA
2. J E Huheey, E A Keiter, R L Keiter and O K Medhi, Inorganic Chemistry: Principles of structure and reactivity, 4th Edition, Pearson Education India, 2006
3. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 4 th Ed, Cengage Learning India Private Limited, 2009.
4. J. B. Taylor, P. D. Kennewell, Introductory Medicinal Chemistry, John Wiley & Sons, 1984.

References

1. S. H. Pine, Organic Chemistry, 5th Edition, McGraw Hill International, 1987
2. 2. G L Meissler and D ATarr, Inorganic Chemistry, 3rd Edition, Pearson Education Inc., 2008
3. 3. Jeffrey H. Simpson, Organic Structure Determination Using 2-D NMR Spectroscopy: A Problem-Based Approach, 2nd edition, Academic Press, 2012 M

Suggested Reading

eves, Stuart Warren, II Edition, 2019, Oxford University Press, New Delhi – 110 001, India
Chemistry, Saunders Publications, USA, 1977 3. L. D. Field, H. L. Li, A. M. Magill, Organic Structures from

Online Resources (accessed on 28 June 2022)

1. https://onlinecourses.nptel.ac.in/noc20_cy36/preview

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	3		-	-	-	-	-	3	3	-	-	-	-	-	-	K1
CO 2	3	2	-	-	-	-	-	3	-	3	-	-	-	-	-	K2
CO 3	3	3	1	-	-	-	-	-	-	2	3	-	-	-	-	K3
CO 4	3	2	1	-	-	-	-	-	-	3	2	-	-	-	-	K4
CO 5	3	3	1	-	-	-	-	-	2	-	3	-	-	-	-	K5
Wt. Avg.	3	2.5	1	-	-	-	-	3	2.5	2.7	2.7	-	-	-	-	
Overall Mapping of the Course						PO: 2.17								PSO: 2.73		

ENTREPRENEURSHIP FOR CHEMISTS

Course Code			
Credits	**5**		
Hours / Cycle	**4**		
Category	**Part NA**	**Core**	**Theory**
Semester	**IV**		
Year of Implementation	**From 2023-24 onwards**		
Course Objectives	• To know about various aspects of entrepreneurship • To learn about business plans, challenges and opportunities in the field of entrepreneurship • To study about Intellectual Property Rights (IPR) • To be aware of entrepreneurial opportunities in chemical industries		

CO#	Course Outcome(s)	PSO Addressed	Bloom's Taxonomy Levels (K1 to K5)
On completing the course successfully, the student will be able to			
CO1	Recall the fundamental concepts and principles of business, entrepreneurship, Intellectual Property (IP) and Chemical industries	PSO3, PSO8	K1
CO2	Understand the fundamental concepts and principles of business, entrepreneurship, Intellectual Property (IP) and Chemical industries	PSO3, PSO8	K2
CO3	Apply the fundamental concepts and principles of business, ethics and entrepreneurship	PSO8	K3
CO4	Analyse and Comprehend the fundamental concepts and principles of business, the misconception in IP, role of chemical industries in India, entrepreneurship skill and the case studies	PSO8	K4
CO5	Compare and evaluate (i) the business environment, challenges opportunities in entrepreneurship in general and chemical industries in specific and (ii) schemes for IP, innovation and entrepreneurship	PSO8	K5

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**COs**	**BLOOM'S TAXONOMY LEVEL**
I	**Business Basics** Introduction, characteristics of business, understanding the business environment, business ethics, types of business organization, key business concepts: Business plans, exploring and understanding the markets need, capability, project management, finance and product design and methods of commercialization.	12	CO1-CO5	K1 – K5
II	**Entrepreneurship - I** Entrepreneur, Entrepreneurship, and Enterprise – Definition; Characteristics of an entrepreneur, role and functions of an entrepreneur; types of entrepreneurships; Entrepreneurship development – Entrepreneurship a dynamic system, key entrepreneurial skills, challenges of entrepreneurship and measuring the entrepreneurship; Government and non-government schemes and programmes on start-ups and entrepreneurship.	12	CO1-CO5	K1 – K5
III	**Entrepreneurship - II** Innovation, Invention, Discovery and Creativity: Definition, Factors important to expertise/skill acquisition; Types of innovation and Drucker's seven sources of innovation; Creative process- five stages of creativity, Innovation as more than problem Solving (Innovation pyramid), developing an invention, innovation and opportunities in India, Global challenges and cooperation's.	12	CO1-CO5	K1 – K5
IV	**Intellectual Property Rights (IPR)** Introduction -concepts, importance of IPR, Types of IPR: Patent, Copyrights, Trademarks, Design, trade secrets geographical indication. Patents – Definition, Elements of patentability, protectable, duration of protection, rights and duties of patentee, assignment and license. Governments schemes in IPR and Career opportunities in IP.	12	CO1-CO5	K1 – K5
V	**Growing a Business in the Chemical Industry** The opportunity matrix: A road map for scaling a chemical business, solution to an existing problem, solution looking for a problem, solution, Current challenges and opportunities for the chemical industries – supply of raw materials, energy, climate change, waste management and environmental impact, role of chemical industries in India and global economies.	12	CO1-CO5	K1 – K5

Textbooks

1. N.S. Gopalakrishnan and T.G. Agitha, Principles of Intellectual Property, Eastern Book company, Lucknow, 2009

2. A. K. Yetisen, L. R. Volpatti, A. F. Coskun, S. Cho, E. Kamrani, H. Butt, A. Khademhosseini and S. H. Yun, Entrepreneurship, Lab Chip, 2015, 15, 3638 (DOI: 10.1039/C5LC00577A).

3. Chemistry - Developing Solutions in a Changing World; The European Association for Chemical and Molecular Sciences (EuCheMS): Brussels, Belgium, 2011

References

1. Chemistry Entrepreneurship Edited by (García-Martínez, Javier, Li, Kunhao), Wiley, 2022

2. The Oxford Handbook of Creativity, Innovation, and Entrepreneurship Edited by Christina E. Shalley, Michael A. Hitt, and Jing Zhou, Oxford University Press, 2005.

3. W.R. Cornish, Intellectual Property, Sweet & Maxwell, London, 2000.

Suggested Reading

1. H. N. Cheng, Sadiq Shah, Marinda Li Wu - Vision 2025_ How To Succeed in the Global Chemistry Enterprise- Chapter 8 (ACS Symposium Series 1157) American Chemical Society (2014).

Online Resources (accessed on 28 June 2022)

1. https://edu.rsc.org/resources/tutor-course-resources-business-skills-for-chemists/4012886.article

2. https://pubs.acs.org/doi/10.1021/acs.inorgchem.1c03288

3. https://ce.ioc.kit.edu/downloads/Chem_Entrepreneurship_Paper_en.pdf

4. https://ipindia.gov.in/resources.htm

5. https://www.startupindia.gov.in/content/sih/en/government-schemes.html

6. https://openstax.org/books/entrepreneurship/pages/4-2-creativity-innovation-and-invention-how-they-differ

M.Sc. Course Articulation Matrix

Course Outcomes	Program Outcomes							Program Specific Outcomes								Cognitive Level
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO 1	-	2	-	-	-	-	3	-	-	2	-	-	-	-	3	K1
CO 2	-	2	-	-	-	-	3	-	-	2	-	-	-	-	3	K2
CO 3	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3	K3
CO 4	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3	K4
CO 5	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3	K5
Wt. Avg.	-	2	-	-	-	-	3	-	-	2	-	-	-	-	3	
											Overall Mapping of the Course			PO: 2.5 PSO: 2.5		